THE SCIENTIFIC MONTHLY

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SCIENTIFIC MONTHLY

VOLUME VI

JANUARY TO JUNE, 1918

NEW YORK
THE SCIENCE PRESS
1918

PRESS OF
THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

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By Dr. BARTON WARREN EVERMANN

DIRECTOR OF THE MUSEUM OF THE CALIFORNIA ACADEMY OF SCIENCES

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Museums had their origin in the effort to preserve and care for the rare and curious objects which travelers brought home from distant lands. Collecting rare and strange objects was first raised to the dignity of a fine art in Italy. The Medici at Florence and the Estes at Modena were the first; they set the example which in time spread throughout Europe.

But the collectors of those days were rarely imbued with the scientific spirit; their motives were largely selfish. They were usually wealthy and cultivated amateurs who assembled and maintained collections for their own pleasure and glorification.

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Fig. 1. San Joaquin Valley Elk (*Cervus nannodes*)

This beautiful animal, sometimes known as the Tule Elk or Dwarf Elk, formerly ranged in vast numbers through the San Joaquin-Sacramento Valley. Only a few hundred now remain. That the species is not entirely extinct is due to the foresight and interest of the late Henry Miller, founder of the great cattle company of Miller and Lux. In the early seventies, when only a few individuals were left, the herd made its last stand on the Kern County ranch of Miller and Lux. Mr. Miller instructed his cattlemen not to disturb the elk in any way. His instructions were carried out and now the herd is in a very prosperous condition. Recently the California Academy of Sciences, with the assistance of Messrs. Miller and Lux, caught and distributed 150 of these Elk to a dozen or more large public or private parks or reservations in California where the conditions are favorable for the increase of the species. Background by Charles Abel Corwin.

It was not until 1753 when the British Museum was established at Bloomsbury and the collections of Sir Hans Sloane acquired, that the idea of a public museum emerged. It was then realized, apparently for the first time, that a museum, to advance art and scientific knowledge, must be liberally endowed, or else fostered by the state. But the founding and development of museums up to recent times need not detain us. With the founding of the British Museum in 1753 and the National Museum at Washington nearly a century later, the idea of the public museum may be said to have become firmly established.

In discussing the development of the United States National Museum Dr. G. Brown Goode considered the history of that institution as falling into three periods:

First, the period from the founding of the Smithsonian Institution to 1857, during which time specimens were collected solely to serve as materials for research. No special effort was made to exhibit them to the public or to utilize them, except as a foundation for scientific description and theory.

Second, the period from 1857 to 1876, during which the museum became a place of deposit for scientific collections which had already been studied, these collections, so far as convenient, being exhibited to the public and, so far as practicable, made to serve an educational purpose.

Third, the present period (beginning with 1876) in which the museum has undertaken more fully the additional task of gathering collections and exhibiting them on account of their value from an educational standpoint.

During the first period the main object of the museum was scientific research; in the second, the establishment became a museum of record as well as research; while in the third period has been added the idea of public education. The three ideas—record, research and education—cooperative and mutually helpful as they are, are essential to the development of every great museum.

Dr. Goode regarded the National Museum first, as *a museum of record,* in which are preserved the material foundations of an enormous amount of scientific knowledge—the types of numerous past investigations; second, as *a museum of research,* which aims to make its contents serve in the highest degree as a stimulus to inquiry and a foundation for scientific investigation; and third, as *an educational museum,* through its policy of illustrating by specimens every kind of natural object and every manifestation of human thought and activity, of displaying

FIG. 2. COLUMBIAN BLACK-TAILED DEER (*Odocoileus columbarius*)

This group represents a summer scene in Mendocino County, California, where the deer shown were taken. At this season the deer assume what is known as the "red coat," which is gradually shed, changing to the bluish coat. The hair then becomes grayer in color as it lengthens for the winter months. In the spring the long hairs of the winter coat are shed and again replaced by the short red coat of summer.

The horns are shed annually, usually in February and March. The entire antler drops off from the skull at the base of the horn or "burr." A new horn sprouts out from the skull and, normally, develops into the antler characteristic of the species. The common belief that a deer develops a new point on the antlers each year and that the number of points indicates the age of the animal is erroneous. Background by Charles Abel Corwin.

descriptive labels adapted to the popular mind, and of distributing its publications and its named series of duplicates. This admirable statement of the scope and objects of the National Museum, made by Dr. Goode twenty years ago, still applies in its general terms to that institution, and equally well to a number of other museums in America.

The one thing which will most strongly impress any one who visits the museums of the east is their activity along educational lines, and the ways in which they are endeavoring to interest the public, and to be of service to the community. It is apparent that the museums of the east are realizing more and more that they owe a debt to the public and to those who have made their existence possible. Until recently most museums have done little or nothing in respect to general education.

> They have been content to be merely vast depositories for collections of priceless value, either unseen or gazed upon in mute wonder by those who visited them.

In such museums visitors "wander listlessly and aimlessly about the halls and galleries, with little appreciation and scarcely any understanding of the treasures that surround them."

But a great change has come about within the last few years. Now, the museum has come to regard itself, and to be regarded by the public, as an educational institution, working in cooperation with the public and private schools, for the good of all the children who can be brought within its influence. It is now realized that a public museum, in order to justify its existence, must be of real service, not only to investigators, but to the general public as well.

To meet the needs of the investigator, the museum must be an institution for research, an institution for the advancement of knowledge and its diffusion among men. A museum furnishes facilities for research and the acquirement of knowledge through, and in proportion to the completeness of, its research collections, and the encouragement it gives to field and laboratory investigations. The knowledge acquired by its investigators through field and laboratory investigations and studies is made known to the world chiefly through the medium of the museum's publications.

The second function of a public museum—perhaps, I may say, the most important function, because it may be regarded as including the first—is that of usefulness to the public in an educational way. Not until recently has this function been fully realized or received attention; but now it is the dominant and

FIG. 3. ROCKY MOUNTAIN MULE DEER (*Odocoileus hemionus*)

This splendid deer is of wide distribution. In California it is found in the Sierras from Kern County northward, coming to the coast in the northern counties. The animals here shown were taken in Siskiyou County, California, in October. This is the largest of the North American deer, the adult male in prime condition weighing nearly 400 pounds. The name "mule deer" is sometimes applied to this species because of its long ears and its mule-like tail. Background painted by Charles Abel Corwin.

controlling thought in many of our museums, great and small.

It is true that most museums, from the very beginning, have maintained considerable collections of natural history objects, and specimens of other kinds, which the visitor might see; but as Director Lucas, of the American Museum of Natural History, has so well said,

> The visitor was greeted by row upon row of animals, most literally stuffed, arrayed in ranks and accompanied by labels whose principal mission was to convey to the public what to them is a most unimportant matter, the scientific names.

But this is not our conception of the modern natural history museum; nor is the modern museum merely a "Haunt of the Muses." It is more than that. It must be not only a place "dedicated to the cultivation of learning" and frequented by men and women devoted to learning and the improvement of human knowledge, but it should be a treasure-house of specimens of the animals, plants and other natural objects of the world, and of objects illustrative of the activities of the races of men.

The educational idea has taken firm hold on many of our American museums. It is manifesting itself in activities along a number of lines, the principal of which are:

1. The installation of large habitat and ecological groups of birds, mammals, etc.

2. The preparation of portable habitat groups for loan to public and private schools.

3. The maintenance at the museum of courses of lectures on natural history, and other subjects adapted to the needs of school children of the different grades.

I can probably best show what this idea is and what a firm hold it has by briefly telling how it is worked out in certain of our more active institutions.

Habitat Groups.—Perhaps the greatest advance of recent years in making museums really educational is in the matter of the installation of exhibits of animals and plants. The improvement has been chiefly with habitat and ecological groups, in giving the animals their natural surroundings, placing them in their natural environment. Until recently in most museums (and in some even to this day) the exhibition specimens of birds and mammals were fastened to a board of some kind and then placed in glass cases, usually against the wall, with no accessories whatever about them, even to suggest in what sorts of places they could be found alive. Now, all that is changed. The species to be shown is shown as a group of individuals—a pair of adults (male and female), one or more young, the nest if it be

Fig. 4. Antelope (*Antilocapra americana*)

The antelope or pronghorn formerly ranged in immense numbers over the plains and valleys of North America west of the Mississippi River from Mexico to Canada. In California great herds were found throughout the Sacramento and San Joaquin valleys and in other valleys to the north, east and south. As a result of persistent persecution and slaughter for their hides and meat, these animals have, in most parts of their range, been entirely exterminated. In southeastern Oregon and northwestern Nevada they are still common. In California small isolated bands are still left. In all these states they are protected by law. The antelope is the only member of the hollow horned animals which annually sheds its horns. Only the outer shell or sheath, however, is shed, and not the entire horn, as in the deer and elk. The antelope is also unique in not possessing dew claws or accessory hoofs on the backs of the feet, as in the deer. The background was painted by Charles Abel Corwin.

a bird, the den in many species if it be a mammal, and the group surrounded by the trees and shrubs, annual plants, and other objects which together make up a bit of just such landscape as you would find the animals in should you seek them alive and in their natural habitat. As only a limited amount or number of units of the environment can be shown by means of the real objects, the setting is made more complete by means of a painted background, the real and the painted being so joined as to make it difficult, in most cases impossible, to tell where the real ends and the painting begins. Along with this improved installation of the group, the problem of proper lighting has also been more satisfactorily solved, as I shall explain later. Among museums which have given special attention to habitat groups I may mention the American Museum of Natural History in New York, the Brooklyn Museum, the Field Museum in Chicago, the Chicago Academy of Sciences, the Milwaukee Public Museum, and the University of Iowa.

Lectures.—A second way in which modern museums are rendering real service to the community is through the medium of public lectures at the museum, on natural history or other scientific subjects of popular or general interest. Not only are courses of lectures provided for adults, but, of greater importance, courses are provided to meet the needs of the different school grades. The lectures usually relate to subjects for which there is found in the museum illustrative material. Instead of the children coming to the museum and wandering through the halls without any real, definite object in view, they are, through observation and explanatory lectures, led to a fuller appreciation of the museum exhibits.

A definite plan of cooperation with the public schools is, of course, necessary. The lectures are upon subjects that form a regular part of the school curriculum. They are adapted to the needs and understanding of the children of the different grades and the courses are maintained throughout the school year. On one day the lecture will be given to, say, fourth-grade pupils; on other days to other grades. The lecturer may give the same lecture three or four times the same afternoon, to as many different groups of fourth-grade children, because all the children of any one grade in the city make too large a number to be accommodated at one time. Definite arrangements are made with the school authorities as to the order in which the classes are to come. The next day, fifth-grade pupils may come, the next day, sixth, and so on.

The American Museum of Natural History in New York

Fig. 5. Desert Mounta in Sheep (*Ovis cremnobates*)

This species of mountain sheep or bighorn is found in the desert mountains of southern California and adjacent parts of Nevada, Arizona and Mexico. The animals in this group were taken in December, 1913, in the San Jacinto Mountains, Riverside County, California. The slender horns of the females have given rise to the mistaken belief that the ibex—an animal found only in Europe and Asia—is found in America. The story that mountain sheep sometimes jump from high precipices and alight on their horns is entirely erroneous, and is on a par with the hoopsnake, sea serpent and other similar stories. In the desert mountains water is usually scarce, and the mountain sheep frequently eat the barrel cactus, the pulpy interior of which contains a large percentage of water; and this no doubt enables the sheep to go for long periods without drinking. Background painted by Charles Abel Corwin.

and the Milwaukee Public Museum have perhaps been most active in the matter of lectures. The lectures given deal with various subjects, as geography, American history, birds of our parks, fur-bearing animals found within 50 miles of the museum, wild flowers of the vicinity, public health, and many other subjects. All the lectures are illustrated by materials and specimens in the museum, by appropriate stereopticon slides (of which each of these museums possesses many thousands), and by moving pictures, photographs and other illustrations. These museums each now maintain a regular department of public education with a competent curator and expert lecturers. Many thousand children attend the lectures, and excellent results are accomplished. Similar excellent work is being done by other institutions.

Although the lecture courses have proved very successful and reach a large percentage of the pupils, they do not and can not reach all. In a large city it is impracticable for the children in the remote, more distant schools to reach the museum. The time required to make the journey to the museum, then back to the school, and the expense involved, are too great. Many children can not afford the cost of car fares. To meet this difficulty it was felt that if the children could not come to the museum, the museum should be sent to the children; and this was done by providing traveling or circulating exhibits or collections, usually called

Loan Exhibits.—These may be habitat groups of small mammals, birds or other animals; minerals, plants, woods and various other objects. For example, it may be a California Quail group showing a pair of adult birds, their nest and young, together with the appropriate surroundings; or it may be a field mouse, adults, nest and young, and the sort of place in which they are naturally found. The case containing the group is small enough to be handled readily, and is made so as to appear attractive. A label accompanies each case, giving the information that school children would naturally wish to know regarding the species. These portable exhibits are loaned to the public schools and are used by the teachers in their nature work and object-lesson teaching. In making up the groups the school authorities are consulted and such groups are prepared as fit into the regular school curriculum.

This is perhaps the most effective way in which the museum can cooperate with the public schools. Several museums are doing excellent work in this line, among which I must mention particularly the Field Museum in Chicago and the American

FIG. 6. MOUNTAIN LION (*Felis oregonensis*)

The mountain lion, in its various forms, is found from Patagonia to Canada, and from the Atlantic to the Pacific. In different parts of its range it is known by different names, as, panther, "painter," cougar, etc. Although not so common as formerly it is still plentiful in certain sections of California, especially in the northern part of the state. The animals in this group were taken in Humboldt County. The mountain lion is the largest of the North American cats. It is very destructive to deer and certain domestic animals, particularly colts and sheep. It has been estimated that each lion in California kills on an average one deer a week throughout the year. So destructive is it that the state pays a bounty of $20 each for its capture. Up to June 30, 1916, the state had paid bounties on 2,534 lions. Although the mountain lion is looked upon as a very fierce animal and more or less of a menace to human beings, it is really a very wary animal, and instances of its attacking man are rare indeed. It is generally easy to tree, even with a cur dog, and chasing it with dogs is the method usually employed in its capture.

Museum of Natural History in New York. A few years ago the Field Museum began this work on a small scale. A public-spirited citizen, Mr. N. W. Harris, saw what they were doing and became deeply interested. Mr. Harris is a man of vision. He at once saw the wonderful possibilities of this method of teaching and the good results that can come from cooperation with the public schools. After investigating the matter carefully, he decided to give to the Field Museum the sum of $250,000 as an endowment for educational work of this kind. With this fund there was established "The N. W. Harris Public School Extension of Field Museum of Natural History." The entire income of this endowment is devoted to educational work. Habitat groups of convenient size and form, attractive in appearance, and such as will teach lessons of real value to the children, are provided in large numbers. Economic collections, such as illustrate or relate to the practical phases of natural production and distribution, geography and commerce, are also made use of. These exhibits are distributed by automobile to the various schools where they are placed in the care of the principals. The cases are allowed to be retained two weeks, and then sent on to the next school on the list. The American Museum of Natural History is also doing the same thing and with very gratifying results.

This practise of sending the museum to the schools, instead of having the school children come to the museum, has the advantage of making it possible to reach a larger number of pupils than could otherwise be reached, and it is more economical of the time of the pupils and teachers. It also makes it easier for the teacher to make the lesson more concrete and more effective.

May I be permitted at this time to speak particularly of the Museum of the California Academy of Sciences and what it is trying to do in the interest of public education. Although the California Academy of Sciences was founded in 1853, just 100 years after the founding of the British Museum of Natural History at Bloomsbury, it was not until recently that any definite attempt was made by it to develop a museum along educational lines. The Museum of the California Academy of Sciences, speaking broadly, feels that it has two primary functions—to promote scientific research with special reference to making known the natural resources of California and the other Pacific coast states, and second, to aid, as best it may, in public education in natural history and other science subjects.

In furtherance of these objects the academy has recently built the first unit of a new museum building in Golden Gate

FIG. 7. NORTHWESTERN BLACK BEAR (*Ursus americanus albifrontalis*)

The black bear in its various forms ranges generally from the Atlantic to the Pacific and from northern Mexico to Alaska. The specimens in this group were taken in Humboldt County, California. In California, as elsewhere, the black bear may be either black or brown. In some instances both black and brown cubs are found in the same litter, and with either a black or a brown mother. Brown bears are sometimes confused with the grizzly which is now believed to be extinct in California. Black bears occasionally kill sheep and pigs, but they live chiefly on nuts, roots and berries; grubs, worms, and insects also enter largely into their menu. As a rule the black bear is a wary animal and will rarely or never attack a man unless wounded or cornered. From one to four cubs (usually one or two) are produced in a litter. The cubs are usually born in January (in California) and are helpless little creatures; their eyes, like those of puppies and kittens, are closed and do not open for some time. They have no teeth and are almost naked. Although the mother bear may weigh three or four hundred pounds, the whole litter of cubs will weigh less than a pound. The cubs shown in this group were about two months old when taken.

Park. This unit, known as the West Wing, consists of a front hall 180 feet long by 60 feet wide, with two rear wings each 128 feet long by 60 feet wide, with a court 70 feet wide between them. Tying the two rear wings to the front is a connecting hall 180 feet long by 18 feet wide. The building is of Bedford, Indiana, limestone and reinforced concrete, and is essentially fireproof. The rear wing on the west is the Research Wing and has two floors. The other wing is for exhibits and has one floor. The front hall is for exhibits and has one floor. An unique feature of the two main exhibition halls is that they have no windows; the lighting is from skylights. The large front hall is devoted entirely to California mammals, and the rear exhibition hall to California birds.

In each of the exhibition halls the cases are built in against the wall. The regulation case for a large mammal or bird habitat group is 25 feet long, 12 feet deep and 18 feet high. Each case has a plate-glass front 15 feet long and 10 feet high. There are 11 of these large cases in the mammal hall and six in the bird hall. In the former are installed habitat groups of various species of large California mammals, and in the bird hall are similar habitat groups of California birds.

Among the groups alreads installed may be mentioned the Valley elk, black-tail deer (summer scene), mule deer (winter scene), antelope, desert mountain sheep, mountain lion, black bear, leopard seal, California sea lion, Steller's sea lion, coyote, Farallon Islands bird rookeries, San Joaquin water bird breeding grounds, desert bird group, California condor, and others. In each group the animals are placed in their natural environment, surrounded by the shrubs, trees, flowers, rocks and other objects such as make up a bit of the scenery which surrounds them in the region where they are found in nature. Then the real is extended by means of a curved painted background which connects so perfectly with the real objects in front as to make it difficult, if not impossible, to tell where the real ends and the painted begins. In addition to these large habitat groups similar small groups of smaller mammals and birds are being installed in suitable places at the ends of the large groups. These usually show a family of a single small species and the den and young if a mammal, and the nest, eggs or young if a bird.

One of the most serious problems in museum construction has been that of proper lighting. In most museums the visitor not only sees the animals in the case, but he sees himself there, and all the people about him, and all the other objects in that

FIG. 8. LEOPARD SEAL (*Phoca richardi geronimensis*)

These interesting seals are fairly common in many places along the California coast, particularly in the bays. Unlike the fur seals which are highly polygamous, the harbor seals are monogamous. On the California coast the young are born in April and May; one pup is the rule. These seals are not migratory, nor are they as gregarious as other seals. They are comparatively silent, not making a loud roaring or barking as sea lions do. They are fond of basking in the sun, especially at low tide. On the land they are clumsy creatures. They move by pulling themselves forward by their foreflippers; in swimming the hind flippers do most of the work. The rookery here shown is at Cypress Point near Pacific Grove, California, where the animals were obtained. The background was painted by Charles Bradford Hudson.

part of the hall. The light *outside* the case is stronger than that *in* it, with the result that everything about the case is reflected in it, always confusing and sometimes quite obscuring the object one wishes to see. This difficulty, we think, has been almost entirely overcome and reflection into the cases practically eliminated by the system of lighting adopted by this museum. This system, as already mentioned, is by means of large skylights over each case and much smaller skylights over the middle of the hall where the observer stands, so small that they let in so little light that there is practically no reflection. Provision is made for artificial lighting at night and on dark days by means of electric lights with reflectors installed outside the cases and above the ceiling glass. There are also shades placed immediately under the skylights, by means of which the light can be modified as required.

The academy has been fortunate in being able to secure several of the best artists in America skilled in this kind of work to paint the backgrounds. One or more backgrounds have been painted by Charles Abel Corwin, of Chicago, Charles Bradford Hudson, of Pacific Grove, California, Maurice G. Logan, of Berkeley, and Worth Ryder, of Oakland. Mr. Corwin has probably had more experience in painting habitat group backgrounds than any other artist in this country. He has done a good deal of work of this kind for the Field Museum, and it was he who painted the really wonderful Laysan Island bird cyclorama for Dr. C. C. Nutting in the University of Iowa. Captain Hudson has also had considerable experience in this field. His backgrounds show an interpretation and finish which can hardly be excelled. But the work of all the artists is of the highest order of excellence. It is difficult, if not impossible, to see wherein any of the backgrounds could be improved.

All matters pertaining to the preparation and installation of the groups have been under the immediate direction of Mr. John Rowley, chief of exhibits. Mr. Rowley is a real artist in his line, remarkably resourceful in devising ways and means for accomplishing the best results. To Mr. Rowley must be given in large measure the credit for the wonderfully attractive and highly instructive habitat groups which are now to be found in the museum of the California Academy of Sciences.

In addition to habitat groups permanently installed in the museum, the academy has begun the preparation of small portable groups and exhibits to loan to the schools. These portable groups are in cases of convenient size and substantially made. The exhibit may be that of a species of bird, mammal, reptile or

FIG 9. CALIFORNIA SEA LION (*Zalophus californianus*)

This sea lion occurs on the sea coast and islands of California from San Francisco southward, breeding in many places, particularly on the Santa Barbara Islands. The rookery here shown is on Santa Cruz Island. Owing to their intelligence and small size this is the species of sea lion that is commonly trained and shown in zoological gardens and elsewhere. The males are darker in color than the females, and are sometimes called black seal lions. Another characteristic of the male of this species is the great development of the bony crest on the top of the skull. In early days sea lions were killed by thousands on the California coast for their hides and oil, but they have now become so reduced in numbers that sealing is no longer profitable. Sea lions as well as leopard seals are now protected on the California coast both by the state and federal governments. Among sealers the males are called "bulls," the females "cows," and the young "pups." The breeding season is from June to August, only during which time the males are found on the rookeries; at other times they go off in bands or singly living their lonely life. Background painted by Worth Ryder.

fish; it may be a group of butterflies or other insects; or it may be typical specimens of instructive minerals, fossils or plants. These exhibits are selected with the specific purpose of furnishing illustrative material for the nature work provided in the public schools. Each exhibit is accompanied by a simple explanatory label.

The museum also maintains a course of lectures throughout the year adapted to adults, and plans to conduct courses adapted to school children of the different grades, as already explained.

As I have already indicated, the educational function or duty is now the dominant influence in most of our American museums. Without curtailing in any way their activities in research work, they are making a special effort to be of real service in the educational field. The feeling among museum men may be expressed in this way: We have long had public schools and public libraries working to educate and train our people, why not public museums for the same purpose? And there are enthusiasts, men of vision, who believe the modern natural history museum will soon be so perfected in its equipment and methods that it will become the most potent force in giving to our children the education and the training that is most worth while.

We all well know how lamentably the public schools are failing to give the education and training they should give. We know how illy prepared our boys and girls are for the life they must live. We know that much which they get in the schools bears little or no relation to the life they are now living or that which they must live as men and women. We know that many of the subjects taught in the schools possess little or no educational value; that others which have value do not receive proper time allotments in the curriculum. For example, arithmetic in the grades receives 25 or 40 minutes per day for 8 years, while physiology and the care of one's health get but 15 minutes per week for a part of one year! It is even worse in the high schools. There the courses of study are devised in many schools to meet college entrance requirements. When we remember that 40 to 50 per cent. of the pupils who enter high school survive only one year or less, that only 3 or 4 per cent. ever go to college, it is evident that courses framed to meet college entrance requirements are meeting the needs of a *very small percentage* of the high-school pupils. It is not true, as we sometimes hear, that the course of high-school studies which best fits for college entrance requirements is the course which best fits for life. We must put it the other way and say that the studies which best

FIG. 10. STELLER'S SEA LION (*Eumetopias stelleri*)

This magnificent animal ranges from the Santa Barbara Islands northward into Bering Sea. Formerly very abundant, persistent killing for its hides and oil has reduced its numbers greatly. Within the last few years they have entirely ceased breeding on the famous seal rocks near the Cliff House at the Golden Gate. A few individuals still resort to these rocks but they no longer breed there. These animals reach a large size. The adult bull shown in the group weighed 1,810 pounds. There is a great difference in size between the sexes, the females being not more than half as large as the males. Fishermen almost without exception claim that the sea lions are very destructive to the commercial fisheries. This is probably true at certain seasons and in some localities, but investigations have not fully sustained the charge. The breeding season of this species on the California coast is the latter half of June. One young is produced at a birth. The noise made by the Steller sea lion is a loud roar, resembling that of a real lion; this, together with the long yellowish hair of the necks of the bulls, doubtless leads to the name sea lion. This group shows the breeding rookeries on Año Neuvo Island just south of San Francisco. Background painted by Charles Abel Corwin.

fit the boy or girl for life are the studies which should best fit him for college should he go to college.

Domination of the high school by the college should stop; it should not be longer tolerated. There are too many subjects in the high-school courses, many of them put there specifically to meet absurd college entrance requirements, which bear no relation to what the average high-school student has ever done or ever will do. They possess no life value. They do not touch the life of to-day; they will not touch the life of the future.

Not long ago I visited a small village school. There I saw a class of country boys and girls, not one of whom is ever likely to go to college, or to be more than a laborer or mechanic or farmer in a small way; yet those poor children were being crucified on the Latin cross for 40 minutes every day. To the life they are living and the life they will live, Latin bears no relation; it does not touch their life anywhere. To them Latin is a subject *in vacuo*. In the high schools there are too many subjects of that kind, and much of the teaching I have seen is teaching *in vacuo*. Although the subject may be a proper one, as chemistry, history, geography or biology, it is often taught without relation to what the child already knows or the things with which he is concerned. Such teaching is "teaching *in vacuo*." The high-school pupil can often truthfully say of the subject and the laborious efforts of the teacher: "It never touched me." But poor teaching can be improved and made good, effective teaching; a useless subject, never.

That our schools are failing to give the education and training which fit for life is evident. The failure is, I believe, primarily due to the fact that the subjects taught are almost entirely memory subjects, or are so taught as to be little more than memory subjects. Little attention is paid to the training of the senses, or to acquiring skill of eye, ear or hand, or to acquiring those habits of accurate recording and cautious reasoning which modern science prescribes. The curriculum is made up largely of *faith subjects*—subjects which merely require the pupil to *believe* something that the text-book or the teacher says. No contact with real things; no training of the eye, hand or reasoning powers; no examination of facts or evidence; no reasoning and the forming of independent judgments; simply a memorizing of useless text-book statements. The facts or data upon which the judgment was based were examined by some one else, and the book and the teacher are like the keeper of a ready-made clothing store—they simply hand out to the pupil the ready-made judgment or conclusion and

FIG. 11. CALIFORNIA RACCOON AND STRIPED SKUNK

This raccoon is found throughout most parts of California, it being especially abundant in the heavily timbered country along the coast. The coon breeds in hollow trees, in holes in the rocks, in blind ditches, and even on the ground in tule swamps. Coons are omnivorous; they eat shellfish, frogs, fish and corn; they sometimes enter hen houses and kill and devour chickens. In the South the negroes are very fond of the raccoon, regarding its flesh as a delicacy. The raccoon ranks third in value among the fur bearers of California. The species of skunk shown in this group occurs throughout northern California except in the warmer interior valleys from Monterey northward. The skunk brings forth its young in holes in the ground, beneath buildings, in stone piles or in hollow logs. They feed largely on insects but will eat flesh of any kind, including chickens. As a fur bearer the skunk is among the most valuable in the United States. In some states skunk farming has become a profitable industry.

will not permit him to question it. Our schools are largely dealers in ready-made judgments and opinions; and nearly all second-hand goods at that.

The child is not taught or given an opportunity to examine the evidence for himself and to reach his own conclusion as to what the evidence shows. The book says it is thus and so, and he must not question the book. It is his duty only to read and believe. He must take on faith what the book and the teacher say. He is even disciplined if he asks any questions or manifests any doubt.

And what is the result? Almost invariably this: Any spirit of the investigator he may have had when he entered school is crushed out of him and he leaves school and goes through life taking things on faith. He becomes a blind follower. He accepts as true anything which he reads or is told by any one in whom he has faith. He never asks to see the evidence; he never reasons; he never forms his own judgments. He can not distinguish fact from fancy, reality from fraud. He falls a ready prey to any fallacy or fraud that comes along, however bald it may be; and the more absurd and bald it is the better he seems to like it.

Of course, I do not mean to say that *all* who go through the public schools are such "easy marks" for the army of frauds and shysters—political, religious, economic, health, and a host of others that infest our land, but it is only necessary to call attention to the thousands who are believers in Ralston Health Clubs, double standards, faith cures, and a score of other frauds and fallacies which flourish in this land, to show that they constitute a very large part of our population. America is said to be the home of shysters and quacks; and the public schools are largely responsible. The remedy lies in radical changes in the courses of study and the method of instruction.

It has been shown that the secondary schools give not more than one tenth to one sixth of their time to observational, sense-training subjects. It is almost equally bad in the primary schools. I wish to quote President Eliot in this connection. He says:

> The changes which ought to be made immediately in the programs of American secondary schools, in order to correct the glaring deficiencies of the present programs, are chiefly: the introduction of more hand, ear and eye work—such as drawing, carpentry, turning, music, sewing, cooking, and the giving of much more time to the sciences of observation—chemistry, physics, biology and geography—not political, but geological and ethnographical geography. These sciences should be taught in the most concrete manner possible—that is, in laboratories with ample experimenting

FIG. 12. CALIFORNIA COYOTE

There are several species of coyotes. The one here shown (*Canis ochropus*) is quite common in the San Francisco bay region. The coyote, wherever found, is a cunning, sneaking rascal, very destructive to ground-nesting birds, rabbits, sheep, pigs and poultry, usually nocturnal and predatory in its habits; nevertheless, an interesting animal which easily gains our admiration because of its sagacity. In most states a bounty is offered for its capture. Background by Maurice G. Logan.

done by the individual pupil with his own eyes and hands, and in the field through the pupil's own observation guided by expert leaders.

And here is where the modern natural history museum finds its place as a factor in public education. The modern museum is in fact many laboratories in one. It is as nearly the fields, hills and all out doors as it is possible to make it within doors. The real objects are there in their natural environment and proper relations. They furnish the materials for observation, comparison, study and the forming of judgments. And they make it easy for the teachers to improve their methods of teaching, to teach concretely.

Indeed, they contain the necessary materials for practically all the teaching that need be done in the elementary and secondary schools. They contain and can supply materials not only for all the observational studies, but most of the other subjects, as arithmetic, language, geography, reading, writing, spelling and even morals. All these subjects become concrete, live subjects when related to real things.

Number work and all the fundamental processes of arithmetic, as addition, subtraction, multiplication, and division, become concrete and easily taught and understood when taught with real objects as illustrative material. The same is equally true of geography, many of the principles and important facts of which can be taught as a part of the study of the museum specimens. And no better drill in language and composition is possible than can be had in connection with the study of real things. In asking and answering questions about them and talking about them, excellent drill in spoken language is had; in writing questions and answers and in preparing descriptions and formal compositions about them, the very best of exercise and drill in language, composition, writing and spelling, is afforded. And drill in oral reading and clearness of expression comes with the reading by the pupils of the compositions and statements they have written.

When a pupil writes a composition on some material object that is put into his hands, some object that he has seen and handled and studied, he writes what he himself knows, he gives expression to that which he himself has experienced. It is knowledge, not mere information. He is dealing with realities, with truth, not with imagination.

And such exercises and studies as these are the very best possible to develop character. To realize the stability of truth, to realize that unchanging, immutable law pervades the universe, that everything is subject to law, that ignoring or violat-

FIG. 13. FARALLON ISLANDS BIRD ROOKERY

In this group, presented to the California Academy of Sciences by the Hon. Wm. H. Crocker, are shown the ten species of sea birds and the one land bird (the little rock wren) that breed on the Farallon Islands. These rocky islands are about 30 miles off the Golden Gate, from which they may be seen on any clear day. Thousands of sea birds resort to these cliffs to lay their eggs and rear their young, one of the most common species being the western gull which, during the rest of the year, is very abundant about San Francisco, following the ferry boats across the bay. Until a few years ago thousands of Murre's eggs were brought each year from these rookeries and sold in San Francisco to the bakeries and pastry shops. The islands are now a federal reservation and the birds and their eggs are rigidly protected. Background painted by Maurice G. Logan.

ing law leads to disaster—all this develops stability of character. They are conditions of mind which cause respect for law and truth and order and honesty, and they develop those traits of character.

And now in conclusion permit me to say a word regarding one more of the interesting and important recent developments in museum activity, namely, the Children's Museum or the Children's Room. This is clearly one of the results of the growing conviction that the museum is a public educational institution which should meet the needs of all ages and classes of people. While many of the public museums of America have realized this need and have been trying more or less successfully to meet it, the institution which has been most successful in this very important field is undoubtedly the Children's Museum of the Brooklyn Institute of Arts and Sciences.

Under the able direction of Miss Anna Gallup really wonderful results have been attained. Children are naturally interested in animals and plants, the material things about them, and the forces and phenomena of nature. As President Eliot has so well said:[2]

> The best part of all human knowledge has come by exact and studied observation made through the senses of sight, hearing, taste, smell and touch. The most important part of education has always been the training of the senses through which that best part of knowledge comes. This training has two precious results in the individual besides the faculty of accurate observation—one, the acquisition of some sort of skill, the other the habit of careful reflection and measured reasoning which results in precise statement and record.
>
> A baby spends all its waking time in learning to use its senses, and to reason correctly from the evidence of its senses. At first it reaches after objects near by and far off alike, but gradually learns to judge by the eye whether or not it can reach the object seen. It tries to put everything into its mouth, perhaps in an effort to estimate size and shape correctly—which at first it can not accomplish by the eye alone, as the adult does. . . . The baby's assiduity in observation and experimentation, and the rapidity of its progress in sense-training are probably never matched in after-life. Its mind also is trained fast; because it is constantly practising the mental interpretation of the phenomena which its senses present to it.

The child undoubtedly acquires more real knowledge during the first five or six years of its life, before it ever enters the formal schools, than it does in all the after years.

The boy on the farm has admirable opportunities to train eye and ear and hand; because he can always be looking at the sky and the soils; the woods, the crops, and the forests; the streams and the hills; he daily, even hourly, sees the wild animals, the birds, the mammals, the insects, that usually abound about him; the domestic animals on the farm he learns to know most intimately; he learns to use various tools, he hears the innumerable sweet sounds which wind, water, birds and insects make on the countryside, and when he is hunting, fishing or merely roaming in the woods and fields and along the streams.

All this is education of the right sort—which is rarely or never equalled in the schools—because it is all most intimate personal experience, the only way in which actual knowledge can be acquired.

That this natural method—the only method by which knowl-

[2] Changes Needed in American Secondary Education."

FIG. 14. SAN JOAQUIN VALLEY BIRD GROUP

Presented to the Museum of the California Academy of Sciences by Hon. Joseph D. Grant. In the spring and early summer it is the practise of the cattlemen of the San Joaquin Valley to flood their land with water, to a depth of 6 to 18 inches, to induce a ranker growth of grass for pasture. Many thousand acres are thus flooded and converted into marsh land, to which vast numbers of ducks, waders and other swamp loving birds are attracted. During the breeding season great numbers of birds resort there to build their nests, lay their eggs, and rear their young. These breeding grounds are frequented by more than 30 species of birds. Among those shown in this group, which shows a typical breeding ground near Los Baños, Merced County, California, are the fulvous tree duck, cinnamon teal, shoveler, red headed duck, coot, American bittern, least bittern, glossy ibis, avocet, black necked stilt, killdeer, red winged blackbird, yellow headed blackbird, tule wren, little black tern, Forster's tern, and the Virginia rail. In order to show in a limited area a considerable number of species it was necessary to bunch the birds a little more closely than they actually occur in nature. The background was painted by Maurice G. Logan.

edge can be acquired—should be so largely, almost wholly, abandoned when the child enters the schools, is hard to understand, but it is lamentably true. The schools, instead of continuing the methods and processes by which knowledge is gained, almost without exception subject the child to processes and methods which result merely in the acquiring of information, most of which is of little or no value in the development of character or in fitting the child to live the life he must live.

The Children's Museum is different from the conventional public school. Its method is that with which the children are very familiar before they ever enter a public school—the method by which knowledge is acquired. The Children's Museum continues this method. The children, even into and through their teens, continue to deal with realities; they continue to use their eyes and ears and organs of taste and smell and touch, for the museum is simply certain parts of nature, of outdoors, brought indoors for examination and study; all selected with reference to their educational value. The imparting of information, or mere book information, has no place, or, at most, a very subordinate place, in a museum.

Unfortunately, the schools, which might have continued this natural method, have for the most part clung to the traditional programs which rely chiefly on studies which train the memory, but which "do not train or drill children in seeing and hearing correctly, in touching deftly and rapidly, and in drawing the right inferences from the testimony of their senses."

A well-appointed children's museum or children's room will have in it those natural objects which have always interested children everywhere. There will be brightly and curiously colored birds and butterflies, moths and beetles, and other insects, curious animals of other groups, attractive minerals, growing plants, and aquariums with interesting animal and plant life; colored transparencies of beautiful flowers, all selected and arranged with reference to the telling of an interesting story, the teaching of a definite lesson.

And there will be in this children's museum simple tools and machinery for training the hand and eye, laboratories where the little girls can learn to do by doing and where they can, through practise, become familiar with many of the simple principles of domestic science and art; and others where the boys can become familiar with the simple tools and machines and become proficient in their use. There is no limit beyond which this training of the hand and eye may not be carried. As an illustration, in the Children's Museum in Brooklyn, a

FIG. 15. DESERT BIRD GROUP

In this group, presented to the California Academy of Sciences by Hon. Wm. B. Bourn, are shown, under natural surroundings, several species of the birds that nest in the Colorado and Mohave deserts of southern California. The particular locality represented is in Riverside County, California. The spring rains transform the desert into a veritable flower garden, the many and varied forms of vegetation sending forth an astonishing amount of beautiful bloom. Then is the nesting time of the birds, which are there in surprising numbers, some of them, as the hooded oriole and the vermilion flycatcher, rivaling the flowers in brilliancy of coloration. The total number of species of birds nesting in this part of the Colorado desert is more than a score, and some species, as Gambel's quail, are very abundant. The nests, however, are usually widely scattered except in the vicinity of water. Background painted by Charles Bradford Hudson.

special feature has been made of wireless telegraphy, and a number of boys who got their training in that museum are now occupying responsible positions in charge of wireless plants or as skilled operators in various parts of the world.

It is of vital importance that the right sort of person be placed in immediate charge of the children's museum or children's room; a well-educated, kindly, sympathetic woman or man who knows the specimens in the museum and the live things in the park or fields or woods about it; and who, above all, knows and loves children; one who can wisely direct the observation and the reading of the children so that they may correlate their reading with what they have seen in the museum or the open, and thus increase rather than stifle their love for animate things, as our public schools almost invariably do. In such a museum it will be arranged so that the children of the different grades will come to the room at different hours and receive in turn the instruction and help adapted to their respective needs.

There is no better thing which any city, town or village can do than to establish and maintain a museum of this kind. In some form or another it is already being done by the Children's Museum of Brooklyn, also by the American Museum of Natural History in New York, the Charleston Museum, the Milwaukee Public Museum, the Chicago Academy of Sciences, and elsewhere. The time is not far distant, I verily believe, when the same will be done in many other cities and towns. It will be done because it so evidently appeals to us all as the *right thing to do,* the right sort of education and training to give to our children. It will be done, because the beauty of it all, for the little children's sake, will appeal to those who have prospered in this world; those with kindly hearts, who love children, and who want them to become the men and women they should become; and the time is now ripe for these good men and women who are able to do so to come forward, and out of their abundance do this splendid work not only for the children of to-day but for those of the years to come.

Habitat Groups in the Museum of the California Academy of Sciences

The California Academy of Sciences has recently installed in its new museum in Golden Gate Park a large number of habitat groups of important species of California mammals and birds, one large hall being devoted to mammals, and another to birds.

The central, controlling thought with these groups has been to make them as true to life as possible and of the highest educational value. To accomplish this object the taxidermist who was directly responsible for the group went to the locality where the animals were secured and studied the local environment, collecting specimens of the shrubs, grasses, flowers, rocks, etc., found there. With these, properly preserved, and with artificial flowers, etc., when necessary, he was able to reproduce the actual environment with great fidelity.

In each group is a curved painted background connecting so perfectly with the actual objects in front that it is difficult, if not impossible, to tell where the real ends and the painted begins.

In every case the artist visited the region where the animals were taken, studied the scenery, made his field sketches and studies, and when he made his final painting he was able to give what is in effect a painting of a real scene somewhere in the region where the species is naturally found.

THE SCIENTIFIC MONTHLY is able to reproduce photographic illustrations of a number of these groups. The groups were installed under the general supervision of Dr. Barton Warren Evermann, the director of the museum, the mammal groups under the immediate direction of Mr. John Rowley, assisted by Mr. Joseph P. Herring and Mrs. M. L. Pariser. The bird groups were prepared under the immediate direction of Mr. Paul J. Fair, assisted by Mrs. M. L. Pariser.

The backgrounds were painted by Charles Abel Corwin, of Chicago, Charles Bradford Hudson, of Pacific Grove, California, Maurice G. Logan, of San Francisco, and Worth Ryder, of Oakland, all well-known artists. Each of these artists has been marvelously successful in depicting the natural environment of the animals with which he had to deal.

POTHOLES: THEIR VARIETY, ORIGIN AND SIGNIFICANCE. II.

By E. D. ELSTON

CORNELL UNIVERSITY

Initiation and Development of Normal Potholes

It is evident from the classification given above that all varieties of pothole depressions have a turning or vortex flow of water (provided with sediment tools) as at least a contributing factor in their formation. Accordingly, it would seem that an investigation of the exact conditions of the initiation and development of the normal type of pothole would furnish the most significant data in regard to the origin of these depressions in general, and also furnish some measure of their function in the process of gorge cutting by young streams. Some results of such a study and deductions based on actual observations with particular reference to occurrences in horizontally bedded sandstones and shales follow.

Ideal Normal Potholes.—Normal potholes are developed by the rotary grinding motion imparted to rock tools—sand, pebbles, boulders—in a depression of the bed of a stream course by the water current. A typical normal pothole should have the following characteristics: At the top the hole should be almost circular in ground plan, with a diameter ranging from three inches to ten feet or more. The depth might vary between six inches and eight feet or more. In vertical section an ideal normal pothole should show the same outline as that of a similar section through one of the old-fashioned iron pots that have wide curved mouths and bulging sides (see Fig. 8). No doubt normal potholes owe their name to this resemblance. There are, however, many deviations from this perfect form. The holes show much irregularity in ground plan as well as lack of symmetry in the bulging of the sides. Very commonly the smooth inside surfaces of the excavations are interrupted by ridges or flutings. Other typical examples of normal potholes are shown in Figs. 9*a*, 9*b*, 10. The kinds of material that may be found in the potholes are of interesting variety. Usually masses of rubbish consisting primarily of sand, gravel, pebbles and boulders and perhaps fragments of other materials are found in holes either temporarily or permanently abandoned by the stream. Some of the pebbles or boulders may be smoothed and rounded, due to the grinding action. In describing the material taken from some potholes in Norway, Brögger and Reusch[25] state that two types of grinding stones may be distinguished: (1) Perfect or regularly elliptical; (2) less per-

Photo by J. S. Hook.

Fig. 8. Section of Normal Pothole, showing similarity in shape to old-fashioned iron pot. Note ridges or flutings on interior surface.

fect with elliptical tendency. According to these writers the perfect type of grinding stones become more numerous near the bottom of the hole. The grinding stones are usually of the harder, more resistant kinds of rock such as sandstone, quartzite, etc. Due to their almost spherical or elliptical form the grinding stones often attract much attention and in not a few cases such beautifully rounded stones have been gathered as curiosities or for use in rockeries.

[25] Brögger, W. C., and Reusch, H. H., "Giants' Kettles at Christiania," *Quart. Jour. Geol. Soc. of London*, Vol. 30, pp. 754–761, 1874.

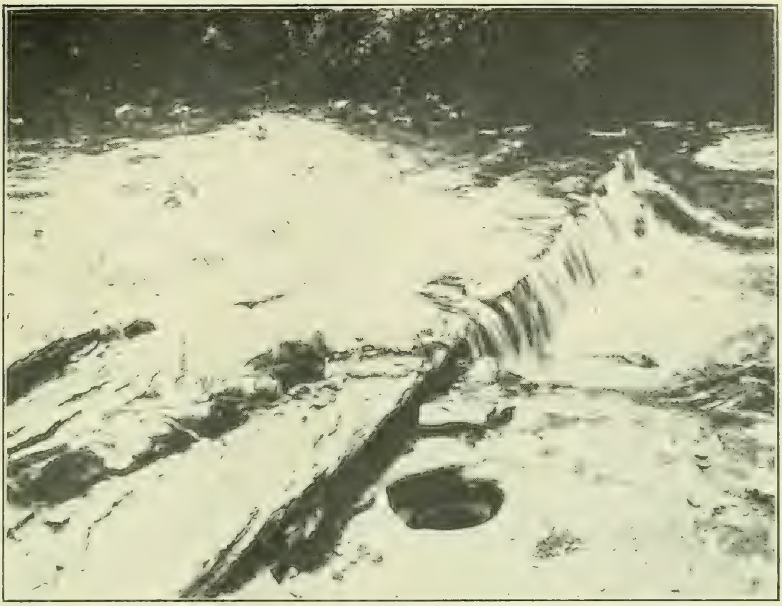

FIG. 9A. NORMAL POTHOLE IN UPPER GORGE OF CASCADILLA CREEK, ITHACA, N. Y.

During periods of high water, sand, gravel and boulders are swirled by the current and become very effective as abrasive agents both in smoothing, rounding out and enlarging the hole and also in reducing to finer fragments the tools themselves by rubbing them against each other and rounding the pebbles.

FIG. 9B. VIEW OF INTERIOR OF POTHOLE SHOWN IN FIG. 9a. Note small pits at right in bottom of the hole. These pits are due to railroad spikes caught in the pothole and then hammered repeatedly against the sides by the water current and fragments of rock.

When the erosive action ceases the holes are choked with this detritus, the greater part of which is sand and silt. In some cases, however, much of the material is rock fragments of the size of gravel or even of larger pebbles. The material in an abandoned pothole very commonly is packed in so closely that much effort is required to pry out the fragments. A pothole in the Ithaca region, so packed, contained, in addition to a considerable amount of sand and gravel, several railroad spikes which had been used as tools in the excavating process

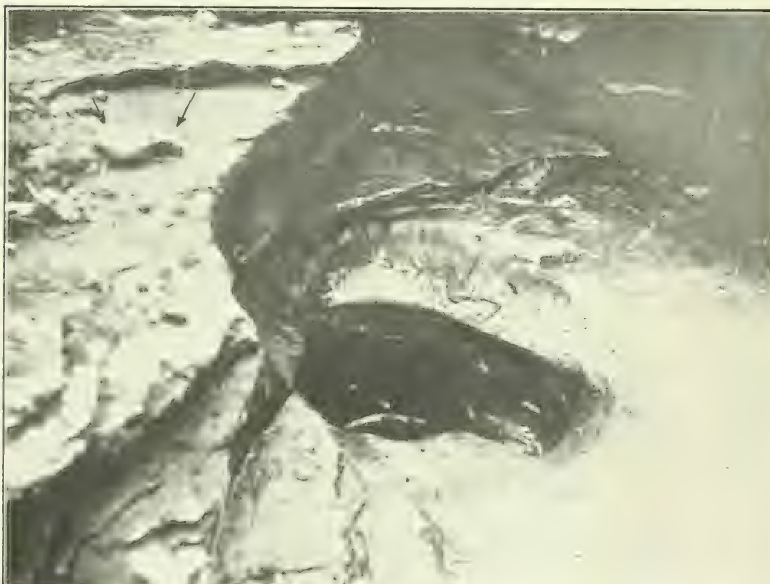

Fig. 10. Another Normal Pothole in Upper Gorge of Cascadilla Creek, Ithaca, N. Y. Note the two rounded grinding stones removed from the hole.

for the points of the spikes had been firmly driven and wedged into niches in the bedrock (see Fig. 9).

Structural Phenomena of Bed Rock Leading to the Initiation of Normal Potholes.—It is immediately apparent that the primary factor in the initiation of a normal pothole development is the presence of some condition of the bedrock channel over which the stream flows that will give a rotary motion to the water. Evidently the chief, and perhaps the only condition that brings this about is the occurrence of some structural irregularity that leads to the development of a shallow depression in the stream course. The possibilities of this kind are quite numerous. There may be mentioned, *irregularity in* *bedding, ripple marks, lenticular concretionary structure, solution irregularities, and joint planes.*

Irregularity in bedding is of very common occurrence in stratified rocks and is well illustrated by Fig. 11. The rock surface, developed along stratification planes, is often very irregular and this condition frequently extends into the structure of the underlying material. As the stream erodes the general area of its channel bottom the tendency is to flake off such bedrock in accordance with its structural undulations. Thus a

Fig. 11. Irregularity in Bedding occurring in Six Mile Creek Valley, Ithaca, N. Y.

hummocky surface is created and in the shallow depressions between the knobs sediment tends to collect.

Ripple marks are familiar features in stratified rocks. Variations in their development are shown in Figs. 12 and 13. The troughs between the crests afford a favorable place for sediment to lodge.

Another special case of irregularity is due to what may be termed "*lenticular concretionary structure.*" This is found where beds containing concretions have been bowed up over the concretions and caused to sag beneath them, as is apparent in Fig. 14. No potholes have been observed in such a formation

Fig. 12. Ripple Marks in Shales in Bed of Fall Creek near Sibley College, Ithaca, N. Y.

Fig. 13. Pothole in Shale. Surface shows rather irregular ripple marks, located near area shown in Fig. 12.

by the writer, but it is quite possible that such structure may cause the initiation of potholes in a manner somewhat similar to that in which it caused the initiation of Tide Pools as de-

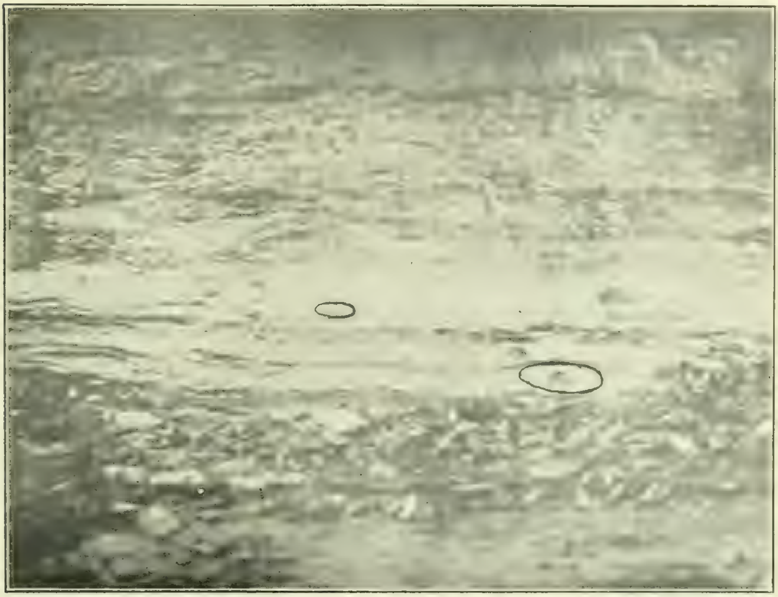

Fig. 14. Lenticular Concretionary Structure in Upper Gorge of Buttermilk Creek, near Ithaca, N. Y.

scribed by Henkel.[26] If one of the concretions should be removed by stream grinding it would leave a shallow depression

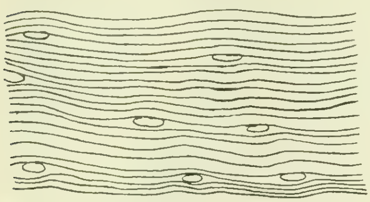

Fig. 15. Lenticular Concretionary Structure.

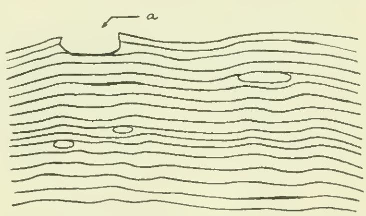

Fig. 16. Depression formed by the Removal of a Concretion.

that would act as a catch-all for the rock tools of the stream and a pothole might eventually develop. See Figs. 15 and 16.

Solution Irregularities.—These slight irregularities, illustrated by Fig. 17, are due primarily to the solvent action of the

[26] Henkel, Isabel, " A Study of Tide Pools on the West Coast of Vancouver Island." *Postelsia*—The Year Book of the Minnesota Seaside Station for 1906, pp. 298–303.

water and are especially common in limestone rocks and are often associated with potholes.

FIG. 17. SOLUTION IRREGULARITIES IN LIMESTONE, TAUGHANNOCK CREEK, NEAR ITHACA, N. Y.

FIG. 18. JOINT PLANES WIDENED OUT BY EROSION AND POTHOLES OCCURRING ALONG THE JOINT PLANES, FALL CREEK, ITHACA, N. Y.

Joint planes seem to be the most important single factor in causing the initiation of the normal potholes. Along a single joint plane the rock is less resistant at some points than others.

This is notably the case in shales, where fragments may often be more readily detached in certain spots adjacent to the joint crevices than elsewhere. The resulting depression, if it is in the course of an eroding stream, frequently becomes enlarged. Again, at the point of intersection of planes, the corners of the rock are readily chipped away by boulders striking against them or such corners may be worn away by the combined processes of stream grinding (corrasion) and solution (corrosion). If the bed rock at the place of such intersection of joint planes is submerged only a part of the time and exposed during periods of low water, it is possible that weathering will

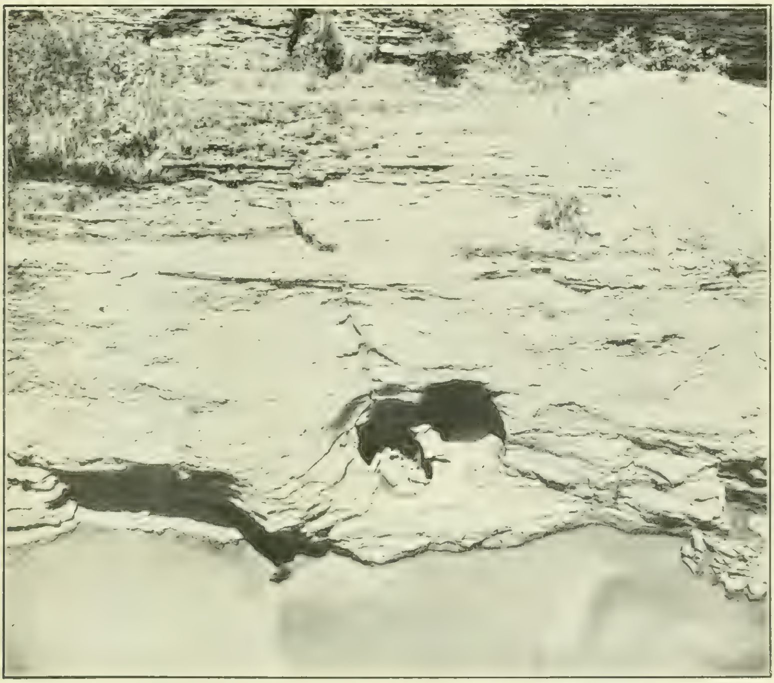

FIG. 19. POTHOLES DEVELOPED ALONG A JOINT PLANE, FALL CREEK, ITHACA, N. Y.

also aid in enlarging the depression. Such hollows apparently afford most excellent sites for the development of potholes (see Figs. 18, 19 and 20).

Joint planes, in addition to occasioning hollows at which potholes may start, may also influence the later development of the holes. The joints do not always extend vertically into the rocks. Sometimes they are inclined away from the perpendicular, or in geological terms, have a considerable *hade*. Assume, as shown in Fig. 21, that the joint plane extends vertically into the rock mass, *i. e.*, that the hade is 0°. If this joint plane cuts the edge of the hole or occurs near the hole, the line of weakness will be continued straight down and in accordance with these conditions, the pothole should theoretically be excavated vertically into the bedrock.

If, on the other hand (see Fig. 22), the joint plane has a large hade, the hole should, if our theory is correct, extend into the rock at an angle approximately equal to the hade, provided

FIG. 20. POTHOLE OCCURRING NEAR INTERSECTION OF JOINT PLANES, CASCADILLA CREEK, ITHACA, N. Y.

that the joint plane does form a line of weakness along which the effectiveness of erosion is concentrated. While no examples have been observed by the writer, where it was certain that such was the case, in several instances it seemed quite possible that hading of a joint plane had been a factor.

Potholes Inherited from Preexisting Conditions.—As will be noted from the foregoing discussion, it is easy to conceive of various structural variations in the bedrock of stream courses, that might cause the initiation of potholes and influence their later development. To deduce on theoretic grounds the probable effect of these structural phenomena is not difficult. Yet, after examining many holes, it became apparent that the connection between their occurrence and such structural features was by no means so obvious as would at first seem probable. Particularly is this true of many of the larger, more typical, well-developed holes. Even when a detailed search was made it proved difficult to find single examples where incontestable correlations could be made between initiating cause and the occurrence.

There is obviously a connection between waterfalls and plunge pools. Furthermore, there is every gradation between plunge pools and normal potholes. The latter often mark the site of waterfalls the crest of which has since receded. Such potholes usually occur in a series leading up to the site of present active development. Excluding these, there still remain a number of potholes, the occurrence of which does not present

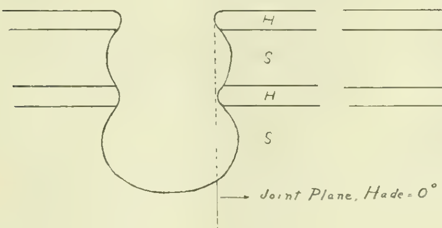

FIG. 21. INFLUENCE OF JOINT PLANE HADE ON DEVELOPMENT OF POTHOLE. Resistant and less resistant layers marked H and S, respectively.

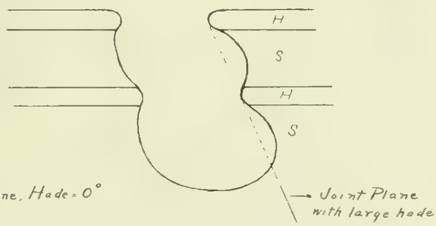

FIG. 22. INFLUENCE OF JOINT PLANE HADE ON DEVELOPMENT OF POTHOLE. Resistant and less resistant layers marked H and S, respectively.

evidence of formation by waterfalls and yet they seem unrelated to existing structural conditions. Perhaps no single one of a number of such holes will show any distinct relation to an initiating cause or reason for development at just that point. What then is the cause of these potholes? Why are they found at such places where no relation seems to exist between them and the structural phenomena present?

It would seem that most normal potholes owe their existence to initiating causes that have disappeared since the formation of the holes. Accordingly it is proposed to describe them as *potholes inherited from preexisting conditions.*

The case may be especially well illustrated in connection with joint planes. Some of the joints are strong in sandstone and notably weak in underlying shales. according to Sheldon.[27] Assume that at an earlier stage in the downcutting by the stream a pothole was initiated in the sandstone layer due to the intersection of joint planes which were strong in the sandstone but weak in the shales beneath. Assume further that this hole attained a considerable depth and development and that its lower portion was cut into the shales in which the initiating joint planes did not continue. In time the stream erosion wore away the sandstone layer. The pothole, however, continued to be eroded in the shales. Once started, the swirl of the water

FIG. 23. SCALLOPED CHANNEL DUE TO POTHOLE ACTION IN WATKINS GLEN, N. Y.

currents continued to be effective and the hole was deepened at a rate commensurate or surpassing that of the general erosion of the stream bed. Thus it remained a feature of the stream course when the bed of the stream has been cut below the layer in which the hole was originally started.

Not only does this development history seem probable where the weak spots are caused by joint planes in the upper layers, but it also seems just as likely to occur if any one of the other structural weaknesses previously described occurs in layers later removed.

[27] Sheldon, P. G., "Some Observations and Experiments on Joint Planes," *Jour of Geol.*, Vol. XX., No. 1, January-February, 1912, pp. 64, 65.

Henkel[28] observed in the case of tide-pools along the west coast of Vancouver Island, that some of the depressions were cut so that their bottom portions existed in sandstone and their top portions were in conglomerate, only a portion of the latter remaining due to erosion. Apparently this is an excellent example of inheritance from preexisting conditions.

The general theory, then, of inherited potholes accounts very satisfactorily for the development of large and small holes situated near each other in a rock surface which is apparently homogeneous throughout. The smaller holes are the most recently formed. They may in the future be extended downward into the underlying material. The material which is now at the surface may later be worn away and the potholes still continue their downward development (provided that conditions of erosion are maintained).

Irregularities of the Interiors of Potholes.—Where strata of unequal resistance to the grinding process of pothole formation occur within the depth of a single hole, the interior is commonly fluted, the resistant layer projecting beyond the weaker layers above and below. Possibly such fluting in some cases is due to variations in the erosive effectiveness of the currents moving in the hole, due to variations in the stream volume and its sediment load.

No conclusive determination of the exact conditions that lead to the progressive enlargement of the diameter of a pothole below the surface has been made. Brunhes and Brunhes[29] assert that centrifugal force causes the velocity of the water to increase at the sides of the hole, hence the tendency toward undercutting. There must also be a certain limiting depth to which a pothole can be excavated by a current of given volume and velocity provided with an optimum of rock tools. The variable factors, however, are so many that it would be difficult to establish any definite relations of this kind.

Pothole Development and Gorge Cutting.—It has been previously suggested that pothole development is a significant if not a primary process in the early stages of gorge cutting by

[28] Henkel, Isabel, "A Study of Tide-Pools on the West Coast of Vancouver Island," *Postelsia*—The Year Book of the Minnesota Seaside Station for 1906, p. 293.

[29] Brunhes, B., and Brunhes, J., "Les Analogies des Tourbillons Atmospheriques et des Tourbillons des Cours d'Eau et la Question de la deviation des rivières vers la droite," *Anales de Geog.*, Vol. 13, 1904, pp. 1–20.

streams. Fig. 2 illustrates this relation very clearly. Cleland[30] cites another instance of even more striking character. He describes a natural bridge formed in impure limestone over the Kicking Horse River, near Field, B. C., by the lateral enlargement and intersection below the surface of adjacent potholes. Some idea of the proportions of this feature may be gained by the figures he gives. The bridge averages ten feet in width, has a span of about eight feet and the arch is six to eight feet thick.

Watkins Glen, a quite famous gorge in central New York, owes much of its picturesqueness to the fact that its bottom course is almost exclusively the result of pothole erosion. The stream flows from one pothole to the next, forming the scalloped channel border illustrated by Fig. 23 as a result. Above, the gorge has been widened by weathering, but there is hardly any question but that these strata were also originally cut through by pothole grinding. In order to determine the rate at which potholes are enlarged, a plaster cast was made of a typical occurrence near Ithaca, N. Y., in the summer of 1914. Some time in the near future it is proposed to make another cast of the same hole and measure the volume of rock material that has been removed. At the same time it may be possible to determine how much the general level of the bed of the stream has been worn down. In this way it is hoped to obtain a suggestion of the quantitative relations of general and pothole deepening of stream channels. It would be interesting to have similar measurements made by observers in other localities as a comparison of results under different conditions would afford a basis for a general deduction of the effectiveness of the pothole grinding process in deepening stream valleys.

Summary

1. Potholes develop only in streams that are actively eroding in fairly well consolidated rock.

2. An initial hollow in the bedrock is necessary to permit of the primary collection of the sediment and stones that are to be the tools with which the pothole is ground out.

3. The stream must carry at least a *moderate* amount of material to be used as grinding tools. Streams heavily laden with sediment tend to deposit rather than erode and too much material chokes the initial depressions.

[30] Cleland, H. F., "North American Natural Bridges," *Bull. Geol. Soc. of America*, Vol. 21, 1910, pp. 321–322.

4. The initial hollow may be originated by any one of the following factors: irregularity in bedding; ripple marks; lenticular concretionary structure; solution irregularities; joint planes.

5. The inception of a given pothole may be due to one or more of these structural weaknesses.

6. The larger holes seem almost invariably to be *inherited from preexisting conditions.*

7. The later development of a hole is influenced by the following factors, among others: the volume and velocity of the stream; the direction of currents; nature, structure and position of the rock, the hade of joint planes; union of two or more holes.

8. Most of the erosion of the holes is apparently accomplished during flood stages.

THE INFLUENCE OF MAGNETISM ON LIGHT

By Professor L. R. INGERSOLL

UNIVERSITY OF WISCONSIN

IT is not such a great while since the various subjects of light, heat, electricity and magnetism, embodied in the science of physics—or "natural philosophy" as it used to be called—were thought of as discrete branches only slightly interrelated. The task of showing the connection between them may be thought of as commenced by Oersted, who discovered, almost exactly a century ago, the effect of an electric current on a magnetic needle. Half a century later the theoretical work of Maxwell supplemented by the experiments of Hertz showed that light is, fundamentally, nothing but a particular manifestation of electrical and magnetic phenomena. But the discovery of the electron in recent times has done more than anything else to unify physics, and the division of the science into branches may be regarded henceforth merely as a separation for convenience in instruction rather than as a natural cleavage.

But while light is now well known to be an electromagnetic wave phenomenon, occupying indeed a position intermediate between the long electromagnetic vibrations or wireless waves, on the one hand, and the extremely short undulations which the X-rays have very recently been shown to be, on the other, the experimental study of the relationship is not simple. Nevertheless a whole series of investigations, initiated by Faraday's capital discovery of the rotation of the plane of polarization produced by a magnetic field, has been carried out in recent years with the aim of finding out the effect of magnetic and electrical influences on light.

The most striking result yielded so far is the effect, discovered in 1896 by Zeeman, of a powerful magnetic field on a source of light. This phenomenon, which is too minute to have been observed by Faraday, who tried the experiment, consists, in its simplest form, of the doubling or tripling of a spectral line according as the source is observed along the line of the magnetic field, or across it, respectively. On the basis of the electron theory the explanation may be outlined as follows: Suppose that in a small monochromatic source of light (*e. g.*, vacuum tube, flame, etc.) between the poles of a large electromagnet one of the countless electrons is rotating in a circular path about the axis of the field, giving rise as it does so to a light wave of period corresponding to its rotation. If, now, the magnet is excited there will be a force acting on this electron—just as there would be on a flexible circular wire carrying a current—which will tend to pull it into an orbit of smaller radius or push it out to a larger one according to the direction in which it is turning. The result will be exactly what would happen to a planet moving according to Kepler's laws: a diminution in orbit means a shorter time of revolution, and *vice versa*. Accordingly, when the field is excited all electrons rotating in one direction will suffer a shortening of their periods, while those turning oppositely will show a corresponding lengthening. Thus a single spectral line is split into a "doublet" whose components will, moreover, be found to be circularly polarized.

The obvious difficulty of this simple explanation arising from the fact that naturally only a very small proportion of the electrons would be found vibrating in circles oriented as presupposed, disappears when we remember that any vibratory motion is resolvable along three axial directions and that the simple harmonic vibrations along either of those perpendicular to the field is resolvable into the circular motions above described. The third vibration is in the line of the field and therefore not influenced by the magnet; hence when the phenomenon is viewed transversely there is a third component in the position of the original line.

It is hard to overestimate the importance of this discovery by Zeeman, leading as it has, on the one hand, to the brilliant researches of Hale and his co-workers on magnetic fields in the sun, and, on the other, to the explanation of many of the effects of magnetism on light.

Most of these effects have to do with polarized light and are allied to the Faraday rotation above mentioned. This experimenter established the fact that when plane polarized light traverses any transparent substance in a magnetic field—the direction being parallel to the lines of force—the plane of polarization suffers a rotation. The effect, which is analogous to that produced by a naturally active substance (*e. g.*, sugar solution), varies in amount with the character and thickness of the material, strength of field, wave-length of light and certain minor factors. Practical use has indeed been made of this well-known phenomenon in connection with a "massless" photographic shutter suitable for use in experiments on the photography of projectiles in flight. The light passes through a nicol prism and is thereby polarized, so that when it reaches a second nicol "crossed" on the first no light is transmitted. Between the two is a tube of carbon bisulphide—a strongly magneto-optic substance—in a helix of wire. The passage of a momentary current magnetizes the helix and rotates the plane of polarization of the light passing through the carbon bisulphide sufficiently to permit the passage of a flash of light through the second nicol.

This effect, moreover, is not limited to transparent substances, for the magnetic metals, particularly iron, have enormous rotatory powers when specified in terms of a centimeter thickness. Indeed, if light could penetrate a centimeter into strongly magnetized iron it would suffer no less than five hundred complete revolutions of its plane of polarization, but the opacity of such substances is so great as to prevent the use of a film of thickness much greater than the ten-thousandth part of a millimeter, so the actual rotation is of the order of only a degree or two. Gases and vapors, especially of sodium, may also produce considerable rotations as shown by the extended experiments of Wood.

For the last dozen years, the writer has made a special study of this subject of rotatory polarization in its various phases. The rotation has been determined for a variety of substances as dependent on the wave-length of light used, not only for the visible, but also for a portion of the long wave, or infra-red, spectrum. The study has not been limited to transparent substances, but has also included the magnetic metals, particularly for the case of reflection (Kerr effect) for various directions of magnetization. Of late the work has been extended to include a comparison of the magnetic with the natural rotation, such as produced by a sugar solution, for a number of active substances. The experimental work has not been without its difficulties; for the eye must necessarily be supplanted by the bolometer when working with the infra-red radiations, and this, with its entailed accessories, makes up an apparatus rather complicated in comparison with the relatively simple arrangement that suffices for the study of rotatory polarization in the visible spectrum.

The results are naturally divided into two groups, according as they are for transparent substances or for the magnetic metals. The magnetic rotation of practically all representatives of the former class shows a rapid diminution with increasing wave-length as far as the writer has been able to investigate in the infra-red, that is, to a wave-length some three times longer than any the eye can see. The rotation for wave-length 2μ (.002 mm.) is less than one tenth of what it is for sodium light. The dispersion curves for different substances are much alike and are in general quite similar to the natural rotation curves (for such of the substances as are naturally active) over the whole spectral region examined. The temperature coefficients of rotation are, however, quite different in some cases.

The metals present a more interesting, as well as more complicated, case than transparent substances. As Kerr showed, half a century ago, when polarized light is reflected from the polished surface of a highly magnetized steel mirror the plane of polarization suffers a slight rotation. This effect has been investigated by a number of observers for the visible spectrum and by the writer on the infra-red side. The rotation-dispersion in the visible spectrum is "anomalous," that is, the effect increases with longer wave-length instead of diminishing as does the rotation in transparent substances. Carrying the curves into the infra-red, however, it is found that the effect soon reaches a maximum and then diminishes rapidly for still longer wave-lengths. Viewed as a whole, the curves resemble very strongly the type of dispersion curve we are accustomed to associate with transparent substances in a spectral region of strong absorption, and it may be that for these metals, *e. g.*, iron, nickel and cobalt, the visible spectrum is a region of similar abnormal properties.

There are a number of other magneto-optic phenomena—some of them requiring experimentation with films of metal less than one-millionth of an inch in thickness—which the writer and others have investigated. In general, however, it may be said that light, while unquestionably magnetic and electrical in nature, yields rather grudgingly to experiments attempting to probe this relationship, and one must frequently content himself with small effects. The explanation of this undoubtedly lies in the fact that the tiny electron whose activities not only give rise to light, but, moreover, determine or modify all the optical properties of bodies, executes its enormously rapid vibrations in magnetic fields of its own which are exceedingly large. To influence these vibrations by our gross experiments with fields which must, after all, be relatively small, is accordingly a difficult matter.

DUST IN INDUSTRY

By HENRY FIELD SMYTH, M.D., Dr.P.H.

UNIVERSITY OF PENNSYLVANIA

THERE are only a very few distinct diseases or diseased conditions which are strictly speaking occupational in origin, such as the specific metallic poisonings, gas and fume poisoning, "Caisson disease" caused by working in compressed air, an anthrax infection from working with infected hides or wool. Other diseases, just as serious and just as truly due to improper working conditions, may be directly traceable to occupational hazards, however, though they may also be caused by or aggravated by other conditions outside of daily work. In these latter instances it is often hard to tell just how much of the trouble is due to faulty working conditions and how much to faulty personal hygiene of the worker at home or elsewhere. As working conditions and manufacturing processes differ so widely in different countries and even in different localities in the same factory, observations made at one time and place do not necessarily hold good as the basis of generalizations. To rightly judge of any industry and of its effect on health studies must not only be made in one place or one factory but in many factories in different localities.

A number of such investigations have been conducted in specially dangerous industries and have resulted in very greatly improved conditions, and in several of our very large cities special clinics have been instituted to treat occupational diseases and to make further studies of working conditions.

Some employers take every precaution they know of to lessen danger to their workmen, not only for the sake of the workers, but because employers are coming more and more to realize that a healthy, vigorous worker is even more valuable than a piece of machinery kept in good repair and well oiled. On the other hand, there are a great number of employers whose only aim is to secure a greater production in less time and at less cost, and who fail to appreciate the drawback to such an aim that unhealthy workmen, poor light, clutter and dirt really are. Bearing these facts in mind, one can see the value of intensive studies of health-hazardous industries in various localities, so that we may learn if possible the part played in disease production by the special hazards and how far these hazards may be lessened or removed, or the workers protected from their bad effects. Among non-specific disease-producers found in industry none is of much greater importance and more generally prevalent than dust. Many industries necessarily are associated with dust in large quantities and often of very irritating nature, though too often much more dust is produced than necessary and that which is produced is scattered over a far wider area than need be.

Dusts produced in industry may be of various kinds and their harmful action on the system depends on the nature of the dust as well as on the amount. These dusts have been classified in several ways. First, as to whether they are mineral, metallic, vegetable or animal in origin, or mixed, but this grouping gives no definite idea as to their action. From the health standpoint a better classification is into irritating, poisonous and infectious. Dust in the air we breathe is inhaled and if insoluble may act more or less as an irritant to tissues with which it comes in contact, depending on the shape and hardness of the particles, hard, sharply pointed or angular particles like flint or steel being much more harmful than smooth clay or soft vegetable or animal fiber dust. Such insoluble dust, particularly animal fiber or hair dust, may carry into the system with it the germs of infectious disease, and many fatal cases of anthrax have been caused by inhaling the dust liberated in the sorting of infected wool or hides. Tubercle bacilli are often thus introduced on dried or drying particles of sputum carelessly expectorated by infected workers.

Soluble dusts are dissolved in the mucus covering the linings of the air passages and may act locally as chemical irritants, causing local catarrhal inflammations, which in turn lower the resistance of the tissues and facilitate the lodgment and growth of pus-producing bacteria, or the poison may be absorbed into the system and cause general poisoning, the most frequent examples of the latter being the numerous cases of lead poisoning occurring among painters, sand paperers and makers and users of white lead, red lead and litharge.

It is remarkable how much dust one can become accustomed to with apparently very little harm being done. This is partly due to the action of the excellent defenses nature has provided. Large heavy particles very soon fall to the floor and if the place of generation of dust is below the level of the nose or mouth of the worker these particles may never reach the respiratory passages unless they are thrown upward with force. Of those particles of irritating insoluble dusts that reach the nasal openings and are inhaled fibers of any length are apt to be caught and retained by the hairs in the nostrils, while a certain percentage of the larger and medium-sized masses and even some of the smaller ones are deposited on the moist membranes of the nasal passages and eventually swallowed with the mucus from the back of the throat or sneezed or blown out of the nostrils. Only the finer particles penetrate to the trachea and bronchi, and there any that lodge on the walls of the larger air passages are swept upward by the current of mucus kept in motion by the countless little whip-like processes of the cells lining these tubes. So finally only the smallest particles, one authority says those under $\frac{1}{100}$ millimeter in size, reach the lungs themselves. Lehmann, working with white lead dusts, found that from 35 to 43 per cent. by weight of that entering the nostrils reached the lungs, the rest either being finally swallowed or breathed, blown or sneezed out of the nares. Insoluble dusts that do reach the finer bronchioles or air cells are taken up by wandering cells or phagocytes and carried into the tissues, or by means of their sharp edges or points work their own way in and there give rise to local inflammation, followed by an increase of fibrous connective tissue, especially marked around the small blood vessels and air passages. This firm non-elastic fibrous tissue replaces the normal more elastic tissue and crowds and contracts the small air passages. The former prevents the normal expansion and contraction of the lungs with respiration and the latter causes dilation of the terminal air cells due to increased resistance to expiration and hinders the normal flow of blood in the lungs, so lessening the amount of oxygen taken up by the blood and the amount of carbon dioxide given off. This slows up the normal tissue metabolism and lowers the general body tone, lessening resistance to disease, especially to infections of the respiratory tract. Such fibrosed lungs yield more readily to attacks of infective bronchitis and pneumonia, and many claim also that they make excellent soil for the development of tuberculosis, though when tuberculosis does develop it is more apt to be a slow chronic process owing to this very immobility of the lungs preventing the rapid spread of infection and giving nature more chance to build a protective wall around the diseased area. Some of the dust particles which the wandering scavenger cells carry into the tissues reach the lymph channels and are arrested in the lymph glands at the root of the lungs, where they remain out of harm's way and do no further damage unless infected. Such glands after death from other causes are found swollen and loaded with gritty particles.

This brief sketch of the fate of inhaled dust shows the importance of dust prevention as a health measure in industry and the value of accurate data as to the volume of dust generated in different processes and the relative proportions of different-sized particles in this dust, as well as the shape and hardness of those minute particles which reach the lungs themselves. Such data as to the amount of dust inhaled have heretofore been very scarce and as a rule based on the amount of dust in comparatively small samples of air, at most a few cubic feet, and often small fractions of a cubic inch, and as air currents in rooms are constantly changing in force and direction, especially if there is much motion of persons or machinery, and as dust production in manufacturing processes varies from moment to moment, such small samples give no reliable picture of actual conditions. The investigators of the New York State Ventilation Commission two years ago developed a new testing apparatus by means of which much larger samples of air can be examined, such sampling extending over appreciable periods of time, so that much more nearly average conditions can be obtained and more reliable conclusions and estimates can be made. This apparatus, the Palmer dust-collecting machine, is essentially an electrically driven centrifugal fan which aspirates a continuous current of air through a fountain of water in a specially designed bulb. All the particles of any but ultramicroscopic size which are floating in the air are retained in the water, a gasoline manometer enabling one to measure the rate of flow of air through the machine. After a test the water is drawn off into a clean bottle and diluted up to a given volume. Knowing the amount of air sampled and the volume of water we know the volume of air that a given fractional amount of the water will represent. This water can then be evaporated and the residue weighed, to determine the weight of dust. The dried dust can be burned and again weighed to determine the proportion of organic and mineral matter present. Chemical tests can be made to determine the amount of any poisonous substances present and finally the dust particles can be examined under a microscope to determine their shape and size and number per unit of air, usually per cubic foot, as well as the relative number of particles of different sizes. For the last-mentioned purposes the commission recommends grouping particles in four or five groups, the smallest being about ten times the diameter of the average bacteria, and the largest about 400 times larger. Those under 0.001 millimeter can not well be counted, and in the work to be referred to here have been disregarded, as they are considered too small to do any serious harm. With this apparatus, samples of from 25 to 200 cubic feet or more of air can be tested, the amount depending on the dustiness of the air. As the optimum rate of sampling is five cubic feet per minute, it will be seen that tests lasting from five to forty minutes give time for normal variations in air currents and dust produced to occur. In this way, the amount of dust per hundred cubic feet of air can be estimated in the shorter tests and actually weighed in tests of 100 to 200 cubic feet. As the average man inhales 30 cubic inches of air at each inspiration and breathes 17 to 18 times per minute, it is estimated that he would inhale about 18 cubic feet of air per hour or 144 cubic feet in an 8-hour working day. With these figures as a basis, it is easy to estimate the weight of dust and its percentage of organic and inorganic matter which a worker would inhale in his working day, of whatever length it may be, in his particular industrial occupation. Assuming that Lehmann's estimate of 42 per cent. of inhaled dust particles actually reaching the lungs and remaining there might be too high for some dusts, it is calculated that at least one third of inhaled dust would actually remain in the lungs.

Last winter the University of Pennsylvania Hospital established a clinic for occupational diseases in cooperation with the Pennsylvania State Department of Labor and Industry. In addition to the routine work of treating patients referred from industrial plants and to making special investigations of the working conditions of these patients, the clinic is engaged in a systematic study of dust hazards and distinctively dusty industries.

The study referred to includes surveys of the industries with determination of the relative humidity in the work rooms, as the amount of moisture in the air influences greatly the amount of dust remaining suspended in the air. Determinations were made, by the use of the Palmer apparatus described above, of the actual average weight of dust per cubic foot in the air of the work rooms, with the estimation of the total amount of dust a worker would inhale in a day's work. Estimations were made of the number of dust particles per cubic foot of air and these were grouped into four different sizes, with the determination of the percentage of each size in the total count, and the determination of the character of the dust, including shape of particles, percentage of organic and mineral matter and amount of any poisonous substances, if present.

Also physical examinations were made and medical histories taken of many employees, preferably of men who had been working a number of years in dusty trades. Finally the rœntgenologic department of the University Hospital made rœntgenographic examinations and radiograms of the chests of these workers, as that is where the effects of long-continued work in dusty atmosphere are chiefly seen.

The value of such work to the industrial physician, the worker and the industry itself can be readily seen. It is thought that a few of the results obtained and the conditions observed might be of interest to the general reader. For purposes of comparison and as a basis of standardization, air was examined in a suburban house and in a laboratory of the university to obtain an indoor standard, and outdoor samples were collected at the same places. The following table gives the number of particles per cubic foot of air, the weight of dust inhaled per working day, with the minimum amount retained in the lungs per day and per year of 300 working days in each industry examined. Each report is an average of tests taken in that industry in different rooms and departments and often in different factories. Sixty-five tests in all were made in nine industries and five tests for comparison which were calculated for twenty-four hour periods. The working days in the industries ranged from eight to twelve hours in length, the longest day being in the dustiest industry. Portland cement making was by far the dustiest trade investigated, and here the actual bulk of dust inhaled is amazing, but the reason for this will be seen when it is stated that from one room in one plant calculations showed that at least half a ton of cement dust and probably much more escaped into the surrounding atmosphere in a day. In a similar room at another plant, there were only about one sixth as many particles in the air, and of these a greater number were of the larger sizes, due to the exhaust ventilation stacks over conveyors which carried off many of the smaller, more dangerous particles. Men were found who had been working over twenty years in cement plants, and the table will show that they must have had from 2 to 4 pounds of cement dust lodged in their chests. Next to cement in the amount of dust created came plush and carpet making and here considerable variations were found in different rooms. The dustiest places were the wool breaker room where dirty raw wool was handled which might readily be contaminated with dangerous disease germs, and another room where old woolen rags of all descriptions were shredded up to be made over into carpet.

RESULTS OF DUST TESTS IN INDUSTRY

Industry	No. of Tests	Dust Particles per Cubic Ft.	Wt. of Dust Inhaled per Diem (in Grams)	Wt. of Dust Inhaled per 300-Day Yr. in Grams	Wt. of Dust Retained per 300-Day Yr. in Ounces	1 Lb. of Dust Retained in	Hours in Day's Work
Portland cement mfgr	11 (2 factories)	6,790,900	0.4559 grams	146.77 grams	1.466 ounces	10.9 yrs.	12
Plush, blanket and carpet weaving	13	145,950	0.0906 "	27.18 "	0.291 "	56 "	10
Steel grinding	3 (2 factories)	578,100	0.0861 "	25.83 "	0.277 "	57 "	9.8–10
Flint grinding	3 (2 factories)	844,040	0.0663 "	19.89 "	0.213 "		8
Asbestos weaving	6 (2 factories)	494,130	0.0573 "	17.19 "	0.185 "		8–10.25
Felt hat making	3	126,020	0.0242 "	7.26 "	0.077 "		8
Pottery mfgr	5 (3 factories)	182,720	0.0187 "	5.61 "	0.06 "		8
Cigar mfgr	19 (6 factories)	102,600	0.0147 "	4.41 "	0.047 "		9.75
Silk weaving	2	87,000	0.0081 "	2.43 "	0.026 "		10
Indoor air average	3 (2 locations)	99,600	0.0492 in 24 hrs.	17.96 in 365 day yr.	0.173 in 365 day yr.		
Outdoor air average	2 (2 locations)	34,000	0.0299 in 8 hrs.	10.92 gm. in 365 day yr.	0.105 gm. in 365 day yr.		
Total	70						
Dustiest cement room		13,560,000	1.0641	319.32 gm. in 365 day yr.	3.419	4.7 yrs.	12
Dustiest wool room		430,100	0.7027	210.81 " " "	3.26	7.08 "	10
Dustiest steel grinding room		1,066,200	0.1599	47.97 " " "	0.514	31 + "	9.8
Dustiest asbestos working room		356,800	0.1161	34.83 " " "	0.373	45 + "	10.25

Here too there was danger of infection as well as mechanical injury from dust. However, woolen dust itself is among the least irritating of dusts, far less so than the hard mineral dusts.

Steel and asbestos dusts are both decidedly irritating, the former being distinctively dangerous, owing to its sharp irregular form. In the dustiest streel-grinding room ball bearings were being dry ground between emery wheels and no effort was made to keep the fine particles from flying off into the air. The asbestos dusts would have averaged much higher except for the presence of very efficient exhaust ventilation hoods over the carding machines in one factory. As will be seen at the bottom of the accompanying table, one asbestos working room was even worse than the ball-grinding room. Flint dust, though ranking fourth in the table, is probably the most dangerous of all except possibly steel, and flint has a reputation for shortening the lives of workers and inducing tuberculosis. One flint mill has an exhaust system, but, as often is the case, it was not working. Pottery manufacturing has a bad name, but conditions were not found to be very bad, as will be seen. Formerly much lead was used in pottery glaze and is yet for some wares, but little was used in the factory visited, the employees being well protected when it was used, and a test of the dust showed only a small per cent. of lead present.

The danger in felt hat making is not so much from the fur dust itself as from the mercury dust, rising from the carrotted fur. The fur is "carrotted" or brushed with acid nitrate of mercury solution to prepare it for the felting process. Cigar manufacturing has a bad name for dust production, but, as seen in Philadelphia, this is undeserved and nicotine tests on the dust showed little or no danger of poisoning of the workers.

The silk factory was the cleanest place visited, and here there was less dust than found anywhere except in outdoor country air. This is partly due to the high degree of relative humidity maintained to make the silk fibers more manageable.

In many of the places where samples were taken relative humidity was tested, and in general it was seen that where there was most moisture in the air there was least dust and fewer large particles proportionately to smaller. Tests of relative humidity also showed that in few if any of the rooms was the humidity too high for comfort, though heat was excessive in many cases where testing was done in hot summer weather. In most instances the relative humidity might well have been artificially increased as a means of reducing dust. This could have been done by the use of humidifiers to add moisture to the air or by supplying cool air in ventilation ducts by means of water sprays or circulation over cold pipes. The mere lowering of the temperature of air increases its relative humidity by lowering its saturation point.

X-ray examinations of the chests of workers in dusty atmosphere showed varying degrees of fibrous deposits in the lungs, as well as fine scattered shadows due to the dust itself. These while well marked in workers in cement and in steel grinders were distinct in potters only after many years of work. Shadows of less degree were also seen in old plush and carpet mill employees, which may have been due in whole or in part to the inorganic matter mixed with the fibrous dust in an old mill not kept any too clean. Evidence of damage to the lungs of cigar workers was absent even in the men working many years at the trade.

Dust conditions in many factories or in parts of factories were minimized by the introduction of strong local exhaust ventilation with hoods over dust-creating machinery, but these were by no means universal and where employed were not always properly constructed or of sufficient size and power, and at times were not even working. Where sufficient suction ducts were in operation the effects of exhaust ventilation on the various-sized particles could be tested and as would be expected it was clearly shown that in addition to lessening total dust it removed a portion of smaller, more dangerous particles.

In general, dust may be prevented or lessened by removal at the source as indicated above, by substitutions of wet for dry processes, by frequent vacuum cleaning or wet sweeping and by increasing relative humidity. In numerous cases dust-generating processes can be entirely enclosed in specially ventilated drums, boxes or rooms, so as to allow no dust to escape into the factory. Where dust can not be prevented dusty processes should be conducted in separate rooms and, especially if the dust is poisonous or very irritating, workers may wear masks or dust helmets. Almost always there can be found some way to protect the workers from excessive dust and such means will be more generally employed when such investigations as these prove more definitely the harmfulness or relative harmlessness of specific dusts and processes.

THE BANANA: A FOOD OF EXCEPTIONAL VALUE

By PROFESSOR SAMUEL C. PRESCOTT

PROFESSOR OF INDUSTRIAL MICROBIOLOGY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE banana of commerce is the fruit of various species of *Musa*, a plant which develops abundantly throughout the whole tropical zone. Many species of *Musa* are known, differing in size and character, and their fruits likewise show differences in size, appearance and flavor. Various common names are given to the different varieties, such as red bananas, yellow bananas, apple banana, date banana, ladyfinger, etc. The banana found principally in the American market is the fruit of the *Musa sapientum*, of which there are a large number of varieties, the most common being the Gros Michel banana. The plants and their fruits differ considerably in appearance and actual composition, according to the environmental conditions of soil, climate and other geographical and geological features.

The banana constitutes the chief carbohydrate food, in fact the principal food of enormous numbers of people in many parts of the tropics, thus taking the place of cereals and tubers, such as wheat, rye, barley and potatoes, in the food relations of the temperate zone. Careful computations have been made by numerous authors showing that the actual amount of food material produced per acre in the cultivation of bananas exceeds that of wheat or any other crop. The banana is therefore to be considered not as a luxury but as a very important staple in the food supply of the world. From this point of view it deserves much higher consideration than it has hitherto been accorded.

Since the edible portion is surrounded by a thick enveloping skin it is effectively protected against the attacks of bacteria, moulds and other agencies of decomposition, therefore if the skin is unbroken it may always be eaten with the assurance of its sanitary quality and freedom from dirt or objectionable material.

THE COMPOSITION OF THE BANANA

Many analyses of the banana have been made by different investigators. Since we are especially interested in the American banana, it is probable that the average of the American analyses may best be quoted: Atwater and Bryant, working under the auspices of the U. S. Department of Agriculture, give the following figures, showing the analysis of the edible portion of the banana, U. S. Dept. of Agriculture, Bull. No. 28, revised edition, 1906, p. 71:

	Water, Per Cent.	Protein, Per Cent.	Fat
Minimum	66.3	1.0	.0
Maximum	81.6	1.6	1.4
Average	75.3	1.3	.6

	Total carbohydrate, Per Cent.	Ash, Per Cent.	Fuel value per lb.
Minimum	16.3	.5	330
Maximum	29.8	1.1	640
Average	22.0	.8	460

The banana as purchased contains, of course, a large amount of inedible material, the skin, which amounts approximately to 35 per cent. of the total weight. Since, however, bananas are ordinarily not purchased by weight, but by number, this does not enter into the general question of either cost or food value. The ash of the banana is principally made up of the phosphates, sulphates and chlorides of potash, soda, magnesia and lime, all of which serve useful purposes in the body economy. It is thus seen that the banana contains all the classes of food materials required for the animal body, although the amount of protein and fat are too low in proportion to the carbohydrate to constitute a perfectly balanced ration. The combination of banana with milk in proper proportion, or its utilization as a vegetable to supplement a diet containing a small amount of meat will produce a ration which is ample to take care of the body needs.

Comparison of Banana and Potato and Other Foods

A comparison of the banana with the potato is of particular interest. Again quoting from the carefully made tables of Atwater and Bryant, page 68 of Bull. No. 28, above mentioned, we have the following figures:

	Potato, Per Cent.	Banana, Per Cent.
Water	78.3	75.3
Protein	2.2	1.3
Fat	.1	.6
Total carbohydrate, including fiber	18.0	22.0
Ash	1.0	.8
Calories per lb.	385	460

It is thus seen that considering the edible portion, the banana approximates very closely the potato in analysis and exceeds it by about 20 per cent. in its fuel or food value. Without giving the detailed figures of analyses, it may be of interest to compare the food value of the banana with that of a variety of other foods which we have come to regard as almost indispensable in a properly regulated dietary. The following table from Bulletin No. 28, mentioned above, shows the calorific value per pound of edible portion, except as otherwise noted, of some of these foods, the average result being used in each case for comparison:

Banana	*460*
Spinach	110
Squash	215
Green peas	465
Onions	225
Parsnips	300
Cabbage	145
Green corn	470
Fresh lima beans	570
Beets	215
Macaroni, cooked	415
Boiled oatmeal	285
Asparagus	105
String beans	95
Carrots	210
Clams, raw	240
Lobster	390
Oysters, solids as purchased	230
Scallops	345
Haddock	335
Flounder	290
Halibut, as purchased	470
Bluefish	410
Chicken, broilers, edible portion	505
Pickled tripe	270
Round steak, very lean	540
Round steak, medium fat	950
Milk, whole, as purchased	325
Apples	290
Cherries	365
Figs	380
Grapes	450
Oranges	240

A casual survey of this table shows that the banana exceeds in real food value many foods of different classes which are in almost daily use, such as whole milk, boiled oatmeal, shellfish and other fish, and fresh vegetables. Comparison of the food value of bananas and meats, as for example, round steak, should not be made without calling attention to the fact that the type of food is different in the two classes. Meats are essentially protein foods and as such are more adapted to the development of tissue than to the quick production of heat, while the banana, on the other hand, is less a tissue-forming substance but is incomparably more effective in supplying the heat-giving materials. In a crude way we might say that the proteins are the foods which make good the losses due to wear and tear in the machinery of the body, while the carbohydrates are the foods which keep the machinery in motion and do work. From this standpoint it is seen therefore that the banana, because of its higher carbohydrate content along with a certain amount of protein, would be a more useful all-round food than a pure meat diet in which the amount of carbohydrate is nil. A comparison with medium round steak, for example, shows in the edible portion in each case 65.5 per cent. water for the steak as against 75.3 for the banana, and protein content 20.3 for the meat and a fat of 13.6 per cent. as against the figures for the same constituents of the banana. On the other hand, the meat possesses no carbohydrate, whereas the banana has 22 per cent.

From the standpoint of the consumer the fairest method of comparison between these facts would be in noting the cost in cents per calories of fuel value obtained. At the present market price of meats the advantage is distinctly in favor of the banana. A similar comparison with fish is not without interest. Taking haddock as a food-fish now largely used, we purchase with each pound of fish approximately twelve ounces of water, that is to say, the haddock contains approximately 81 per cent. to 82 per cent. of water as against 75.3 per cent. in the banana. The fish shows a larger proportion of protein, but the fat content, however, is less than in the banana and there is no carbohydrate, wheras, as we have seen, the banana, is rich in this quick-acting, heat-giving substance. From the standpoint of calories, therefore, the banana exceeds the common food-fish considerably and from the standpoint of real costs the odds are greatly in favor of the fruit. If we compare the food value and cost of potatoes and bananas at the present retail price, $1.00 per peck and 25 cents to 30 cents per dozen, respectively, we shall find that of these two substances which are essentially similar in their analyses, there is a decided advantage in favor of the banana. At present prices, April, 1917, when purchasing bananas, one cent will buy 65.9 calories on the average, while in buying potatoes this sum secures 46.6 calories—a 40 per cent. difference in favor of the tropical fruit. In this connection it is perhaps well to call the attention to the fact that the banana can be cooked in a variety of ways and may replace the potato admirably. It may be baked, boiled, fried, served as chips, or "French fried," and in all these ways is an excellent and highly nutritious article of food. For use as a vegetable in the ways just mentioned, it is found of advantage to use fruit which has not reached the state of full-ripeness as the starch content is then greatest and the sugars less, while for desserts and for eating in the natural state the rich sugary fruit is more acceptable.

Bulletin No. 7 of the Bureau of Public Health Education of the New York Dept. of Health, issued February, 1917, says:

The onion, like most green vegetables, is of value in the diet chiefly for the mineral salts which it contains. It is these and not its protein that make it a valuable addition to bread and meat. Bread and cereals and meat are described by the chemist as having an excess of acid-forming over base-forming mineral matters. Green vegetables and fruits are of the opposite character, having an excess of base-forming minerals. A proper balance of these two classes of minerals in the diet is essential to health. There is danger at the present time, when vegetables are unusually costly, that the health of the community may suffer from a deficiency of base-forming minerals in the diet. It is important, therefore, to call attention to the fact that apples, bananas and oranges, which have not greatly advanced in price, may be used as substitutes for vegetables. They contain the same mineral matters in varying proportions. Apples, bananas and oranges all surpass onions in their excess of base-forming minerals. On Saturday, February 24, a member of the Home Economics department of Hunter College investigated the prices of fruits and vegetables on the upper east side of Manhattan. A few of the prices, with some other facts, are given below:

	Avg. Cost lb.	Per Cent. Refuse	Avg. Cost per lb. Edible Portion	Food Units per lb. of Edible Portion
Bananas	$.04	35	$.054	460
Cooking apples	.04	25	.05	290
Small oranges	.05	27	.0635	240
Onions	.15	10	.165	220

It is therefore evident that these fruits are all cheaper than onions.

It is also clear that on the basis of food value, the banana is nearly a third cheaper.

An analysis made in the laboratory of the writer gave the following results:

Analysis of Banana Ash

	Per Cent.
Silica	2.19
Lime	1.82
Iron oxide	0.18
Phosphoric acid	7.68
Magnesia	6.45
Soda	15.11
Potash	43.55
Sulphur trioxide	3.26
Chlorine	7.23

That is, the ash is largely made up of the base-forming salts, the carbonates, phosphates, chlorides and sulphates of potash, soda and magnesia.

Below will be found a table, which has been prepared from analyses shown in Bulletin No. 28, previously referred to, and from the data accumulated by Professor H. C. Sherman, of Columbia University, and other authentic sources, where is shown the analysis of a number of foods both of animal and vegetable origin and their comparative calorific value based on present prices. The costs per pound have been obtained as a result of a number of actual purchases made at retail in New York City and are therefore reliable.

The Nutritive Ratio

The nutritive ratio shown in the table may require a slight amount of explanation. This is based on the fundamental fact that proteins, carbohydrates and fats supply the actual food material to the body. Of these, protein alone is nitrogenous material, while fats and carbohydrate contain no nitrogen. Nutritive ratio really expresses the relation between the energy derived from the nitrogenous food and that derived from the non-nitrogenous nutrients and is determined by a computation of the calorific value of the proteins as compared with fats and carbohydrates. Since the fats have a heat-giving value which is approximately 2¼ times that of either carbohydrates or protein, the energy relation of nitrogenous to non-nitrogenous material is not an exact expression of the percentages of protein and non-protein, but of the fuel or power-producing value. The figures in the table therefore represent the real amount of energy derived from the total carbohydrate and fat calories as compared with the energy derived from the protein.

In this connection it should be explained, as suggested earlier, that the nitrogenous and non-nitrogenous foods serve somewhat different purposes in the body economy, since the nitrogenous foods are mainly for the repair of tissue, while the non-nitrogenous ones are for the development of power (energy). For this reason it is undesirable and uneconomical to have too much protein. Only the nitrogen actually needed for repair and building of tissue is utilized, the remainder being excreted. There is no storage against a future shortage as in the case of fat. Therefore in a properly balanced diet the amount of protein food should not ordinarily exceed 15 per cent. of the total fuel used. Moreover, the actual amount of fuel used varies with age and occupation. Those doing hard manual labor need more energy and consequently more food. Growing children burn their food rapidly and need more protein in proportion to the total than do adults.

The general relation of foods to the body needs as well as their relative cost based on calorific value is well expressed in the following quotation from the bulletin on "Food: Fuel for the Human Engine," prepared by the recognized expert, Dr. Eugene Lyman Fisk, and issued by the Life Extension Institute of New York during the present year (pp. 5–6)

> There are three main groups of fuel foods: Here they are in order of cost per calorie, *i. e.*, those giving the most energy for the money heading the list.

Starchy Foods	Sugars	Fats
Bananas	Sugar	Drippings
Cornmeal	Corn syrup	Lard
Hominy	Dates	Salt Pork
Broken rice	Candy	Oleomargarine
Oatmeal	Molasses	Nutmargarine
Flour	Most Fruits	Peanut butter
Rice		Milk
Macaroni		Bacon
Spaghetti		Butter
Cornstarch		Cream
Dried lima beans		
Split peas, yellow		
Dried navy beans		
Bread		
Potatoes		

> About 85 per cent. of the fuel should come from this group, using starchy foods in largest amounts, fats next and sugars least. Fats, starchy foods and sugars are almost pure fuel, like coal, while cereal foods also contain some building and regulating material.

The same bulletin, presenting a table of the raw materials in common use in the order of their cost per pound, places bananas at the bottom of the list, *i. e.*, the cheapest food.

The High-Power Fuel

The banana is not only a higher-power fuel for the body, but it is also rich in the desirable salts. The onion has long been considered a valuable food adjunct because of its mineral salts. The banana is even more valuable.

A little known commodity in America is banana flour, but in view of the shortage of materials it is one which should be seriously considered. The fully grown, but unripe banana, is the source as it is desired to obtain the carbohydrate in the form of starch before it goes over to soluble sugar. The peeled fruit is dried and ground, the water content is removed to approximately 15 per cent. and during this process the other ingredients are concentrated.

According to the eminent English dietetic expert, Dr. Robert Hutchinson in "Food and the Principles of Dietetics," we find:

The unripe banana is dried and used to produce banana flour or meal. A sample of such a flour had the following percentage composition:

Moisture	Moisture	Proteid	Fat	Carbohydrates	Mineral Matter
Banana flour	13.0	4.0	0.5	80.0	2.5
Wheat flour	13.8	7.9	1.4	76.4	0.5

I have placed alongside of it the composition of good wheat flour, compared with which the banana meal is rich in carbohydrates and mineral matter, but very poor in proteid. If rice, on the other hand, had been taken for comparison, it would have been found that banana flour was about equal to it in nutritious value.

The *Lancet*, February, 1900, in a discussion of the banana as food says:

For some reason not yet explained, the starch of the banana is much more digestible than are the cereal starches, besides which the fruit contains a notable proportion of nitrogenous material.

In a later article (*The Lancet*, October 17, 1903), this journal states:

There can be no doubt of the nutritious character of banana flour, and the starch in it is peculiarly easy of solution and digestion in the alkaline digestive juices of the body. Banana flour is readily dissolved, for example, by the saliva.

Dr. Hutchinson also calls attention in "Food and Dietetics" to the fact that dried bananas compare favorably with dried figs in nutritive value.

During the recent rise in the cost of foodstuffs, Dr. Graham Lusk, at the request of the New York State Board of Health, compiled a low-cost meatless dietary of high efficiency value. In speaking of this he said:

Potatoes with their valuable alkaline salts had to be excluded from the diet because of their prohibitive price.[1]

It is noted, however, that sliced bananas and sugar appear as a component of luncheon or supper. Many articles have appeared during the past ten years pointing out the high food value and the wholesomeness of this fruit.

The complaint is sometimes made that uncooked bananas are indigestible. Making a careful study of the subject, it is found that this statement is only partly true and should be modified to read that "uncooked, unripe bananas may be indi-

[1] *Science*, Vol. XLV., April 13, 1917.

Food	Refuse, Per Cent.	Water, Per Cent.	Total Indigestible Nutrients, Per Cent.	Digestible Nutrients: Protein, Per Cent.	Digestible Nutrients: Fat, Per Cent.	Digestible Nutrients: Carbohydrate, Per Cent.	Ash, Per Cent.	Food Value: Per Pound Calories as Purchased	Food Value: Edible Portion	Food Value: Nutritive Ratio 1:	Avg. Time of Gastric Digestion, Hr. : Min.	Cost per Lb. as Purchased in Cents	Cost per 100 Calories as Purchased in Cents	Calories Purchasable for 5 Cents
Bananas	35.0	48.9	1.6	.8	.4	14.3	.6	300	460	19.7	1:45	5	1.66	300
Beans, string	7.0	83.0	—	2.1	.3	6.9	.7	180	195	—	3:45	16	8.88	56
Beans, fresh Lima	55.0	30.8	—	3.2	.3	9.9	.8	255	570	—	—	9	3.53	141
Beets	20.0	70.0	—	1.3	.1	7.7	.9	170	215	6.8	3:45	15	8.82	57
Cabbage	15.0	77.7	.6	1.2	.2	4.6	.7	115	135	4.2	4:30	14	12.17	41
Onions	10.0	78.9	—	1.4	.2	6.5	.5	205	215	—	3:30	8	3.90	138
Potatoes, Irish	20.0	62.6	1.2	1.5	.1	14.0	.6	295	370	9.5	2:30	8	2.71	185
Potatoes, sweet	20.0	55.2	1.6	1.2	.5	20.8	.7	460	570	18.3	—	10	2.18	230
Squash	50.0	44.2	.4	.6	.2	4.3	.3	105	215	7.8	—	6	5.71	88
Tomatoes	—	94.3	.5	.7	.4	3.7	.4	95	95	6.6	2:05	15	15.79	32
Beans, dried	—	12.6	7.9	17.5	1.6	57.8	2.6	1,520	1,520	3.5	2:30	20	1.31	380
Apples	25.0	63.3	1.2	.3	.3	9.7	.2	220	290	34.7	1:30	5	2.33	215
Grapes	25.0	58.0	1.7	.9	1.1	13.0	.3	335	450	17.2	—	10	2.98	168
Oranges	27.0	63.4	1.0	.5	.1	7.7	.3	170	240	15.8	—	5	2.64	240
Strawberries	5.0	85.9	1.0	.8	.5	6.3	.5	175	180	9.3	—	20	—	—
Cod (dressed)	29.9	58.5	.5	10.8	.2	—	.6	215	325	0.1	—	10	4.65	108
Flounder	61.5	32.6	—	5.4	.3	—	.5	115	290	—	—	10	8.70	58
Haddock	51.0	40.0	—	8.4	.2	—	.6	165	335	—	1:30	10	6.06	83
Mackerel	44.7	40.4	.7	9.9	4.0	—	.5	365	645	—	—	25	6.85	73
Oysters (solids)	—	88.3	.6	5.8	1.2	3.3	.8	335	335	1.0	2:55	30	8.95	56
Milk, whole	—	87.0	.5	3.2	3.8	5.0	.5	310	310	4.3	3:15	5.5	1.77	282
Eggs, uncooked	11.2	65.5	1.1	12.7	8.8	—	.7	635	720	1.7	—	28	3.90	138
Beef, fresh:														
Round, medium	7.2	60.7	1.4	18.4	12.2	—	.8	890	950	1.5	—	30	3.37	148
Ribs	20.8	43.8	1.8	13.5	20.0	—	.5	1,135	1,433	3.3	—	20	1.76	284
Beef, roasted	—	44.1	—	22.3	28.6	—	1.3	2,805	—	—	4:15	—	—	—
Beef, dried and roasted	4.7	53.7	4.5	25.6	6.6	—	5.5	790	840	0.6	—	16	2.03	221
Beef, boiled and salted	—	38.1	—	26.2	34.9	—	.9	1,620	—	—	3:20	—	—	—
Corned rump	6.0	54.5	—	14.3	22.0	—	3.1	1,195	1,270	—	—	30	2.51	199
Veal cutlets	3.4	68.3	1.2	19.5	7.1	—	.8	690	705	0.8	5:00	22	3.66	137
Mutton, hind quarter	17.2	45.4	—	13.8	23.2	—	.7	1,235	1,495	—	3:00	25	2.02	247
Lamb, hind quarter	15.7	51.3	—	16.5	16.1	—	.9	985	1,170	—	—	26	2.47	202
Ham, smoked	14.0	34.8	—	14.2	33.4	—	4.2	1,675	1,940	—	—	30	1.79	279
Bread, white	—	35.3	2.9	7.8	1.2	52.0	.8	1,200	1,200	7.0	3:30	16	1.33	376

The outstanding fact that at once impresses the careful student of these and similar figures is that dried beans and bread alone are cheaper than the banana when measured in fuel value. The banana to-day provides more actual food for the same cost than any fresh fruit or vegetable, or fish, meat, milk or eggs.

gestible," for all evidence shows that the thoroughly ripened banana is not only digestible, but it is one of the easiest foods to digest in the whole dietary. Dr. Arnold Lorand of Carlsbad states that "as far as their digestibility is concerned I have personally noted that when eating a perfectly ripe banana it almost melts in the mouth when simply turned over several times without any actual mastication and only a few stringy fibers in the middle of the fruit will remain. In this way two or three large bananas may be eaten without there being any feeling of discomfort in the stomach. Of course bananas are only thus digestible when quite ripe; those still somewhat green are less so, especially when they feel hard on the outside, although when very well masticated they are easily dissolved." As a matter of fact, many people assume that when a banana begins to show brown or black spots on the skin it is past the period of ripeness, whereas it is approaching the point when it may be regarded as perfectly ripe.

Comparative studies on the length of time required for foods entering the stomach to be digested and passed on to the intestinal tract, have been published by numerous investigators. One which has stood the test of time shows the following figures:

Foods	Average time of digestion. hr. min.
Ripe bananas	1.45
Oatmeal	3.5
Beans	2.30
Cabbage	4.30
Onions	2.5
Green peas	2.35
Boiled potatoes	3.30
Tomatoes	2.5
Turnips	4.0
Vegetable marrow	1.45
Boiled beef	4.15
Roast beef	3.20
Roast mutton	3.15
Roast pork	5.20
Soft boiled eggs	3.30
Boiled fowl	3.0
Codfish	3.30
Mackerel	4.0
Apples	2.30
Nuts	4.0
Oranges	2.45
Plums	3.40

This table shows that of all these common foods the banana is the most readily digested. This is explainable by the fact which was previously mentioned, that in the mouth during the process of mastication the carbohydrate is largely transformed into assimilable sugar and the further process of transformation in the stomach requires but a relatively short time. A meal of steak and potatoes would be seen, according to the table given, to occupy approximately three and one half hours for the digestive changes of the mouth and stomach to take place, whereas the ripe banana fruit would be digested and ready for absorption in half that time. It has already been shown that the banana is actually richer in nutrients per pound of material than the common food-fish or the common food vegetables. The table just cited above shows that it also is a more easily digested food than fish or vegetables, requiring a shorter time period for the digestive fluids to act in order to bring it into usable form.

General Conclusions

The statements which have preceded should not fail to make it clear that in a period like the present when we are facing a general shortage of cereal and other carbohydrate food we may turn to the banana as one possible solution of our difficulty. The fact that bananas may be obtained in abundance throughout the year, that they may be shipped for long distances under suitable conditions without being impaired in any way, that they may be used either as a fruit or as a vegetable, cooked or raw, in their normal form or dried or powdered, shows clearly that in this remarkable fruit we have an adjunct to our dietary which should not be underestimated. Used in connection with dried beans or peas or with dairy products such as milk and cheese or with the lean meat, it serves perfectly to secure a properly balanced ration.

It is practically the only food which during the last two years has not shown a marked increase in price and to-day will stand comparison with any food upon the market on the basis of caloric costs. Everything points to its continued favor not merely as the "poor man's fruit" as it has sometimes been called, but as a staple food for universal use, and it is to be hoped that it will be employed in continually increasing amounts whether as a substitute for other foods which have become prohibitive in price or because of its own inherent quality.

RESULTS AND EXPECTATIONS OF RESEARCH ON FISHERY PROBLEMS

By Dr. PHILIP H. MITCHELL

U. S. BUREAU OF FISHERIES AND BROWN UNIVERSITY

TO speak of calories in the days before this war was to be outlawed as a conversationalist. Now the word is in the vocabulary of every housewife and even at the club or hotel you may hear men grumbling that they are fed on calories. With equal certainty we note the popular adoption of the scientific lingo of the engineer, the chemist and the statistician. In strenuous war times the people turn to science with renewed interest and confidence. They even submit humbly and expectantly to scientific dictation. It is hard to imagine the American public in peace times submitting to the admonition, "Eat more fish instead of meat," no matter how many statisticians might recommend it. Yet that slogan is warmly received now. Sometimes the public confidence in the victorious power of science is almost pathetic, as in the case of a hope for a submarine panacea. In the Utopian republic respect and confidence toward science would be based on knowledge of its power and progress and neither distrust nor overconfidence would hamper the usefulness of scientific results. That happy state does not exist, so that science should still take pains to make clear to the laity why research has produced and will produce results of benefit to humanity. During this wave of sympathy with science it is timely to show the justification for the expenditure of government funds and private endowments for scientific research and to state some of the needs for the future.

Results and hopes of any one of our large and productive laboratories in state or endowed universities or in research institutions would alone give a fitting exposition of the human usefulness of research. With equal propriety one might choose the work of any or all of our government bureaus. My own experience gives me opportunity to know some of the results and aims of the United States Bureau of Fisheries. The description of the scientific work does not pretend to completeness or any sort of cataloguing, but merely to presentation of a background for the suggestion of possible lines of future effort. There is no intent to imply that the Bureau has announced its purpose to pursue the problems here stated. They are merely the problems which through conference with various members of the bureau's staff and through my own researches have come to my attention. They are taken from all portions of the field of biology.

General biological surveys and intensive observations of the flora and fauna of waters in restricted areas have proved their usefulness. Of course much of the work of that character has served to locate fishing grounds. In some cases an abundance of fish of certain species not previously used could be pointed out. For example, the biological surveys of the continental shelf of our Atlantic seacoast revealed the presence of tilefish. Subsequent observations, extending over a period of years, made it possible to record their catastrophic decrease in numbers followed by their slow increase, so that when fishermen were persuaded to go after tilefish abundant schools were found at once. Within two years after the first shipload of tilefish was brought into port the supply in the markets of New York and Boston amounted to nine millions pounds annually. This constitutes a real addition to our food supplies. Biological surveys show so great an abundance of the species, extending over so large a habitat that fishing activities are not likely to deplete them. Barring unpredictable circumstances tilefish should be a staple commodity in our markets. Similar results may be expected from surveys locating beds of sea-mussels. Though treated as a great delicacy by European culinary art the mussel has not been appreciated here. A demand, stimulated chiefly through the efforts of the Bureau of Fisheries, is being created. Extensive beds located in many of our coastal waters are being mapped out. They could yield a satisfactory supply. If this knowledge were used to good advantage by the shell-fisheries industry another important addition to our food resources would be made. At this time, when clam digging has in so many communities been worked almost to the extinction of the clam and when the oyster industry is complaining that many of their most productive waters are no longer available for oyster culture because of pollution, we must find some means of increasing our supply of edible shell-fish. While efforts are directed toward the development of improved methods of clam and oyster culture, we must also avail ourselves of the ocean's munificent supply of sea-mussels. A slightly different type of useful result is seen in the introduction of the manufacture of ornamental "artificial ferns" from marine hydroids. A knowledge of the location of these growths made it possible to build up a considerable industry.

These three examples are selected from many which might show the value of biological surveys as carried out in marine investigations. As a matter of fact, the vast resources of the ocean have scarcely been touched. The more we can know about them the better shall we make use of them. Some of the specific problems of this type that are awaiting investigation include the determination of the causes of fish migration, of the abundance of certain species during certain years, of the scarcity of some species during longer or shorter periods over areas sometimes very large. Why should mackerel be so marvelously abundant for a few years during the '80s and then be comparatively scarce for nearly thirty years, reappearing again in huge schools all along our New England coast? Similar variations in the abundance of many of our common fishes are on record. We ought to know whether they are due to changes in food supply, to meteorological conditions, to fluctuations in ocean currents, to fish diseases, to variations in the suitability of breeding conditions, or to other causes. Extensive oceanographic observations, especially biological surveys, including a study of the ultimate sources of the food of fishes and the distribution of many species at different seasons must be made. Since the higher forms live at the expense of the lower ones explanations of the food supply of fishes must include a study of the microscopic life of the sea. It seems probable that bacteria and diatoms, those minute vegetative forms so generally abundant, are really the ultimate feeders for life in the sea. It is perhaps difficult for the casual observer to realize that filtering specimens of sea water day after day and month after month would yield material important in determining the migrations of fishes, but such observations to show the distribution of diatoms will in all probability help to solve the question of the distribution of all life in the sea. Not only the microscopic plants, but seaweeds, seem to possess fundamental importance in maintaining a supply of nutrition for marine fauna. To what extent the various common seaweeds play a significant rôle in what might be called the metabolism of the sea, remains to be determined.

Even compared to such general biological survey work, intensive studies in comparative anatomy and morphology have also yielded and will continue to yield significant results. Consider, for example, the importance of studies on the life history of the oyster. They have made possible the development of modern methods of oyster culture, an industry more highly developed in America than in any other country. Much remains to be done to fill the gaps in our formation. What conditions are responsible for the failure to obtain during certain seasons a "set" of young oysters? Why were seed oysters once abundant in certain localities which do not now produce them? To what extent do oysters lend themselves to artificial hatching, so that the present occasional discouraging failures in the seed crop may be obviated? These are still among the unsolved problems of oyster culture now receiving earnest attention. It would not have been possible to attack them unless knowledge of the morphology and life history of the oyster were far advanced. Similar information on the developmental history of the clams and mussels is available. Its application to clam culture is just beginning and will no doubt become more important in the not distant future. The cultivation of sea-mussels is still an unknown art but when they are known for the delectable food they are, sea-mussel growing may also become an applied science. The story of the fresh-water mussel, how it is reproduced, how it becomes parasitic on the gills of certain species of fish, and while growing there is transported to a new habitat, how it then drops off, becomes "planted" and develops to furnish an article of great commercial value as the basis of the pearl button industry—all this constitutes one of the most interesting chapters in biology. It is a striking instance of the development and application of morphological investigation. Further work on the optimum conditions for reproduction, on the kinds of fishes which may serve as hosts during the parasitic period, and on other similar problems is going forward.

The developmental history of the lobster has been of equally striking use. A knowledge of the different molting stages through which the young lobsters pass made possible the devising of special cultural methods for rearing lobsters to a stage at which they are able to escape their enemies, hide beneath rocks, and, in short, take care of themselves. Artificially hatched lobsters reared to this stage may be liberated with some hope that thereby the depleted supply of this table luxury will be increased. Such researches on invertebrates, interesting as they are, seem small in the importance of their food productive results alongside the embryological and anatomical studies of food fishes. These are the basis of all fresh- and salt-water hatchery work. Future extensions of such activities will require amplification of our knowledge of the developmental history of many species.

Studies in fish pathology contribute their share to the success of fisheries. Here perhaps in better measure than elsewhere are shown unexpected application of research supposed to be in pure science without practical usefulness. Long-continued observations on the occurrence of various species of parasites in a number of common food fishes made it possible to distinguish the harmlessness to human beings of certain of the parasites. When, therefore, health authorities of the city of New York, alarmed at the discovery of parasites in butter-fish, seized so many of them in the fish markets that an estimated loss of $30,000 occurred within three days, the bureau was able to furnish decisive information. The parasites had been proved to be harmless and to have been present in a large proportion of butterfish as examined over a period of many years. The sale of these fish was therefore continued and a large food loss prevented. This is one instance. Other similar cases have occurred. A complete knowledge of the parasitology of fishes is desirable from the standpoint of safeguarding human food, but the application of this knowledge should not stop there. Fish pathology should be able to furnish information helpful in the work of increasing our supply of fish. It has been shown that some loss of food fishes certainly occurs as the result of parasitism and other fish diseases. The cure and prevention of infections in a number of kinds of fishes, notably those, like trout, occurring in limited bodies of water, has been possible. An almost unlimited field remains to be developed here for marine fishes. We have little idea as to what extent disease is a cause of their depletion. The nature and the prevalence of such diseases, the life histories of parasites, whether bacterial, protozoan or of other nature, must be worked out much more fully than has been done to date. With such information available it is to be hoped that means of control might be devised.

The work which the biochemist may do for the solution of fishery problems covers a varied field. The metabolism of aquatic forms has received some attention. The application of that knowledge to the maintenance of proper nutrition in fishes artificially reared and of suitable oxygen supplies in the water of fish hatcheries has been useful. If this country is to adopt, as prudence strongly advises, a more extended custom of rearing fish domestically in small ponds all the problems relating to the most economical and effective methods of nourishing fish in confined waters must receive more attention than they have had. The need of information about the physiology of nutrition of a specific aquatic form has already been emphasized. I refer to the oyster. It was formerly possible to obtain oysters in a well-nourished condition, the so-called "fat" oysters, so as to supply the market adequately. The best nourishment for oysters, however, is found in those brackish waters around which growing population now tends to furnish pollution. Oyster beds have been forced further and further away in many localities from the best feeding grounds and successful oyster culture has become more difficult. Transplantation of stock to good feeding grounds has to be resorted to, the latter are overcrowded and the production of really well-nourished oysters is diminished. Oyster culture in certain European localities has come to the use of rapid, forced "fattening" in small ponds. The most efficient application of any such method can only be based on a knowledge of many possible foods for the oyster and a well-developed study of its metabolism. Such investigations have been fostered by the bureau for some years and need to be further extended. Knowledge of the nutritional processes in a few marine organisms will throw at least some light on similar problems connected with others and surely the metabolic histories of all forms which may be artificially reared will have their practical significance.

The work of the specialist in dietetics is required in fishery problems. Since the early work of Atwater on the composition of American food materials, including extensive studies of fish and shell-fish, very little has been done to determine the food value of fishery products. In recent years our ideas of real food requirements have been radically revised. We no longer speak merely of the protein requirements of the body. We distinguish relatively great differences in the food value of the proteins from different sources. These distinctions can best be made in accordance with technique now developed by elaborate and well-controlled feeding experiments. Food values, in short, have to be determined biologically. Almost no work of this sort has been carried on with the proteins of fish and shell-fish. We desire to avail ourselves as far as possible of the comparatively inexhaustible food resources in the ocean. Particularly do we hope to supplement our expensive proteins, replacing meats, in some measure at least, with fish. To what extent we should do that depends properly upon the relative food value for human beings of fish proteins compared with others. A similar problem in nutrition is the vitamine content and the presence of various metabolism catalyzers in fishery products. It has been stated, though not yet perhaps entirely proved, that cooked foods no longer contain the so-called vitamines which might be present in the raw product. This idea together with the seemingly established fact that vitamines are commonly present in animal tissues has led to claims which need to be substantiated. For example a more extended consumption of raw oysters has been recommended. That this may be sound advice and that we may thus healthfully increase our ingestion of vitamines is perhaps true, but it ought to be proved. Similar investigations of many foods await, to be sure, an attack, but for none of them would the usefulness of results seem more immediate than in the case of fishery products. Nowhere else is there available so great a store of food from animal sources immediately and comparatively cheaply accessible. The tremendously valuable work on the general nutritional value and limitations of some of our great food staples, like the cereals and the dairy products, as it has been carried on by certain of the physiological laboratories of this country should soon be followed by similar studies on fish and shell-fish.

Investigations in industrial chemistry occupy by no means a minor field among fishery problems. The manufacture of fish glue, the best methods for the preparation of fish fertilizers, the manufacture and industrial utilization of a great variety of fish oils, the preparation of potash and other potassium salts, of iodine and bromine from giant kelp and other sea-weeds are among the well-known chemical engineering attainments concerned with marine products. In the present world-wide shortage of hides the utilization of various fish skins in the tanning industry has of late received considerable attention from the Bureau of Fisheries. Future developments of these efforts will no doubt be observed with considerable interest. In this group of industrial problems, however, much remains to be accomplished. One has only to observe the large amount of waste in the form of fish offal now discarded from the receiving docks of any fisheries establishment to realize that we have a long way to go before we reach true conservation. To what extent the organs of fishes may be capable of yielding internal secretions or other preparations of therapeutic value remains to be shown. Better salvage of fats and the preparation of fertilizing material by more economical methods are perhaps to be developed in the future.

Appreciated only by those having the true research spirit is the fact that the more fundamental the research problem solved, the larger the number of practical difficulties solved by it. Any fool can see what a knowledge of the laws of electricity means to the modern world, but it took the genius of a Franklin to prophesy the importance of electrical research in its early days.

Countless illustrations of practical applications of scientific knowledge are brought forward to show how science is justified in dollars and cents even if one refuses to justify it on the plea of satisfying the thirst for knowledge. The so-called "pure" scientist and the "practical" scientist no longer gibe each other. They have long since come to understand that the work of neither can attain its full significance for mankind without the other's aid. It would probably be extremely difficult to find a man who would like to classify himself exclusively as either a "pure" or a "practical" scientist. Indeed no one experiment or group of experiments constituting a single research, if conceived and carried out by a sane mind, is likely to be entirely lacking in either general scientific interest or practical human value—if only you can see the interest and value! Unfortunately a large proportion of the world does not. When once convinced they applaud, but they still demand to be shown the connection between research and life. That a study of surface tensions in an oil emulsion should reveal a method for the successful preparation of a delicious food out of a material that would otherwise be wasted is not easy to believe. A long jump of the imagination is required unless the intermediate steps are explained. It is simple enough. When various researchers had shown that a trace of sodium soap increased, by its surface tension effects, the permeability of tissues to water, it was to be expected that a very dilute soda solution forming a trace of soap in desiccated fish would enable it to soak up water rapidly enough to make possible the preparation in any kitchen of a delicious dish out of a decidedly unappetizing dried fish. Relationships of this kind as they appear out of a group of problems to one worker have been sketched in this paper. If one of the co-workers in every science laboratory or unit group of researchers would take the time and trouble to at least state what they believe they have accomplished and what they hope to do there might be on record a reliable answer to the questions of the interested public. This is being increasingly done in these days of the progressive magazines, but even yet information is still obtained too often through an irresponsible newspaper reporter—the modern personification of old dame rumor. If this paper makes clearer to any one the problems confronting fisheries research, or if it induces any workers to cooperate in the solution of them, its object is attained.

THE DIAGNOSIS OF POTENTIAL NEUROSIS

By Dr. JOHN J. B. MORGAN

PRINCETON UNIVERSITY

THAT psychologists are alive to the need of the elimination of the mentally unfit from those recruiting for military service is shown by the recent plan of the American Psychological Association to examine all the men by means of a comprehensive set of mental tests before they are accepted. If the outline is adopted and psychologists are set to work the next question will be the selection of some series of tests of proper diagnostic value. In all probability intelligence tests will occupy a large part of the testing program, but there is one large group of individuals who should be eliminated that neither intelligence tests nor any physical examination would detect; namely, those who in a short time break down under the special strain that they are forced to undergo in active service. The number of such cases that have occurred make it exceedingly worth while to endeavor to detect such individuals before they are sent to the front. If discovered they could be given less strenuous work, but none the less important, they could be saved from mental disruption and the loss to the government would be obviated.

It does not take a psychologist to know that resistance to mental strain is a variable quantity as are all other physiological and psychological facts. Some individuals in the midst of a great amount of excitement can remain perfectly composed, seemingly impervious to the influences at work about them. Others are roused to react with greater vigor, but experience no apparent harm from their increased activity. Others are easily nettled by the slightest emotional excitement and recover but slowly and with difficulty. While we have no information on the characteristics of the individuals who are the first to succumb mentally, it at least seems plausible that those who can adjust themselves with least ease to additional mental strain would fall into this group. The selection of these individuals might be made by a test which would subject them to unusual mental exertion or shock; those being regarded as potentially neurotic who are unable to meet the situation by proper adaptations. This at least seems more hopeful than any classification made on the basis of intelligence tests. Mental stability is by no means correlated with intelligence.

We have shown in our work on sound distraction[1] that the most significant phenomenon that is evident in experiments designed to find the effect of environmental conditions upon psychophysical activity is the adaptation of the subject to the change in experimental conditions. If one shows no observable difference in his response to two situations, it is evidence that adaptation is perfect, not that the two situations are identical, of equal complexity or equally desirable. If one manifests a difference in his response to two different situations, this difference is not a measure of the difference between the situations, nor a measure of how much they differ in their effect upon the subject; it is simply an indication of how far the change between the two situations is beyond his power of adaptation. The writer believes that this fact opens a promising method of showing individual differences in ability to meet exceptional situations, and is hopeful that some simple test along the line to be suggested later may be found to be useful in the present crisis.

As a suggestive illustration of our point we will show the different ways in which the subjects responded to noise distraction. The experiment consisted of giving an individual the task of responding to visually presented material by translating it through a series of codes and then reacting on the one of ten keys which the exposure and translation designated. Each response caused a new exposure so that the subject could work just as rapidly as he chose. After he had worked at this task for a period of twenty to thirty minutes loud noises were introduced, continued for some time and then stopped, the sitting ending with a period of about ten minutes of work in quiet. In another experiment the subject was given the task of memorizing paired-associates under both quiet and noisy conditions.[2] In both experiments records were kept of the breathing of the subjects and of the amount of pressure they used in reacting upon the keys. A brief comparison of the various ways in which the individuals responded in the memory experiment is given in the original article and will not be treated further here. We will, however, make a comparison of the individuals in the discrimination reaction experiment.

In this experiment there were twenty-one subjects whose records are available for our purpose. We have made a brief

[1] *Archives of Psych.*, 1916, No. 35.

[2] *Am. Jour. of Psych.*, 1917, *28*, 191–208.

of their records and present them in the table; the letters in the first column designating the subjects as given in the original monograph. The first column of figures gives the percentage of increase or decrease in the time records of the subjects when the noises were first introduced; the second gives the percentage of increase or decrease of the end of the noise period as compared with the beginning; the third gives a comparison of the time records after the noises stop with those in the latter end of the noise period. The next three columns give the percentages of increase or decrease in the keep pressure records when the same periods are compared. A plus percentage indicates that the keys were pressed with greater vigor. The last three columns in the same way give comparisons of the breathing ratios. The breathing ratios were found by dividing the expiration time by the inspiration time; and indicate, we believe, the extent to which the subjects articulated as tney worked.

TABLE

SHOWING THE PERCENTAGES OF INCREASE OR DECREASE IN TIME, KEY-PRESSURE AND RATIO OF THE BREATHING EXPIRATION TO THE INSPIRATION TIME DURING THE COURSE OF AN EXPERIMENTAL SITTING IN WHICH NOISES WERE INTRODUCED AS A DISTRACTION. A, first part of noise period compared with preceding quiet; B, last part of noise period compared with first part of noise period; C, quiet succeeding noise compared with last part of noise period.

Subjects	Time			Key-pressure			Breathing Ratio		
	A	B	C	A	B	C	A	B	C
O	— 2.5	5.2	— 5.0	29.3	—16.4	—21.0	7.28	3.7	— 9.5
P	33.0	—20.6	— 5.8	93.8	13.9	—56.1	19.2	—24.2	9.7
Q	1[illegible].2	—27.0	3.7	161.0	—21.6	—23.4	—11.4	51.8	—30.6
R	10.8	— 8.5	2.1	19.8	—10.0	—20.8	—37.1	25.9	15.9
S	10.4	— 7.9	3.3	18.3	8.0	—37.2	—19.7	18.2	— 4.8
T	—10.5	— 5.8	15.1	146.8	4.5	—32.4	—16.7	153.5	—52.9
Bl	0	—12.9	— 7.1	8.0	— 7.4	—12.0	48.4	—30.1	—10.7
Sp	2.1	—10.4	1.2	21.8	—12.3	— 8.7	22.2	2.5	— 1.5
Sa	6.8	— 3.8	1.5	9.7	—43.6	—17.2	3.4	4.4	—36.4
Br	9.9	—18.4	— 8.1	27.0	— 7.1	—14.0	— 7.8	28.5	—24.2
Bo	— 9.6	— 4.5	1.6	13.4	— 2.0	3.0	5.7	— 2.0	— 6.5
Ch	— 9.6	0	0.7	14.9	26.5	—22.9	20.6	14.2	—10.5
Cr	— 3.6	1.0	— 1.4	—22.8	—19.2	— 4.3	33.0	—22.6	— 6.7
Re	18.5	— 9.4	— 2.9	7.1	—18.1	—15.1	14.7	— 2.5	—15.7
Pf	25.8	—26.8	6.4	19.5	—17.6	— 4.0	8.8	— 1.0	19.8
Me	1.5	—10.7	2.6	0.6	— 3.7	2.5	1.8	2.4	—15.2
Ca	0.8	— 1.0	—17.2	32.5	— 5.7	—34.0	— 0.5	22.1	— 7.9
De	3.5	2.9	— 4.3	26.7	— 2.6	—16.2	31.7	4.1	—20.4
Hi	—10.9	1.5	— 1.0	9.0	—14.5	—10.3	32 1	33.3	—20.5
Kr	—12.8	— 2.9	9.6	37.7	—16.2	—34.3	—10.3	48.7	—21.0
Ta	9.3	—18.3	— 1.7	3.1	37.7	—14.2	21.4	120.3	—47.5

Of the twenty-one individuals thirteen showed a loss in efficiency when the noises were first introduced, seven showed a gain and one no difference. Of the seven who manifested a gain in efficiency, six showed that they were in a state of greater muscular tension because they pressed the keys with greater force when the noises were introduced, and five of the seven showed by their breathing that they articulated to a greater extent in the noisy period. Of the thirteen who showed a loss in efficiency all showed an increase in muscular tension, eight indicated greater articulation in the first part of the noisy period and ten in the latter part of the noisy period as compared with the first part. The second column of the table shows that only four do less in the latter part of the noisy period than in the first part, three of these being of the group who did better when the noises first came than they did in the quiet. Of these three (O, Cr, and Hi) O and Hi both pressed the keys harder and gave a higher breathing ratio. Cr pressed the keys progressively more lightly, but shows a strong initial articulation adaptation. He evidently was not much excited by the situation, he did not become tense, but simply chose the means of adaptation that was of service in the situation and successfully met the conditions at hand. Sixteen improve in efficiency in the latter part of the noise period, and of these only four do not show less muscular tension at the same time, while eleven show an increased breathing ratio and five a decreased. The third columns of each group of records show that most individuals relax after the noises cease. Eleven individuals show a loss in efficiency, nineteen show less muscular tension, and eighteen a smaller breathing ratio, *i. e.*, less articulation. It is possible that inability to relax after a strain would serve as a valuable diagnostic sign. It is perhaps no bad sign for one to be aroused by a situation, but if he can not adjust himself to the return of normal conditions he is wasting valuable energy and may be more likely to break down under unusual situations.

We have cited these cases to show the great variety of responses that are manifested by university students. It is likely that none of these were of the type who could not withstand considerable mental strain; academic training is in itself a good eliminating agent. In a random group of individuals it is certain that we should get even greater variation in response.

It may be thought that intelligence tests would serve the purpose we suggest since they aim to test an individual's reaction to a more or less novel situation; and, as a novel situation would involve additional effort on the part of the subject tested, if he could not exert this effort he would of course fail in the test. This is true in a measure, but in intelligence tests the emphasis is placed upon adjustment to the novel and not upon the cost of the adjustment to the individual. An intelligence test might be of value as a task to be given the subject if a measurement could be made of the amount of strain the solution caused him and whether he recovered from the strain in a reasonable length of time. A measurement of the stress under which one is working is a very difficult and uncertain affair, even in an elaborately controlled experiment, and would certainly not be practicable in the testing of recruits. A more hopeful method would seem to be along the line of making the difference between two situations so vastly different in complexity that it would require a great effort in order to adapt oneself quickly to the one after having worked in the other. This would simply be an extreme of the situation offered in our distraction experiments. An individual who might react to a moderate change in the experimental setting with little or no loss in efficiency in the work at hand might, if the change was severe enough, show a great loss or even a breakdown. The selection of a task which would give an adequate record of efficiency and the creation of two experimental situations differing greatly in their effect upon the task in hand would be the problems to be solved. They do not seem to be beyond solution by any means.

The accounts of the initiatory rites of savages and of earlier civilizations abound in methods of testing the powers of physiological endurance of the young men. They recognized that a body resistant to fatigue and strain was essential to their life of hunting and warfare. Those who could not meet the tests were not allowed to play the part of a man, but were given easier tasks. To-day physiological and medical examinations are made in order to select those with able bodies, but this war has demonstrated that a large part of the strain placed upon the soldier is mental. War is no longer a match of physiological prowess, it is essentially a match of brain power. This makes it essential that we have a means of selecting the mentally hardy to take the leading parts in the conflict. Intelligence tests will probably play the rôle in the mental examination that the physiological test does in the body examination. It is, however, recognized that a medical examination is just as essential or more so than a physiological. If a man is infected with some disease he is eliminated; if he is incipiently or potentially a neurotic he should be eliminated with even greater care. At present psychiatrists have no means of judging who can endure mental strain with impunity, and it seems an opportune time now to discover the means of making such a diagnosis. If no test can be used at present with enough confidence to make a selection of the recruits, tests that look promising could be made on all those examined and the records of those who succumb compared with the records of those who survive the strain. This would give data that would be valuable not only in war time, but also for use in vocational guidance in times of peace. In the event that such a procedure is adopted we trust that tests whose aim will be to eliminate those least able to adapt themselves to situations of unusual mental strain will receive the attention that they deserve in the testing program.

Plan of the University of Pittsburgh.

THE PROGRESS OF SCIENCE

THE PITTSBURGH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE meetings of the American Association for the Advancement of Science and the national scientific societies affiliated with it open at Pittsburgh on December 28. Careful consideration was given to the question of the advisability of holding scientific meetings in time of war. It was the judgment of the officers of the government consulted as well as of scientific men that such a meeting would contribute in important ways to national organization and preparation. A great part of the sessions will be devoted to problems directly concerned with the prosecution of the war and with altered conditions at home due to the war. Research in pure science will also have its place on the program. And this is as it should be, for when peace comes great responsibility will be placed on the scientific men of the United States to maintain the leadership in investigation which will probably have passed to us.

The great industrial city in which the meeting is held typifies the importance of the applications of science in modern life, while the rapid development of its educational and scientific institutions fits this city for a meeting of scientific men. The Carnegie Institute and the Carnegie Technical Schools, the University of Pittsburgh with the Mellon Institute, form a civic center in Pittsburgh admirably suited to the simultaneous meeting of a large number of separate scientific organizations.

The American Association held the last of its regular summer meetings in Pittsburgh in 1902. At that time the Carnegie Institute had been open seven years. The Schools of Applied Science had not been founded and the University of Pittsburgh was a small institution with scattered buildings. Under the directorship of Dr. W. J. Holland, in 1902 as in 1917 chairman of the local committee for the meeting; the institute has enjoyed a rapid development. The Schools of Applied Science have been built and liberally endowed. The University of Pittsburgh in 1908 acquired its present site and has begun the erection of the great group of buildings according to the plans shown in the illustrations. The Mellon Institute of Industrial Research, based by Robert Kennedy Duncan on a plan of industrial fellowships in chemistry representing a new method of education and research, has for about two years occupied its new building erected as a part of the development of the university.

In the course of the fifteen years since the previous Pittsburgh meeting, the association has developed as rapidly as the scientific institutions of Pittsburgh. At the time of the meeting in 1902, there were about 3,500 members, with a registration at the meeting of 435. There are now some 14,000 members of the association, and there will meet with it at Pittsburgh more than twenty national scientific societies which have become affiliated with the association. The meeting at Pittsburgh may not be as large as was the meeting in New York a year ago, when there were some three to four thousand scientific men in attendance, but the programs will certainly be of more than usual interest.

The subject of the address of the retiring president Dr. Charles R. Van Hise, of the University of Wisconsin, will be on the "Economic Effects of the World War in the United States" and many of the discussions before the sections of the association and the special societies will be concerned with problems relating to the national emergency and with national preparedness. The addresses of the chairmen of the sections are:

SECTION A.—Luther P. Eisenhart. The Kinematical Generation of Surfaces.
SECTION B.—Henry A. Bumstead. Present Tendencies in Theoretical Physics.
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THE GEOLOGICAL WORK OF PRESIDENT CHARLES R. VAN HISE

THE address of Dr. Charles R. Van Hise as president of the American Association for the Advancement of Science is on an economic subject. Since his election to the presidency of the University of Wisconsin in 1903, he has devoted himself largely to work in education and in economics, not, however, neglecting the geological researches in which he had attained such high distinction.

Due to Dr. Van Hise's early training in chemistry and metallurgy, and to his field work in pre-Cambrian regions, his dominant interest in geology has been in its chemical and physical phases. For many years he was engaged in the detailed mapping of pre-Cambrian formations in the Lake Superior country, during that time having published, with his associates, seven monographs of the United States Geological Survey. His interest in correlation problems involved in Lake Superior surveys led to a broader consideration of the pre-Cambrian of the United States, the results of which were broght together in a correlation paper (Archean and Algonkian) published in 1892, which was the first attempt to bring some order out of chaos in this field. While the correlations then proposed were based on necessarily incomplete data, and have been superceded in part by later work, his contribution to the subject marked an important step in advance which has been the basis for a great deal of the subsequent work on correlation.

Pre-Cambrian geology is inseparable from structural geology, and Van Hise's development of the principles of structural geology, published in connection with his principles of pre-Cambrian geology (1896), has served as a text on this subject for many years.

Closely involved in a study of the Lake Superior pre-Cambrian is the origin of the copper and iron ores, to which subject Van Hise has made many notable contributions. Enlarging his field studies of ores to cover the lead and zinc ores of the Mississippi Valley and other ores through North America, he was in a position in 1901 to present a general discussion of the genesis of ore bodies ("Some Principles controlling the Deposition of Ores," *Trans. Am. Inst. Min. Engrs.*), in which he emphasized the relationship of ore concentration to the movement of ordinary ground waters, though recognizing other agencies as effective. While more recent studies have modified his conclusions in some particulars, his contribution to the subject remains to-day as probably the best known presentation of this point of view.

In connection with the studies above mentioned, Van Hise found it necessary to consider the problem of metamorphism of rocks, and out of this came his great monograph on metamorphism, in which the subject was for the first time presented systematically and intelligibly to the general geologist. His broad outline of metamorphic zones, conditions and processes has been the basis for much of the development in metamorphic geology which has proceeded since that time.

In the fields of pre-Cambrian correlation, genesis of ores, structural geology and metamorphic geology, Van Hise's contributions have been in each case distinctive in their systematic presentation and perspective. Even where treating previously known subject matter, his vigorous and comprehensive style brought the subject home in such perspective that much of the subsequent work along these lines has been strongly influenced by his work. He drew his pictures with bold, incisive lines, which challenged attention. Some of the salient features of his investigations have been the classification of deformative processes on the basis of zones of rock fracture and rock flowage, the classification of metamorphic processes on the basis of zones of katamorphism and anamorphism, and the emphasis on the normal flowage of underground waters in connection with the concentration of ores. Later studies in all these subjects have required certain modifications of the general principles laid down by Van Hise, but in their broad outlines they still figure largely in the investigations of these fields of geology, and, even where not fully accepted, their influence is felt in the impetus they have given to advancement of knowledge in these fields.

THE COAL SITUATION IN THE UNITED STATES

AT the present time, when the fuel situation forces itself upon the attention of every one, any discussion of the coal problem that goes into the causes of the present unsatisfactory state of affairs should receive a careful hearing. Such a discussion is to be found in a bulletin by Chester G. Gilbert, entitled, "Coal Products: An Object Lesson in Resource Administration," just published by the United States National Museum and constituting the third paper of the series, "The Mineral Industries of the United States," in course of issue by the Division of Mineral Technology of this institution.

The author points out the magnitude of the coal resources of the United States and the dependency of national welfare upon their proper development. Yet with more coal than is found in any other country, or indeed on any other continent, this country has long been dependent upon foreign sources for such essential products made from coal as dyestuffs, fixed nitrogen, and many important drugs; and is today, with the first pinch of war stress, uncertain whether the fuel needs of the American home can be met during the coming month. The American public has never faced these shortages as phases of a single problem, but has first become alarmed at the dye shortage, then over the nitrogen dearth, and now shiver in anticipation of a meagre fuel supply.

To explain the present coal shortage by transportation congestion or labor difficulties is to offer a superficial cause. These dilemmas of course are the concrete means through which the trouble makes itself felt, but back of them stretches a far-reaching failure to work out a proper development for America's greatest resource. The trouble is not that insufficient coal is mined and transported, but that the present output is inadequately used. Our coal could be made to go a third further in meeting the nation's needs.

Progress in coal utilization depends fundamentally upon the production of more coke. At present the situation is limited by the needs of the iron industry. The quantity and type of coke thus far produced has been determined by its metallurgical use. Sporadic attempts to apply metallurgical coke to household purposes have met with failure and placed coke in an unfavorable light. Coke must be made of such kind as to be suitable for domestic use. This can be done; and the accomplishment is an urgent necessity. Domestic coke, in reality, will be artificial anthracite.

There is room in our industrial system for a greatly changed utilization of coal; in short, for "coal" to be used in the form of anthracite, artificial anthracite (domestic coke and steam-engine coke), metallurgical coke, gas for illuminating and power purposes, benzol for automobile engines, and at the same time made to yield a sufficiency of nitrogen, dyestuffs, explosives and other coal-product chemicals. There is present need for all these products. The problem is to make the necessary readjustments, such as may be done through the development of domestic coke, the application of coal-gas to power-plants, the adaptation of benzol to automobile engines, and so on. When this is accomplished, the fuel efficiency of our coal supply will be 25 per cent. greater, transportation difficulties for domestic fuel will be lessened, and in addition the country will be cultivating a wide range of industries, giving employment to labor and using the part now wasted of our most important single resource. These by-product industries growing out of proper coal development will serve to render the nation industrially independent in a great many essentials in agriculture, pharmacy, photography, textiles, disinfectants, explosives, refrigeration, painting, paving, water-proofing, wood preservation, and in an ever-widening circle of requirements.

Such an attainment will require a long process of organized adjusting. It can not be legislated into existence. It is a matter wherein the government can take the lead by shaping a suitable economic policy. It is particularly a matter wherein enlightened public opinion can contribute by appreciating the situation and directing action toward proper industrial coordination and growth.

The solution of the whole coal problem, in short, does not consist in cutting down industrial activities to meet present coal output, nor in circumscribing the scale of economic life to fit present misdirection of coal resources, but lies in working toward an industrial situation that will both permit and demand a widespread treatment of bituminous coal so as to yield on the one hand a smokeless fuel, an artificial anthracite so to speak, suitable alike for the home and the factory; and on the other a host of by-products essential to the industries of the nation.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Franklin P. Mall, professor

JEAN GASTON DARBOUX.

Professor of Mathematics in the University of Paris and permanent secretary of the Paris Academy of Sciences in whose death France loses one of the group who have given that country distinction in mathematics.

of anatomy in the Johns Hopkins University and director of the department of embryology of the Carnegie Institution; of Dr. Richard Weil, professor of experimental medicine in Cornell Medical College; of Professor Edward Hull, F.R.S., late director of the Geological Survey of Ireland; of Mr. W. Duddell, F.R.S., the electrical engineer, and of Professor C. E. Bertrand, the plant-anatomist and paleobotanist of Lille.

Sir J. J. Thomson has been nominated by the council of the Royal Society for reelection as president. Dr. William Gilson Farlow, professor of botany at Harvard University, has been elected a corresponding member of the French Academy of Sciences.—The anniversary address of the New York Academy of Medicine was delivered on November 15 by Dr. Henry Fairfield Osborn, LL.D., president of the American Museum of Natural History, on "The origin and nature of life."

A special board of chemists to investigate explosives, the uses of gases in warfare and to act as advisers to the Bureau of Mines, has been appointed. The board will study the problem of increasing the production of materials used in explosives manufacture and will advise the bureau in the operation of the recently enacted law regulating the sale of explosives. The members are: Dr. William H. Nichols, of the General Chemical Company, New York, chairman; Professor H. P. Talbot, head of the chemical department of the Massachusetts Institute of Technology; William Hoskins, of Chicago, a consulting chemist; Professor H. P. Venable, of the University of North Carolina; Professor E. C. Franklin, of Stanford University, and Dr. Charles L. Parsons, of the Bureau of Mines.

THE SCIENTIFIC MONTHLY

FEBRUARY, 1918

WEATHER CONTROLS OVER THE FIGHTING IN THE ITALIAN WAR ZONE

By Professor ROBERT DE C. WARD

HARVARD UNIVERSITY

SO obvious have been the weather controls over military operations in the present war, that even the layman has not failed to note the importance of this factor in the course of his reading of the war news in his daily paper. In every-day conversation mention has often been made of the rain and the mud in Flanders; of the heat and drought of Mesopotamia; of the snowstorms of the Trentino; of the hazy spells usually selected by the Germans for their air-raids on England. The subject is one which merits careful study. It has an interest as a matter of historical record. But it also has a very immediate and a very practical side. By means of daily weather forecasts, such as are now being made by the expert meteorologists on all the war fronts, the military commanders are often able to plan operations in such a way as to take advantage of weather conditions favorable to their purposes, and, at least to some extent, to guard against those conditions which are hostile. Again, a knowledge of the climate and weather of the different war zones, and the experience which the armies have already had with them, may be of immense benefit to us, now that American troops are already on the firing-line on the western front and may soon also be engaged on other fronts. For our military tactics; the clothing and equipment of our troops; the whole matter of our transport; the organization of our aviation service, all depend, far more directly than most people realize, upon the weather. With the matter of daily forecasts, the present paper is not concerned. What is here attempted is to bring together such meteorological facts and controls, from one of the most interesting of all the war zones, as may help in an understanding of the campaign in that area up to this time, and may, if American troops are sent there, be of practical service.

In the matter of meteorological interest, the most dramatic fighting thus far during the war has taken place in the mountains. In the earlier months of the war, the Russians against the Teutonic allies in the Carpathians; somewhat later, the Russians against the Turks in the Caucasus and on the highlands of Asia Minor; and, since the spring and summer of 1915, the Italians against the Austrians and now against the Germans, in the Alps, have had the hardest fighting against weather conditions. Because of the present interest in the Italian war situation, the present paper will deal with some of the larger and more striking weather controls in that particular area.

There are three subdivisions, climatic as well as topographic, of the Italian war zone: the Alps of the Trentino, the Carso plateau in the east, and the northern lowland. Of these, the Alpine section has been the scene of the longest fighting, and also presents the most striking meteorological controls. It is, therefore, here first considered. No other part of the Great War has been fought for so many months under equal conditions of hardship. Nowhere else has the struggle between man and man been accompanied by so continuous a struggle between man and nature.

The Alpine complex lies as a barrier between the climates of northern and western Europe, with their relatively mild winters, moderate summers, and rainfall fairly well distributed throughout the year, and the Mediterranean province on the south. The latter, because of its irregularity of outline, vertical as well as horizontal, has many varieties of climate, all relatively mild, except at higher elevations, and with winter rains over most of the area. Owing to the great diversity of Alpine topography, it is impossible to give any detailed description of the climates of the peaks, the slopes and the valleys. Moreover, sufficient meteorological records are lacking for such a presentation. In any such varied topography, temperature, humidity, cloudiness, rainfall, snowfall, winds, are so largely controlled by local conditions of altitude, of exposure, of the immediate surroundings, that every place has, in a sense, its own climate. The effect of altitude upon temperature is often offset by the control due to topography or to exposure. The severe winter cold of the deep valleys during clear, calm spells seems less unbearable than higher temperatures, accompanied by furious gales, on the mountain peaks and upper slopes. Thus, while a detailed description of climates is out of the question, it is also true that a generalized account must be very broad. This much may be said: High mountains mean cold and snow, even in summer. They mean more clouds and rain and thunderstorms than the lowlands have. They mean more wind; more violent storms; deeper snows; a harder struggle against the elements. Severe, indeed terribly severe, have been the meteorological handicaps in that mountainous country where fighting has been going on in the clouds, amidst ice, and deep snows, and avalanches.

The war in the Alpine sector began in the warmer months of 1915. Yet even in that milder and more peaceful season of the year, weather controls at once played their part. Late spring and mid-autumn are times of frequent and heavy rainfall in that region. Hence swollen rivers, flooded passes, deep mud, "bad weather," were to be expected and were experienced, even in summer. Over and over again, heavy rains and "fog" checked the fighting. These "fogs," often mentioned in the despatches, are doubtless in most cases not real fogs, which lie on the ground, but clouds, for much of the fighting has taken place at altitudes well within the cloud zone. Such "fogs" often interfered with artillery firing and with aeroplane observation, but were several times taken advantage of, by one side or the other, for making surprise attacks. Summer lightning played among the troops fighting on the rocky mountain-sides. Torrential downpours swept the passes and temporarily stopped engagements. Hail beat in the faces of the men as they charged up the steep slopes. In view of the well-recognized importance of snow in the later (autumn-winter, 1917) developments along this Alpine front, it is worth noting what the conditions were earlier in the campaign. June 21, 1915, a despatch from Brescia noted the occurrence of a heavy snowstorm on Monte Altissimo, with temperatures below zero (C.). The despatches of June 24 mentioned that there were more than 2 feet of snow on the lofty Stelvio pass, where spirited fighting was going on. On July 1, 1915, it was reported that "the mountaineers (Tyrol) do not remember a season when there has been so much snow on the heights on July 1. The mountain streams, which are usually dry at the end of June, are now deep and almost impassable. The Italian troops are encountering snowstorms and thick fogs, which have interfered with long-range firing." Snowfalls toward the end of September, 1915, checked the fighting.

The two winter campaigns (1915–16, 1916–17) in the Alps brought, as was to be expected, snows many feet deep; howling gales, avalanches, and bitter cold. Under such conditions large-scale operations were not possible. Many precautions had to be taken. Snowshoes and skis, extra-heavy clothing, blankets, fur chest protectors and sleeping-bags, and foot-warmers were supplied. White coverings were worn for protection amidst the snows. To supply the troops with warm clothing, offices were opened in the Italian cities, where furs of all kinds were brought in to be made into winter garments. Provisions were assembled in specially-constructed weatherproof huts. The shelters for the men were fitted with stoves. The trenches were lined with straw and boards. Special arrangements were made for supplying hot rations to the troops. Galleries dug under the snow were several times used as a means of approaching the enemy's trenches. In spite of all precautions, hundreds of the troops were invalided home with hands and feet frostbitten.

After the remarkable Teutonic offensive, in mid-autumn, 1917, which brought the Austro-German troops down on to the plains of northern Italy and for a time seriously threatened Venice, military operations were suddenly and most aggressively renewed in the Trentino sector, chiefly in the region of the Asiago plateau. The enemy made desperate attempts to capture the mountain positions and to penetrate on to the lowlands, in order to turn the Italian left flank and thus make the Piave line untenable before winter should make such a task impossible because of snow-blockades in the mountains. Once again the terrible winter weather of that rugged country played its part in the fighting. The Teutonic advance began "in driving snow, and cold, and pouring rain" (second week, November, 1917). The official and other despatches mention bitter cold (November 27, 14° F.) ; lack of shelter owing to the terrific artillery action and the constant shifting of positions; insufficient supplies of water; drifting (though light) snow; biting winds; the use of caves "from which hung huge icicles" for shelter. One account notes the fact that the Italians were often "compelled to remain motionless for a long time lest they should be discovered by the enemy against the whiteness of the snow."

That the coming on of winter at once, and in full vigor, with deep snows, and raging "blizzards," would have been the best possible ally to the Italians, was well recognized by all the military commanders. For in normal winter weather, the Teutonic lines of communication both by railroad and also by the narrow mountain roads, would be paralyzed, or at least badly blocked, and the transport of heavy artillery, of munitions and of supplies would become difficult or impossible. Each additional day that the Italians were able to delay the advance of the Austro-German armies brought winter's help one day nearer. Each day made the Teutonic offensive more difficult. It is, therefore, easy to understand why the enemy's general staff was ready to make such continuous and desperate attempts to break through before the worst of the winter weather should come on. The fighting was against time. A winter campaign on the lowlands is far more practicable than in the mountains, owing to milder weather, and little snow. From numerous reports, coming from various sources, it is clear that the early part of the present winter (1917) was unusually favorable to the enemy. It was cold, but usually clear, and the heavy snowstorms characteristic of the late fall and early winter were entirely lacking. The snow, instead of being several (5–10) feet deep in the mountains, as it was a year ago in November and early December, was (up to mid-December) only a few inches deep in most places. A despatch of December 6 said that one deep snowfall "would be worth divisions to the Italians." Gen. Diaz said on December 9, "with normal winter conditions prevailing in the north, the enemy would now be in the grip of impassable snows." Small wonder is it that the Italians prayed for snow in the mountains; and for an end of what they termed "Austrian weather" which they felt had lasted from the first day of the retreat from the Isonzo front. Light snows fell from time to time, but the long-hoped-for deep snows did not come. It is always natural that man should overestimate, or underestimate, the extent of meteorological conditions which are helping or hindering him in warfare. Hence it is both interesting in the present survey, and as a matter of historical record, to give here an Associated Press despatch, dated Italian Army Headquarters in Northern Italy, December 25, which gives, on the authority of an Italian meteorological expert, the actual conditions as to the meteorological characteristics of the early winter of 1917.[1]

The entire mountain region, where heavy fighting has been going on in recent days, is having the unusual experience of a holiday season with green slopes and summits and little or no snow. One of the generals on the front said that every foot of snow was worth divisions in obstructing the enemy.

"This is one of the mildest winters we have ever had," said the major in charge of the weather branch of the high command, "and from a military standpoint the weather conditions are of the highest importance both for our troops and, particularly, in their effect on the enemy's transportation of supplies and troops."

Taking the report furnished by the high command to-day on the

[1] The special meteorological service organized in connection with the Italian military staff has already published several bulletins dealing with military meteorology. Among the subjects so far considered are the climates of the various districts within the war zone, also details regarding avalanches, with lists of places especially subject to them.

weather at all vital points, the major pointed out the extreme variation in the mountains, plains and valleys.

Here at headquarters the report showed two degrees above zero Centigrade (35.6° Fahrenheit) and no snow, while the same report showed —15° Centigrade (5° Fahrenheit), and seven feet of snow in the Ortler Alps.

Further east, in the Adamello Alps, which are the next highest to the Ortler, there are about three feet of snow as compared with nine feet last year.

Around Lake Garda the condition is much milder. Monte Pasubio, where the Austrians made their big drive last year, now has four feet of snow, as against twelve feet last winter. But all these snow-covered points are in the active military region for the present.

The entire area of the present fighting in the Brenta valley is free from snow and the weather is mild. This is the valley where the Austrian route brings supplies and troops from Trent and the Asiago and Brenta fronts. Between the Brenta and the Piave rivers, which is the principal region of the fighting, Monte Grappa, which usually has four to six feet of snow, now has only ten to twelve inches on the northern slopes and six inches on the southern slopes. The temperature is from —5° to —12° Centigrade (23° to 10.4° Fahrenheit).

Montes Asolone, Pertica and Bolarolo, where the heaviest fighting has occurred in the last few days, have only a few inches. It varies from three to five inches and seldom lasts, owing to the mildness. In the foothills there is no snow and the temperature is always above freezing.

The reports show similar mild conditions in the Carso and the Julian ranges to the east, through which the Austrians maintain their communications with the invaded regions of eastern Venetia. The mildness is so pronounced that the enemy is able to operate four distinct lines of communication leading to Gorizia, Udine and Venetia.

The unusual weather conditions are proving an important factor in the campaign, for while severe cold and heavy snows would hold the enemy in their grip, the present mild and almost snowless season permits operations to proceed.

Late in December (31st), the despatches noted the fact that enough snow had fallen to make transportation difficult.

One larger consequence of a slackening of operations in the Trentino sector may be mentioned. Heavy snows there would doubtless mean the transfer of large numbers of Austro-German troops to the western front, to the lowlands, or, in case of an Allied attack on Pola, to that section.

The other portions of the Italian war area, the plateaus (Carso, Bainsizza) in the northeast and the eastern portion of the northern Italian lowland, may, in conclusion, be considered together. For the general temperature conditions of the plateau, the records of three stations, grouped together, at an average elevation of 1,700 feet may be noted. These have a midwinter (January) mean of 30°; a midsummer (July) mean of 66.7°, and an annual mean of 48.4°. Their *average* lowest temperatures in winter are 5.4°; their *average* highest temperatures in summer are 84.4°, although in any single year the minima and maxima are likely to vary several degrees lower or higher. For purposes of comparison, Laibach and Trieste may be added.[2]

In winter, the plateau is noticeably colder than the immediate coast, and cold northerly winds are very apt to blow from the interior down to the northern shores of the Adriatic.

Trieste has a mean annual rainfall of 42.83 inches, with an average of 109 rainy days, the rainiest months being June and October; and the driest, December to April and July–August. Göritz has a mean annual rainfall of 63.50 inches; 139 rainy days; maxima in June and October, and minimum in January and February.

More or less fighting has been in progress on the Carso plateau since Italy entered the war. Here, in the late summer and autumn of 1915, the men suffered from the heat, even in their light gray cotton uniforms, and later the general cold-season storms of that region, and the fogs, often interfered with military operations. The time for the great main Italian offensive, about the middle of May, 1917, seems to have been chosen between floods on the Isonzo River. The troops were able to cross on pontoons. Usually at this season the river is practically impassable except on fixed bridges, for this is the time when the spring rains and melting snows in the Carnic Alps cause the rivers to flood. The passage of the Isonzo was forced in a heavy fog. Italy's strong offensive on the Carso plateau could not be begun any earlier on account of "terrible atmospheric conditions." Great difficulty was experienced because of lack of water on this dry plateau. Each day, according to one despatch, 450,000 quarts of drinking water were carried up to the thirsty men. Temporary relief, both in supplying water and in limiting military operations, resulted from thunderstorms and occasional general rains. Early in July (10th) the Austrians began a night attack, on the Vodice, in a violent thunderstorm. In the darkness the enemy had almost reached the Italian positions when a sudden flash of lightning revealed the attacking party, which was completely repulsed. Stifling heat was reported late in August. It is worthy of note that the southern soldiers of Gen. Cadorna's army were espe-

	Laibach	Trieste
[2] January	27.5°	37.8°
July	67.3°	73.6°
Year	48.2°	55.2°
Mean min.	—0.4°	19.6°
Mean max.	88.7°	93.9°

The warmer winters of the coast are clearly indicated.

cially mentioned for their valor and fighting abilities during the conquest of Monte Santo. Gen Cadorna evidently pushed his troops to the utmost in order to smash the Austrian armies and to gain as much territory as possible before winter should make large-scale operations impossible. There were signs, also, that Italy was preparing for a winter campaign against Trieste when operations could no longer be continued farther north. There were two classes of difficulties, both directly or indirectly climatic, which added greatly to the already seemingly impossible task of the Italian armies. One of these was the problem of supplying water to the men who were fighting on the dry plateaus and on the mountain slopes far above the rivers. Until pipe-lines could be laid, water was carried up, in small quantities, on the backs of men, to the thirsty soldiers who could often look down, thousands of feet, on to the rivers running in flood far below them. The other difficulty was the stormy autumn weather. Heavy rains changed peaceful streams into raging torrents. Fogs and mists interfered with visibility. Increasing cold added to the discomfort and suffering.

The great Austro-German offensive began in the last week of October. The Italian front lines were broken through (October 24) "in a drenching rain and mist, under the most depressing conditions," which rendered the Italian barrage ineffective in opposing the onslaught. As one correspondent put it, "Austria is hiding behind the skirts of autumn." The Italian mountain positions "were surrounded and made untenable before the fog lifted." The use of deadly gases was favored by a light wind and the damp air. Several days of stormy weather were followed by a fine spell, which favored a rapid advance on the part of the Teutonic troops, across the mountains and through the valleys. During the earlier stages of their retreat, the Italians suffered greatly from cold torrential rains. Much interest centered in the stages of the Italian rivers. It appears that, while the heavy rains added to the difficulties of the hurried Italian retreat, they also delayed the enemy's advance, by swelling the rivers, softening the ground, and preventing effective reconnaissance and bombing on the part of the enemy aviators. The reports regarding the condition of the Tagliamento, the Livenza and the Piave rivers were very contradictory. These are not broad, deep and swiftly-flowing streams, always difficult to cross, but vary greatly according to the rains, becoming shallow during fine spells. Apparently at times the invaders were favored, and at other times the defenders. On the whole, the balance seems to have been in favor of the Teutonic troops. The Piave was reported as flowing with a full head of water in mid-November, owing to recent heavy rains. These same rains helped to flood the lowlands. The sector of the lower Piave was further rendered difficult to cross by the release of the flood-waters through the opening, by Italian engineers, of the dikes, so that a considerable area to the north of Venice was several feet under water. On December 13 a report noted the occurrence of "downpours" during two days, filling the Piave which had nearly "run dry," and effectively flooding the inundated section over which the waters had fallen from 5 ft. to 1 ft. Taking advantage of this low water, the Austrians had made an advance. The high and low stages of these rivers have been a constantly fluctuating factor in military operations on their banks.

The larger climatic characteristics of the Italian lowland, across which the battle-front now stretches, are well shown in the excellent meteorological records which have for years been kept at several of the larger cities. Thus, Venice, Vicenza and Padua have midwinter (January) mean temperatures of about 35°, midsummer (July) means of about 75°, and mean annual temperatures of about 55°. Venice has the highest values (1.5° to 2° F.) in each case. The absolute minima have been between 7° and 15°; the absolute maxima, between 95° and 100°. Belluno, at about 1,300 ft., has slightly colder winters (30.2°), somewhat cooler summers (69.3°), and a lower mean annual, 50.9°. Its lowest reading is 4° (3.9°) and its highest nearly 100° (99.7°). "Mediterranean" climates are as a whole distinguished by comparatively moderate rainfalls, and by dry summers. These stations on the northern Italian lowland, however, have a somewhat different rainfall distribution. They are alike in having a minimum in the winter, and maxima in spring (May) and autumn (October). The amounts vary as follows: Belluno, 50.67 inches; Vicenza, 47.56 inches; Padua, 33.70 inches; Venice, 29.53 inches. In addition, Udine has a mean annual of 60.94 inches; 145 rainy days; maxima in June and October, and minimum in January–March. In the Venetian Alps the rainfall is much heavier. The number of rainy days is between 100 and 125; the probability of rain usually being greatest in May and October, and least in August.

Northern Italy is on the track followed by storms coming, in winter, from the Gulf of Genoa or from the western and southern Mediterranean, and moving in an easterly or northeasterly direction. These storms bring general rains, and occasionally snow. Snow is, however, infrequent, as is seen by the record of an average of days with snow, as follows: Venice, 2.0; Vicenza, 3.9; Udine, 4.3; Padua, 4.7; Trieste, 6.5.

PARASITES IN WAR TIME

By Dr. MAURICE C. HALL
RESEARCH LABORATORY, PARKE, DAVIS & CO., DETROIT, MICH.

PARASITES, always of major importance in tropical countries and of considerable importance in the temperate zones, take on increased importance with the onset of war. In a general way this is due to two factors. In the field of human medicine it is due to the fact that the sanitary and hygienic provisions of armies in the field can not maintain the high level attained in peace times among civilian and soldier elements of the population, while the throwing together of persons of the most diverse habits of cleanliness and regard for personal condition, under such unfavorable circumstances, affords a chance for the spread of such parasitic pests as would under ordinary conditions be confined to those who were habitually careless or unmindful of these pests, or who were exposed to them by virtue of geographical or environmental conditions. In the field of veterinary medicine, the increased importance of parasites is due, not only to the spread of parasitic diseases among horses purchased all over the country and brought together on the picket line, but also to the fact that present-day war conditions call for the conservation of all resources, especially food and factors in food production, and for the elimination of losses from parasites which in peace times may be ignored as matters concerning only the individual who sustains the loss, but which in war times must be regarded as subtractions from a relatively limited and highly necessary sum total of the common possessions of the nation, the loss of which ranks with losses in battle as factors in defeating our armies and the ends for which they fight.

In the field of human medicine, there are two problems: The immediate problem is the control of parasitic diseases and the diseases, bacterial or otherwise, associated with the parasites; the remote problem will concern itself with preventing the importation into this or other countries heretofore free from them, of the various exotic diseases with which soldiers may be brought in contact by association with troops brought from tropical and semi-tropical regions where these diseases are prevalent.

Among the parasites of man that deserve mention, lice should be regarded as of first importance. Wherever men are thrown in close physical contact in the trenches and dug-outs and in crowded billets in the wrecked structures still standing in the vicinity of the contested areas in France, there is ample opportunity for the spread and multiplication of these annoying and dangerous parasites. Leiper has referred to these pests as the "minor horrors of war," and they are not peculiar to present-day trench warfare. The world's wars have regularly been fought by lice-infested soldiers. In our Civil War lice were familiarly known among the soldiers as "graybacks" and anecdotes of that conflict commonly deal with these ubiquitous insects. It is said that General Mott once stopped in a walk through a camp to observe with interest the close investigations that Private Lindaberry was conducting along the seams of his shirt. "Are you picking them out?" he asked. "No, sir," was the reply, "I'm taking them as they come." It might be noted in passing that this method of hand-picking, elsewhere applied to the eradication of the cattle-tick and the boll-weevil, is still used as a practical means of control for lice in the present war—a palliative, if not entirely remedial, measure. As an illustration of the utility of applied entomology in this connection may be noted the practise of placing lousy garments on ant hills, which is said to result in the careful removal of the lice by the ants. This is not a particularly valuable or widely applicable method, of course, but the purely entomological aspects of louse control are so important that Vaughan has recommended that entomologists versed in medical entomology be attached to our army units.

Louse control, however, calls for a knowledge of more than entomology. It presents large problems in therapeutics, the therapeutic agents employed being primarily insecticides within the field of medical rather than entomological science. Over two hundred insecticides (and substances suspected, often on very little evidence, of being insecticides) have been tested since the outbreak of war, and the large literature dealing with this topic which has appeared since 1914 is still in poorly digested condition, with varying and often conflicting claims for the same insecticides. However, experience has established beyond question the value of kerosene and gasoline in controling lice, as these substances kill both the lice and the eggs, or "nits," very quickly. In some instances, companies of men have been stripped and thoroughly sprayed with these substances, with excellent results in controlling the trouble and with but little personal discomfort on the part of the men. As regards ointments for individual use, ordinary petrolatum (vaseline, cosmoline, etc.) has been found quite effective and is rated by Castellani with kerosene or gasoline as among the most effective insecticides. For the most part, however, the clothes louse, or body louse, the most important of the lice attacking man, lives in the clothing, especially in the seams, and must be killed here. For this purpose dry heat affords a very satisfactory control measure, an adequate heat resulting in the coagulation and desiccation of the protoplasm of the louse and its egg. In addition to sprays, applications and heat, there is quite a range of supposedly valuable remedial and preventive measures, including sachets of various designs and contents, muslin underwear impregnated with sulphur and naphthaline, body cords smeared with mercurial ointment and worn about the waist, ordinary soap-and-water cleanliness—and even chiropractic measures have been advocated. It appears that the correct chiropractic procedure, according to the publication cited, involves an adjustment of the first lumbar vertebra, but offhand it would appear better to confine manual manipulation to hand-picking or else apply the pressure to the lumbar region of the louse rather than to that of the patient.

The importance of lice is due less to their own irritating activities as blood-suckers than to the fact that they carry the dreaded typhus fever germs; the prevention of typhus is lice control. This is a menace to which our army is now and will be exposed. It is impossible to raise large armies without including louse-infested individuals, and Vaughan notes that we had such individuals in our army on the Texas border, though there was no exposure to typhus. But since lice are a menace and freedom from lice a defense in the presence of typhus, our medical corps will need to devote considerable attention to delousing measures for the protection of our troops.

Another parasite which attacks from the outside is the itch mite, the cause of itch, or scabies. This little relative of the spiders burrows in the skin, causing an itching sensation, and the fingers of the victim, in an effort to relieve the itching, complete the job of producing sores and scabs. An interesting bit of news from the front in this connection is to the effect that soldiers suffering from this distressing complaint have been cured by exposure to chlorine gas during gas attacks by the Germans. Subsequently the proposal has been made to clear out certain insect pests in valley lands by the use of heavy poison gases as an agricultural measure.

The numerous biting flies and mosquitoes frequently find exceptionally favorable opportunities for breeding in war areas where remedial measures, such as oiling bodies of water or draining them to prevent mosquito breeding, can not be applied to the contested No-Man's Land. Trench-helmets are no protection from these flying projectiles, though a gas-mask might be! Perhaps even more favorable are the opportunities for the breeding of the numerous non-biting flies which live as maggots in dead bodies of horses, other stock and of men. Many of these maggots readily adapt themselves to life in wounds and in the summer or in the more tropical war zones, infestation of wounded and sick men with these maggots becomes a rather common and often serious complication. It is rather surprising to find, however, a statement from a medical officer in the war zone to the effect that gas gangrene, one of the most serious conditions encountered in this war, rarely appears in wounds infested with maggots.

Among the worm parasites, hookworms deserve especial consideration in this country, since a large part of our army comes from the hookworm-infested sections of the South. Stiles has already called attention to the occurrence of hookworm disease found among our soldiers from the South and urged the desirability of detecting such cases and using the appropriate anthelmintic treatment to rid these men of their parasites. The importance of this action is fairly evident. Hookworm disease results in anemia, lassitude and inertia, and the task of overthrowing Prussian militarism and the armed application of Pan-Germanic philosophy can not properly be regarded as a task for anemic and inert troops. The examination of soldiers for hookworm disease would incidentally disclose other parasitic infestations. Hookworm disease is contracted commonly by the invasion of the skin by the larvæ, which develop from hookworm eggs in the excreta of hookworm subjects, and trench conditions afford uncommonly favorable conditions for the spread of this disease. It is true that adequate measures are taken for the disposal of excreta under most of the working conditions of the present war, but there are many extraordinary conditions under which these measures can not be taken, and in spite of the care and authority of medical officers there are always men who neglect or ignore the provisions made for the common safety and welfare. And it is precisely the men accustomed to the lack of sanitary provisions in infected rural communities who might most easily fail to appreciate the value of these provisions under the stress of war conditions. Another aspect of the matter is this: This continent is practically free from the Old World hookworm, *Ancylostoma*, but so is Europe practically free from our Afro-American hookworm, *Necator;* while we would not be grateful for an importation of *Ancylostoma* in returning troops, neither would our allies approve a dissemination of *Necator* by our soldiers abroad.

Among the worm parasites, *Strongyloides,* a worm associated with a diarrhea, has a peculiar interest. This parasite also occurs in this country and Stiles has recently recommended that soldiers so infested be discharged, for the reason that no satisfactory treatment for this condition is known. In view of the lack of a known dependable treatment and the disability due to the disease, this is good advice—but may we now expect our slackers to seek an infestation with *Strongyloides* to escape army service?

The same difficulties in sanitation that make the acquirement of hookworm infestation easy make it easy to acquire *Strongyloides* or the other common intestinal parasites, such as ascarids, whipworms and pinworms. It may also be found that infestation with the dwarf tapeworm, *Hymenolepis nana,* the commonest tapeworm parasite of man in this country, will spread in the war zone. Reports state that the trenches swarm with rats, and as this tapeworm appears to be normally a parasite of rats, occurring in man as a result of the contamination of food-stuffs by these enemies of mankind, it is conceivable that this worm will need attention.

Rats, however, have an importance in connection with disease which exceeds their importance as carriers of the dwarf tapeworm. They are the reservoirs of the dreaded bubonic plague and the rat fleas commonly present on them are the habitual transmitters of the disease from rat to rat and from rat to man. Should plague-infested rats appear among those in the trenches, practically any measures for combating the rats would be justified and the campaign against the Central Powers would have to be subordinated to a rat-killing campaign in which the use of poison gases would probably be a weapon of major importance in destroying rats and fleas alike.

The conditions of present-day warfare also afford opportunity for the spread of disease, characterized in part by diarrhea, due to amebic and flagellate protozoa. These minute organisms may be spread rather directly from the excreta or carried from the excreta by flies. These diseases are already present on some fronts and are receiving a considerable amount of investigation along the lines of preventive measures and treatment.

The more remote activities of our medical corps in preventing the importation of exotic diseases of a parasitic nature may only receive brief mention here. Such diseases as coccidiosis, a protozoan disease, occurring in the Balkans and elsewhere, are not known to occur in man on this continent, nor is bilharziasis, a disease occurring, among other places, in Egypt. In the latter disease, worms may occur in the blood vessels of the lower bowel or of the urinary bladder, causing an inflammation and hemorrhage of these organs as a result of the passage of their eggs through the tissues. The list of parasites of man not known to occur in this country and known to occur in some of the widely distributed war areas is a long one, but it is unnecessary to enumerate. Our medical corps can be depended on to take the necessary measures to prevent our troops from becoming infested and to provide proper treatment or adequate quarantine for those who by carelessness or inadvertence become infected.

In this connection it might be noted that war conditions call for new investigations in the field of anthelmintic treatments for worms. Along with the cessation of importation of other drugs due to the war, the supply of thymol, the drug commonly in use in this country before this war for the treatment of hookworm disease, was shut off, with the result that a superior remedy, of American origin, oil of chenopodium, has come into general use. The plant from which this remedy is obtained is one that was used by the Indians before Columbus discovered America and has been used as a home remedy and by the Southern "mammies" for many years, but it required a war, with its stoppage of commerce, to bring about a high degree of interest in this American product.

In the field of veterinary medicine, as has been noted, there is ample opportunity for work in controlling parasitic diseases among horses in the army and in preventing enormous losses to our live-stock industry by eradicating parasites. Of major importance are such diseases as Texas fever of Southern cattle, a disease caused by a protozoan parasite in the blood and carried by an external parasite, the cattle tick; scabies in cattle, sheep and horses, due to mites closely related to those causing itch or scabies in man; stomach-worm disease of sheep, due to a blood-sucking worm; and "worms" in pigs. Other parasites which do much to swell the grand total of losses are the various lice, true ticks and so-called ticks, and other biters and bloodsuckers which live on our stock, and the lungworms, hookworms, palisade worms, tapeworms and flukes which live in them.

The increasingly successful campaign against the cattle tick which carries Texas fever is an epic in the warfare of veterinary medicine against disease. It is a warfare in which the names of great leaders, executives and laboratory men stand out conspicuously, men from the U. S. Bureau of Animal Industry and from the experiment stations of the Southern states. In a warfare as real and as systematic as the conflict of militarism and democracy, the tick has been attacked from a quarantine line that once extended rather directly across the United States from Virginia to California and from this far-flung battle-line the tick has been driven toward the Gulf of Mexico from county to county and state to state. Wedges have been driven into the line and the tick forces have been split by drives down the Mississippi River states. Recently, December 1st, the entire state of Mississippi was released from quarantine and the governor designated the day of release as a day of rejoicing to celebrate the event. In the general order releasing this state a total of over 65,000 square miles was released. At first the campaign against the tick was a scientific problem, the study of the foe's weaknesses, habits and life history and the development of offensive and defensive weapons. This problem was presently solved; suitable dips to be readily applied by swimming the cattle through a dipping vat furnished the weapons with which to begin an offensive. The quarantine line blockaded the enemy and kept the tick from fresh supplies of food among the Northern cattle. The problem then became one in diplomacy. At favorable points the tick was able to make a stand with the aid of strong allies, uninformed, misinformed or hostile individual stockmen who objected to dipping, who met the inspectors with a club or a shotgun. It is a striking feature of this phase of the tick-eradication campaign that men trained only as veterinarians should have acquitted themselves so admirably in such delicate and dangerous situations. With a minimum amount of actual clash and combat, this opposition was overcome by argument, persuasion and friendly discussion. There is little of this opposition remaining, the task is more than half completed, and the work yet undone is hastening to a conclusion. The time is fast approaching when through the cooperation of the federal and state authorities the last tick will be dipped or collected as a museum specimen, or whatever is appropriate for a last tick, and the tick and Texas fever will become extinct in this country. Already the slogan is "A tick-free South in 1921." When that time comes, the South, with its abundance of feed, rich soil, abundant rainfall and long-growing periods for crops, will take over a large part of the live-stock industry of this country. Were the tick eradicated right now, in this fourth year of the great war, it would immensely strengthen the hands of this country in coping with the problem of meat supply during that war. The annual losses attributed to the presence of the tick are estimated at $50,000,000, a loss of meat and leather that is especially hard to contemplate at this time. The cattle tick is a very real enemy that deserves to rank in destructiveness, if not in wilful *Schrecklichkeit*, with the invaders of Belgium and the destroyers of the *Lusitania*.

While the campaign against the cattle tick has been pressed in the South, the drive against sheep and cattle scabies in the West has pushed on until the objectives have been almost attained. These diseases have cost this country dearly, and at one time sheep scab was the terror of the Western sheepman. At the present time the only terrain still held by the enemy is in California and Texas, where there is still some sheep scab. Cattle scabies has been practically exterminated over the one and a quarter million square miles first quarantined. The saving in wool, leather, mutton and beef, all unusually valuable in these days of war, constitutes an indemnity that repays us many times for the outlay which it has cost to prosecute this campaign.

Unfortunately, the report with regard to another enemy of our live-stock, the stomach worm of sheep, is not so cheerful. Sheep suffer little from bacterial diseases and are immune to tuberculosis, but they are attacked by numerous animal parasites and by an ally of the parasites, the sheep-killing dog. The ownerless cur and the uncontrolled sheep-killer stand with the stomach worm in opposition to the sheep and mankind and are at this time nullifying much of our efforts at conservation by their attacks upon the mutton and wool supply of this nation. There are medicinal treatments and preventive measures of great value in controlling stomach-worm disease, but these measures are not generally known and used to anything like the extent they should be. It would perhaps be well for the federal and state agricultural authorities to send well-informed men into communities where sheep were kept, to explain and demonstrate these methods. As for the sheep-killing dogs, they should be placed by law beyond protection and made the legitimate prey of any one who can find the time to shoot them or otherwise remove these parasites of the sheep industry.

The big ascarid worms of pigs are another constant source of loss to our live-stock industry, and are especially severe in their effects on young animals, a general truth in regard to parasites. The U. S. Department of Agriculture has on a number of occasions urged the use of oil of chenopodium against these worms, and it is to be hoped that adequate measures of treatment will be used during the coming year, to aid in conserving our swine industry with its fat supply, which Germany found so suddenly and extremely valuable after her ill-advised slaughter of a large part of her swine to conserve food they might eat. There is at present a desire to control worm infestation in swine by the use of such procedures as feeding mineral mixtures of various sorts and various stock feeds. Such preparations may have value in furnishing mineral constituents to swine or in improving their appetites, but if they have anthelmintic value the writer is unaware of it and has not found it experimentally. Such preparations, if aimed at parasites, are ammunition wasted.

The numerous external parasites of stock can be, and decidedly should be, controlled by dipping, and there is no lack of suitable dips. Some of the internal parasites can be controlled by appropriate medication, whereas others need much more study, never more necessary than now.

Our newly reorganized Army Veterinary Corps will find ample occasion to recognize the importance of parasites in war times when they are compelled to cope with mange in cavalry, artillery and transport horses. At times certain stations in the French army have had as high as 60 per cent. of their horses disabled with this disease, and its control is not a simple matter. The presence of large numbers of lice on these horses will demand attention. Worm infestations in horses often occasion damage of a serious character, with the complication that these infestations are not readily recognized. That our veterinary corps will prove capable of coping with these conditions can not be doubted. The veterinary corps of the armies of the Allies and of the Central Powers have met the problems of modern warfare with the ready development of practical field measures, supplemented by research where necessary, and in the doing of this have been the recipients of numerous citations and decorations for conspicuous bravery under fire. The veterinary corps of the United States Army is calling into the service numerous veterinarians from private life to assist the small corps of veterinarians heretofore attached to our correspondingly small regular army, and in the development of practical and ingenious measures for meeting emergencies the American veterinarian will show himself second to none.

In attacking the problems of parasite control in war times, this country is fortunate in commanding the services of many able helminthologists, protozoologists and entomologists. There already are in the government service a number of these men, among whom might be mentioned Ashford and Craig in the army, Stitt in the navy, Stiles in the Public Health Service, Ransom in the Bureau of Animal Industry, Cobb in the Bureau of Plant Industry, and Howard, Hunter, Knab and Bishopp in the Bureau of Entomology and the Division of Insects of the U. S. National Museum. In addition there are many able and well-known men associated with these. Other men who may be drawn on are associated with such institutions as the Harvard School of Tropical Medicine, the Tulane School of Tropical Medicine, and the Rockefeller Foundation, while numerous other workers in these lines are scattered throughout the country. And we can count upon the assistance and co-operation of the numerous and able parasitologists of France and England in dealing with war-zone problems in parasitology.

No discussion of war-time parasites would be complete without mention of the profiteer that fattens on the body politic, the alien enemy that invades our institutions and destroys our substance, the slacker who, like the hookworm, is nourished by our organism but fails to function in its defense and support, but the treatment, remedial or surgical, for these parasites is not in the hands of our physicians and veterinarians; under the leadership of our able President, that affair is the affair of every loyal American.

THE CHEAPEST SOURCE OF INCREASED FOOD SUPPLIES

By Professor E. G. NOURSE

UNIVERSITY OF ARKANSAS

AMERICA to-day is seeking every means by which she may increase her agricultural output, and particularly is she concerned in finding those means of increase which will impose the lightest burden upon her supply of labor and of capital. This is the moment's phase of a problem which had begun to vex us seriously in recent years, but which is bound to become vastly more difficult in the future—a condition toward which the present war is a distinctly aggravating force. One solution of the problem is to be found through a choice of crops such that each portion of our land area shall be utilized for the growing of those products for which it is naturally best suited.

We are talking much about thrift now-a-days. Surely no part of the thrift campaign can be more fundamental to our welfare than this which concerns itself with the thrifty or economically effective administration of those natural resources upon which we must depend for the production of the foods, textiles, and other material means of human well-being.

The European colonists who settled our eastern seaboard faced precisely the sort of problem which we are here discussing, viz., the selection for tillage of those crops to which the soil and climate of the new land were best adapted. Naturally the force of inertia was all in the direction of holding them to the cultivation in America of the slender list of staples which made up the bulk of the output of western Europe at the time. But in terms of soil and climate America was a far jump from the mother lands and, after a few early disasters, considerable changes were effected in the old farm practise. Taking counsel from the Indian, the settlers adopted maize and found in it a much more powerful ally in conquering the new lands than they had possessed in any of their accustomed cereals. In potatoes, both the sweet and the miscalled "Irish" varieties, they found a cheaper source of starchy food than from any product of their previous acquaintance. Of non-food articles, tobacco and cotton early established themselves in high esteem.

When the great army of American pioneer farmers poured across the mountains to take up our agricultural domain they undertook to raise only the proved staples of their colonial predecessors and to do it by a simple system of extensive field culture. This was inevitable in view of the fact that they were pioneers going out to prove up on the land, not settled husbandmen expecting to bring it to its final condition of utilization. They dropped silk and linen from their wearing apparel and most of the delicacies from their diet. Little even of pleasing variety was left. But in the half dozen staple products they had what might be called the primary colors both of a diet and of a farm system. They had fat, starch and protein, and they had a few well-chosen crops with which to subdue virgin lands and lay the solid foundation of an enduring agriculture. But in neither case did they have the full spectrum. Their products were not capable of supplying the normal human desire for varied food or textiles, nor of catching or utilizing the varied productive power of different soils and climates. It is left to the modern day to produce the full rainbow of that achievement. And that is the point which I am driving at.

Possibly it can best be illustrated by giving something of a chronological account of the development of our resources as it has actually taken place. Whether we look north or south, east or west, we see very clearly that the process has been one of carving out the great chunks of territory suitable for certain staple products—the cotton belt, the corn belt, the wheat region. If you follow the main track of the pioneers you will walk over smooth prairies and fertile plains. While some hard labor was spent upon improving the hillsides of the northern colonies in early times it was south along the broader coastal plain that agriculture flourished and cotton plantations and tobacco fields expanded. And when the land chosen for this particular sort of crops was full, resort was not taken to land of other character by using it for other products. No, the tobacco fields of Virginia were repeated in the limestone soil of Kentucky and the cotton fields of the Carolinas and Georgia were followed by cotton fields of a like character culled out from among the varied resources of Alabama, Mississippi, Louisiana, Arkansas, and finally the black prairies of Texas.

Not less did northern agriculture push westward with its slender range of crops and its fastidious selection of lands naturally suited to their growth. The Genesee Valley of western New York, then Ohio, the greaat Northwest Territory, the Missouri Valley, and the Red River Valley of the North were stages in the journey. The march of corn was stopped at a dry frontier on the west and a frost line at the north, but wheat found new provinces to conquer in the San Joaquin, the Inland Empire of Washington, Montana, and the Canadian Northwest. In general, the pioneer sidestepped the wet lands, the dry lands, and the rough lands. To him they were poor lands, even worthless lands. He had no need to be thrifty about land, for there was always plenty of it—in fact, too much.

But now the point of view has changed. We are close upon the limit of our resources and asking where we shall find more land with which to supply our ever-growing needs. And the answer is, by finding out what productive qualities exist in the acres which have been discarded in this early reconnaissance development of our country and, by suitable means, drawing out the full measure of this productive power. In not a few instances it appears likely that the stone rejected of the builders may become the head of the corner.

With the reclamation of her arid and swamp lands America has of late years become much concerned. Such endeavors, however, should consist not alone of dams and ditches and dredging operations. Sometimes in lieu of such works and sometimes supplementing them should go a wise choice of drought-resistant or of water-tolerant crops. The pioneer with his moist-land crops and his moist-land methods was baffled when he reached the subhumid zone in his westward advance. After one disastrous attempt he admitted defeat and withdrew, leaving the land beyond the 100th meridian as waste land and his primitive sod house as the monument of his ill judgment. But the "dry-farmer" has refused to let all those fertile acres go untouched when markets offer a good price for grain and fodder and meat. Hence he has reformed his tillage methods so as to conserve all the moisture possible. But furthermore he has chosen a different set of plants to help him, turning from the hard drinkers to a group of more abstemious habits, able to do their bit on 15, 20, or perhaps 25 inches of rainfall instead of 30, 35, or even 40. He has turned to durum wheat and milo maize, kafir corn, kaoliang, and the whole group of non-saccharine sorghums. And he has found in alfalfa perhaps the best of all the dry-land crops, not so much because it *wants* only little moisture but because of the fact that it *can do* with relatively little and will work for all it gets. Given much water, it will yield heavily and often, but, planted where rainfall is scarce, it will delve deep to bring up all there is in a 15-foot layer of the soil and thus yield one or at most two cuttings on the subhumid land.

Much work has been done in recent years, as we have begun to see the value of these lands, so good in all but one particular, to find the crop by which at least a portion of their potential productivity might be realized. Scientific explorers of the Department of Agriculture since 1898 have searched far and wide to find whatever kind of plant life had been evolved by nature or developed by man to fit such conditions elsewhere as we face in America. Professor Hansen went back to the motherland of alfalfa in Turkestan to find in the driest habitat the most drought-resistant strain of the plant. We have gone to Arabia for the date palm, to Africa for kafir, Manchuria for kaoliang, but have not forgotten that for sheer "bone-dryness" our own cacti beat them all.

If we turn now to the question of wet lands it is evident, if one reads the history of the pioneers, that a very large part of our country was in its native state too wet for the plants with which the European settler was familiar. There are perhaps two reasons why this problem may strike one less forcibly than that of the arid lands. First, because the wet areas were, in general, smaller scattered patches, nothing so spectacular as our "Great American Desert" and also because a readier means of reclamation was at hand in even crude methods of drainage. But from the slough-holes of the glaciated North to the alluvial river bottoms of the South there are probably 80,000,000 acres of land—an area three times the size of Great Britain and Ireland—now useless because too wet. Most of this can be made productive only by the installation of drainage works, but it should be remembered that even so a wise selection of crops is necessary if the drained land is to be successfully utilized. For drainage removes the surplus water; it does not prevent flooding, and many soils, even when drained, are still of such a character as to be suitable only for special crops—rice, celery, cranberries, onions; not for the old stand-bys, corn, oats, wheat, hay and cotton.

Kalamazoo celery, Wisconsin cranberries, the onions from Iowa muck lands—not to mention peppermint and spearmint—are, I suppose, fairly familiar, but doubtless many people are not yet aware that within the last few years the South has begun to turn some of her over-moist lands to the raising of certain species of aroid—a subtropical root crop which thrives in wet environments. Most important is the dasheen, first cousin to the "elephant-ear" of your parks, its leaves a salad plant, its stems a vegetable surpassing asparagus, its tuberous roots a good substitute for potatoes and claimed to make a flour better than wheat. Not mine to boast of the dasheen, but it does appear to hold out much hope for profitable utilization of lands in the Southeast with 50 to 70 inches of rainfall. It is now grown and milled commercially and in increasing amount.

One of the neatest illustrations of learning how to play one's hand in a wet country so that the surplus moisture takes the odd trick instead of losing the whole game was recently furnished by a small community in central Arkansas. These farmers had been following the conventional type of agriculture of the region —cotton and corn. But nearly every spring the River Petit Jean covered the fields with back water for a short time. So, while the soil of this section was good and the climate all that could be desired for most of the season, yet returns were poor because of a short period of submergence early in the growing season. Neither young cotton nor corn can bear to have their feet wet.

Levees are expensive and not altogether trustworthy; so two young men who owned a farm thought they would try to use the river instead of fighting it. They decided to ally themselves with a crop that could stand flooding, in fact that required it—rice. To this use their "buckshot" soil was quite as well adapted as for cotton and corn, and the river offers a cheap and abundant source of water supply for the later portions of the growing season. This shrewd choice of a crop has brought instant attainment of the potential productiveness of a section which would otherwise have remained a precarious venture in crop-making or have required the expenditure of much time and money before it would have been rendered suitable for corn and cotton. At the same time society would have been losing a valuable resource, for the lands which, by reason of soil, topography, climate and water-supply, are capable of producing rice are relatively rare, whereas corn and cotton thrive over very wide areas.

It would be wearisome to attempt to go into all the many kinds of agricultural unfitness which may be overcome by the judicious choice and adaptation of farming enterprises. The West has great stretches of lands which are alkaline—an infirmity which is frequently aggravated by the introduction of irrigation, but which may be combated by the use of alkali-resistant crops. In this group the sugar-beet has proved itself one of the best, though cotton bids fair to prove a worthy rival in the warmer portions of the alkali zone. Barley is probably the most successful representative of the small grains, and there is a fairly good list of forage plants, which—praise Allah!—includes a number of the legumes. For extreme conditions we have the ubiquitous cactus, now happily de-spined, and perhaps ultimately the Australian salt-bush.

Likewise the problem of sandy land has baffled many a cultivator accustomed to the technique of loam and clay. Even in the time when the colonists were belaboring the barren hillsides of New England they were not enough humbled to try the sandy barrens of New Jersey. But the modern truck and fruit grower is not too proud to fight for even such unpromising resources. The light soil is easily worked and, for such products as are made up mainly of water and a little sugar, is tolerably productive. Not only in New Jersey, but in practically every state in the South, fortunes are being drawn from such lands through the medium of berries, melons, peaches and numerous varieties of fancy vegetables.

But of all the agricultural Cinderellas, none presents more engaging possibilities than those offered by the hill lands. Probably we have not yet come as close to a sensible mode of using such resources as in the case of most other types of land. Certainly it would seem that it was in this field that the most egregious blunders have been made in the past, for flat-land agriculture *can* be carried on to the hills and persisted in (to the harm of the land and the impoverishment of the worker), whereas Nature more sternly turns men back from land too wet or too dry. We know that the hills of New England were pressed into flat-land uses by reason of certain peculiar circumstances and with most melancholy results. And in every other hill section—Appalachian, Ozark, or wherever—we find either that the early settler turned his back upon the hills or else essayed to raise his valley crops instead of devising a hill technique really suited to the circumstances. Hence the backward and unprosperous hill folk.

Allow me to illustrate this point from a situation with which I am somewhat familiar, the Ozark hills of northwest Arkansas. The first rush of land exploitation flowed to the north and south of this region. Grain farming took up the region to the north; the cotton planters, as has already been mentioned, swept through as far as Texas on the south, cutting out the most suitable cotton lands and spreading up the valley of the Mississippi, the Arkansas, the Red River, and the White. When Oklahoma was opened up, the wheat belt spread downward from Kansas and the cotton belt spread upward from Texas till the main stream of pioneer agriculture flowed together on our west, leaving the Ozarks an island of land ill suited to the uses of a pioneering people. This is not to say that the region was a desert or unpopulated. But in general the population which did come into this territory tried simply to carry the crop practises of the flat land up into the hills—and with sorry results, indeed. Though things have largely changed to-day, one may still ride through certain sections and see a native farmer or his wife following a "littie ole rabbit mule" and an eight-inch plow up and down over stony hillsides, which it was a crime even to have cleared. To try and force corn, the small grains (they are cut with a cradle), and cotton from such land is the most thriftless of all ways of employing nature's resources and the labor of human beings. But those very hills are a fine old residual limestone formation, the soil beloved of alfalfa and many of the nitrogen-gathering legumes. It is suited too to raising the finest of peaches and apples and strawberries. The wooded hills furnish splendid pasturage for cattle and hogs and the small creek bottoms will produce an adequate supply of grain and forage for the short winter season. As soon as man makes the nature of the soil and topography his point of departure and not the habits of his past he can fit upon the resources of this region a splendid type of diversified farming, producing a good living to the farm family and salable specialties of a high order.

Similar conditions have existed in the mountain region of the Appalachians and Northeast. The fertile Shenandoah was praised, and backs were turned upon the rough Piedmont sections of Virginia. But to-day the Albermarle pippin and a host of other good fruits, not to mention superior livestock, make the Piedmont a fair rival of her haughty elder sister. So of sheep-raising and horse-breeding on the hillsides of Vermont and New Hampshire, which were once insanely belabored to produce wheat; peaches in the rocky lands of Connecticut, and fruit and butter from the broken portions of New York.

Now all these are well and permit of establishing a prosperous agriculture upon even hilly lands. But they are only the beginning, for as soon as slopes become very steep or the land very much broken even standard methods of orchard cultivation are precluded, and we must fall back practically upon forest conditions, but with the chance for more than a forest product. Here it becomes a matter of selecting tree crops of great value. The Italian gets a cheap substitute for butter from his olive trees and, while we may not alter our habits of consumption to effect such an economy, we have already a substantial olive industry in California. And the high food values of various nuts have been practically ignored in the United States. The pioneer used such products because of stern necessity, but the American farmer has been so intent upon the conventional crops as to think little of the possibilities of nut culture upon those parts of his farm ill-suited to plow methods.

Likewise, he has done no more than passively accept from the persimmon a portion of its spontaneous product, but this is in fact a fruit of considerable economic value and readily capable of improvement. The Department of Agriculture has introduced the large Japanese and Chinese persimmon and they offer a highly promising field of development in the future. From China also has come the Tung-oil tree, capable of producing one of the finest painters' oils from lands otherwise yielding products of small value. Spain is the seat of an important cork industry, but experiments have shown that the cork-oak can be grown upon our own rough lands. And bamboo also presents future possibilities.

And so on indefinitely. The land which was spurned, and very properly so, in the days of our agricultural development can not be unthriftily left in idleness in the coming days when we shall press more heavily upon our natural resources for subsistence. In some cases it is doubtless best to go to the expense needful to render such lands suitable to the products we have been accustomed to raise. In others it can not be done or, if at all, only at too great an outlay. Within the limits set by our tastes (and many of them can be re-educated) it is most economical to humor Madame Nature, to let her produce those things for which she shows a preference or for whose production she is already equipped.

Such an issue of expediency presses itself upon our consideration peculiarly amidst the exigencies already confronting us as a result of war conditions or presaged by after-war forebodings. Capital is being destroyed at an unprecedented rate, and men are being killed and maimed in numbers that can not soon be replaced. And it was upon more man power and larger outlays of capital that all our plans of an enlarging agricultural product were being based. The men and money which might have gone to build great irrigation and drainage works or to furnish the labor, the tractive power, the farm implements, and the fertilizers for a more intensive agriculture are fast being spent upon the battlefields of Europe. How then shall we hope to augment production at the very time when these productive factors are being squandered in a tragic enterprise elsewhere? Through shifting the burden, by every ounce we can, upon that third great member of the economic partnership—Nature; by so adapting our culture as to utilize our natural resources at the peak of their effectiveness; by choosing crops that catch step with Nature's spontaneous endeavors. And what is good policy for war time will be no less effective in adding to our welfare in times of peace.

THE RELATION OF THE STATE UNIVERSITY TO RESEARCH WORK IN WAR TIMES

By Dr. R. W. THATCHER

UNIVERSITY OF MINNESOTA

A DEMOCRACY is not organized for war. Its aims are those of peace; its fundamental conceptions are those which can result only in peace. When, therefore, war is thrust upon it, a democracy must suddenly readjust itself to new and unexpected conditions. Under such an emergency, it is inevitable that every loyal citizen shall desire to do something to help. This desire manifests itself immediately in proffers of service to the government, and oftentimes in individual initiation of projects intended by the patriotic investigator to yield war-time results.

The first step which democracy must take in war times is to make its government supreme in authority. Freedom to criticize our elected officials is a privilege which seems to be very dear to many American citizens; not less dear is the privilege of employing one's own time and talents in whatever direction he chooses. But in war times, individual ideas and individual preferences must be surrendered to the public good. Successful prosecution of war can be accomplished only by coordinated effort. Coordination can be brought about only by centralized authority.

Modern warfare is essentially a conflict of intelligences. Each side endeavors to outwit the other by the production of new engines of war, of new agencies of destruction, of new plans for defense. All of these demand research of the highest skill, capable of most intense application and of quick and sure results. One of the most important lessons of the early days of the present war was that no nation can afford to sacrifice its scientific workers or break down its research agencies.

The universities, particularly those which have been built up by state and federal funds, are the agencies to which the government has the right to look for research assistance in winning the war. It is essential, therefore, that these universities do everything that they possibly can to maintain their research organization and facilities at the highest possible stage of efficiency. For that reason, I am urging that research men in our universities be not stampeded by their own individual desires to do some unusual service in war times or by the public clamor for some special war-time effort. The most patriotic service which we can render is to be ready with our laboratories, our shops and our men equipped and working at their highest possible efficiency whenever the government calls upon us for the particular task which it assigns to us as our special part of the national plan.

It takes time for the government to elaborate its plan. Some of us are inclined to become impatient and to desire to turn immediately to some special war-time work. Many voluntary emergency organizations have been formed and hosts of suggestions have been proffered to government officials, doubtless resulting in hindrance if not in positive annoyance in the performance of their war-time duties. My suggestion is that we "sit tight" and perform our regular duties in the most efficient way possible until it becomes clearly apparent what special emergency service each one of us can render to the government.

The government has already organized its research council and its various departments for the prosecution of war-time work. The scientific men of the country and the various laboratories with their special facilities for research have been listed. This constitutes research mobilization. There must necessarily intervene a period during which some units can only "stand and wait" while the general plan of attack is being formulated. If it falls to our lot to wait a little before our particular task is assigned to us, let us not stand idle, but rather keep our equipment well polished and efficient by constant use. It may be that some of us can actually evolve new war-time plans for research which we can pass on to the proper government officials through the National Research Council; but until we are quite sure that our ideas are worth while and likely to serve a national need, let us keep patiently at our regular research problems. We shall then be in position to turn quickly to any emergency task which the government may assign to us on the basis of the work which it knows we are already doing.

Not less important is the careful and thorough training of the young men in our institutions who have not yet been called into federal service. The making of a skilled research worker is a long-time process at best, and we ought at this time to increase rather than decrease our research teaching and, if possible, to speed it up by concentrated work.

Again, while the winning of the war is our present all-absorbing task, we look forward with confidence to the time when the world has been made "safe for democracy." The necessary reconstruction of our national industry to meet the needs of world food supplies and world industries, as well as to meet the competition of other nations whose skilled energies have been turned to peaceful pursuits, will demand that American men of science be ready, as they have never been before, to match their research skill against that of the whole world. This means constant maintenance of all our research agencies and organizations at their highest efficiency.

My advice and suggestion to individual research workers is, therefore, that we hold ourselves in readiness to undertake any task for which the proper officers of the government call upon us, as the research workers best prepared to do that particular task; but that until that special task is assigned to us, we keep steadily and conscientiously at our regular research work as our highest patriotic duty in these war times.

Turning now to the question of the attitude of the university administration toward research, I should like to say that, in my opinion, the lesson of the war ought to result in a recognition of the rapidly increasing value to the public of state-supported research work. State and federal money has been appropriated in the past for agricultural experiment stations, and more recently for mines experiment stations, and a proposition for engineering experiment stations is under consideration. But the pressure upon these institutions for popular instruction or demonstrations of what is already known of methods of scientific operation of farms or industrial plants has often seriously hindered the development of real fundamental research work. I am not arguing now for better support for that type of research which is characterized by the "seeking after truth for truth's sake," worthy as that may be; but rather for the necessary fundamental research which must be the basis for future industrial development.

Great industrial corporations and various institutions or "foundations" of a semi-public and semi-philanthropic character have recently come to recognize the value of research to the development of the particular industry or cause which they represent. But the general public, as represented by the state legislatures or other public agencies which appropriate public money for specific uses, have been and are still loth to recognize the value to the public of a skilled research scientist. As a result, we have numerous and embarrassing examples of the loss to our universities of many of their most promising research men by reason of too tempting offers of larger salaries by industrial corporations or other agencies such as those I have mentioned.

I believe that the public should be entitled to the results of scientific researches of the most skilful kind, and that the benefit of such work ought not to be limited to private use or available only to private gain. For that reason, I feel strongly that our universities, and the public agencies which provide the funds with which they are to operate, ought to recognize the immense value to the general public of the unselfish service which the research men of our university staffs are rendering, but which they can not be expected to continue to give to the public if they are continually offered higher salaries and better facilities for work in privately supported or endowed laboratories. Such recognition should have come even if the war had not intervened; but it is doubly due now that the war-time emergency and the necessities of reconstruction work after the war have so emphasized the necessity for and the value of scientific research work.

SNOW AND ITS VALUE TO THE FARMER

By Dr. ANDREW H. PALMER

U. S. WEATHER BUREAU

SNOW falls everywhere in the United States except in certain portions of Florida and California. The amount which falls each winter varies greatly in different parts of the country. It ranges from little or none along the coast of the Gulf of Mexico to more than 500 inches in the high Sierra Nevada Mountains. In the more densely settled eastern portions of the United States it ranges from 10 to 50 inches, and measurable amounts fall on from 10 to 50 days of the winter half-year. Here the proportion of the total annual precipitation (rain, snow, hail, sleet, and dew) which occurs in the form of snow ranges from 10 per cent. along the Atlantic coast to 20 per cent. in the vicinity of the Great Lakes. The amount of snow which falls at any particular place also differs from year to year. Some winters are almost free from snow, while others bring abundant snowfall. In the elevated portions of the West, nearly all the precipitation occurs in the form of snow, partly because the summer half-year is comparatively a dry season, and partly because of altitude above sea level. The principal controls which determine the amount of snowfall at any place are the winter temperatures and the amount of moisture in the air.

Snow as it falls averages about 10 per cent. water by volume. In other words, 10 inches of newly fallen snow are usually equivalent to 1 inch of rain. An inch of rain simply means the rain contained in a layer of water 1 inch deep uniformly distributed over the ground. This is equal to a little more than 100 tons of water to the acre. However, falling snow varies greatly as to density, "wet snow" containing relatively more water than "dry snow." Immediately after reaching the ground snow begins to settle, and in the course of time its density is increased to three or four tenths that of water. That which has been subjected to alternate freezing and thawing, or that which has been compressed by the weight of overlying snow often approaches the consistency of ice. The settling pro-

A Cottage in the Snow.

ceeds regardless of whether the air temperature is above or below freezing (32° F.). When the temperature is below freezing, gravity alone causes the snow stratum to become more compact, without loss of its crystalline structure. When the temperature is above freezing, melting begins at the surface of the snow, the resulting water percolating through the underlying snow to the ground beneath. There is usually a lag in time between the beginning of melting and the first run-off.

Under conditions favorable for plant growth the moisture contained in a soil of uniform texture is about 25 per cent. of the volume of the soil, broadly speaking. But the maximum capacity of such soil for water ranges from 30 to 50 per cent.

Photograph by Fred Rath

A Cottage shrouded in a Mantle of White. To most people snow suggests extreme cold. However, the woman here shown does not appear to suffer from cold, in spite of the frigid environment.

Photograph by Fred Rath.

JANUARY IS A MONTH OF RARE DELIGHT ON THE FARM.

of its volume. Though they show little uniformity in texture or in water content, most soils, under ordinary conditions, can absorb additional moisture. When snow falls upon unfrozen ground it may keep the surface soil from freezing. The snow cover checks the loss of heat through radiation, while some heat is received from below. If such a cover persists throughout the winter the soil may remain unfrozen, and, if so, it will readily absorb water when the spring thaws set in. When an unsaturated soil freezes it is relatively porous, and can absorb moisture as unfrozen soil can, but at a slower rate. When snow that has fallen upon frozen soil melts, a larger proportion of the resultant water is lost through run-off than occurs following the melting of snow lying on unfrozen ground.

Though the root systems of most annual crops are limited to the first foot of soil, the underlying three feet serve as a reservoir from which they derive much of their sustenance. It has long been recognized that water is wealth, and that the water supply of a country is an important part of its agricultural capital. In one sense this part of the capital is administered through the first four feet of soil and subsoil, where water moves freely in capillary action. Snow conserves as well as replenishes this soil moisture during the winter season.

The Significance of Snow to the Farmer

In cities, snow probably does more harm than good. It makes walking difficult, delays transportation, and interferes with wire communication. In great cities like New York, Chicago and Boston the cost of removing snow from the streets amounts to hundreds of thousands of dollars every winter. To the farmer, however, snow is an asset, not a liability. Although it does make roads impassable until "broken in," and although in the plains of the West a heavy fall of snow temporarily cuts off the food supply of grazing cattle, snow may rightly be considered an agricultural resource. "A snow year, a rich year," says one proverb. An enumeration of some of the more important factors showing the great value of snow to the farmer follows.

As a protective covering or blanket, snow serves very much like leaves or straw, only in a lesser degree. Frost in the ground is simply capillary moisture which has been congealed by temperatures below freezing. Frost will penetrate to a greater depth in newly plowed land than in a pasture. For the

The Marvin Shielded Rain and Snow Gage, used by the U. S. Weather Bureau to Measure Snowfall. The curved plates forming the sides eliminate the effects of wind currents, thus permitting a true "catch" of snow in the enclosed cylinder.

Photograph by Fred Rath.

Abandoned to Winter—a Cottage submerged in Snow. When deep snow like that here shown melts, much of the water soaks into the ground.

same reason it will penetrate deeper in bare than in snow-covered ground. The protection afforded by the snow results partly from the snow forming the covering and partly from the air associated with it. Experiments have shown that a 2-inch covering of snow will reduce the daily heat exchange between the earth and the air above it almost one third, and that a 4-inch covering will reduce it about two thirds. For example, in an investigation which extended over a period of about eight days, during which the extreme range of the air temperature amounted to 34°, a thermometer 2 inches beneath the surface of the snow showed a range of 25°, one at 4 inches a range of 14°,

Cottages almost submerged in Snow.

one at 8 inches a range of 3°, and one at 12 inches a range of but 1°. No range in temperature was observed at the bottom of a 24-inch cover of snow. Moreover, there was a distinct lag in the time of maximum and minimum temperature as the depth of the snow cover increased. It was found that it took 12 hours for the cold to penetrate the 12-inch cover, causing the lowest temperature to occur there at the time of the highest temperature in the open air, and *vice versa*. The diurnal heat exchange in deep snow on the ground is only about one half that in a grass-covered meadow, and about one fourth that in bare sandy soil. Furthermore, it is twice as much on clear as on cloudy days. The denser the snow the poorer it is as a pro-

Photograph by Fred Rath.

THIS PICTURE, TAKEN IN THE MOUNTAINS OF CALIFORNIA, SHOWS SNOW WHICH UNON MELTING WILL FURNISH IRRIGATION WATER FOR THE FERTILE VALLEYS FOR WHICH THE STATE IS FAMOUS.

tector. Loosely packed snow containing much air mixed with it serves as the best blanket. Besides being a poorer conductor of heat, and therefore a better protector than ice, loose snow permits the respiration of submerged vegetation, which proceeds even at temperatures far below that at which actual growth is possible. Grass and grain are sometimes smothered when the snow, through alternate thawing and freezing, is converted into ice.

Besides serving as a blanket which checks the loss of heat from the ground either through conduction or radiation, a covering of snow prevents evaporation from the soil. Soil moisture, conserved and replenished by the snow, is thus made available to the roots of trees and perennial plants during the cold season, when little rain falls. Moreover, such a cover prevents the violent winter winds from tearing the dormant vegetation. Furthermore, snow permits the penetration of some light, and recently it has been recognized that light can replace heat to a considerable extent in the various processes of vegetation. Again, it is known that killing from cold is due to the removal of water from the plant protoplasm, the freezing be-

LAKE SPAULDING, AN ARTIFICIAL RESERVOIR IN THE HIGH SIERRA NEVADA MOUNTAINS OF CALIFORNIA. Water from melting snow collects in this reservoir and is subsequently used for irrigation and power purposes.

ing largely intercellular. A plant's ability to withstand cold depends in large measure upon the capacity of its cells to give up water without injury. In most kinds of vegetation, and particularly in winter buds and woods, a rapid fall in temperature requires that water be given up faster than the plant cells can afford to lose it, the result being serious injury or death. As a means of checking this rapid decline of temperature, either in snow-covered branches of trees or in snow-covered vegetation on the ground, another value of snow is easily recognized.

Snow has aptly been called "the poor man's manure." The reason is obvious. Melting snow moistens the soil gently and gradually without condensing particles by pounding them and without floating up any clayey mud to the surface to encrust the land when it dries. Rain compacts the surface soil, but snow and frost loosen it. Alternate freezing and thawing mellows the soil. When water freezes it expands. The expansive force is

SNOWBOUND.

very great; it is sufficiently powerful to break up and to crumble solid matter with which it is associated. This is the reason why coarse lumps or clods of soil fall apart in the spring. For the same reason marl strewn over the surface of the ground in the autumn becomes a powder before spring.

Snow also checks the run-off when the temperature is low. Ground water is replenished more easily by the melting of snow, or by rain falling on the snow, than it is when an equal amount of rain falls upon bare ground. Moreover, the bene-

HOUSE IN THE SNOW.

Photograph by Fred Rath.

ONLY THE CHIMNEY OF THIS COTTAGE CAN BE SEEN, THE REMAINDER BEING SUBMERGED IN SNOW.

ficial effects persist longer. Snow is not melted by cold rain as readily as most people imagine. Dry winds, direct sunshine, and high air temperatures are much more effective.

As a source of moisture snow is perhaps less important than rain, generally speaking. However, in the western portions of the United States the winter snows furnish practically all the water used for irrigation and power purposes throughout the year. Fortunately, the snowfall in the western moun-

Photograph by Fred Rath.

A RAILROAD CANYON IN A REGION OF EXCESSIVE SNOWFALL.

tains is abundant. Packed by compression, as well as by alternate freezing and thawing, great banks and drifts of snow solidify to ice. Slow melting follows in the spring and summer, the resulting water collecting in natural and artificial reservoirs to form the only available summer supply.

In various other ways snow is valuable. Just as transportation by water involves less waste of energy than by rail, so it is easier by sled than by wagon. There is smaller loss of energy due to friction and to wear and tear. Logging and lumbering, as well as the transportation of bulky and weighty quantities of grain, wood, coal and ice, could not be accomplished easily without the snow. A snow cover prevents the occurrence of prairie fires. Forest fires are least likely in midwinter, for the same reason. They usually occur during the spring, sum-

Photograph by Fred Rath.

BRANCHES OF TREES HEAVILY LADEN WITH SNOW. (Note the railroad snowsheds in the background.)

mer and autumn months, when vegetation is dry, and there is little to check the spread of a fire once started. Moreover, snowflakes remove certain microbes (disease germs) and dust particles from the air through which they fall. For this reason water derived from the melting of snow which has fallen in or near cities is not fit for drinking purposes.

SNOW AND GRASS.

Every farmer has observed that a good hay crop follows a winter of abundant snow. After such a winter the subsoil is

Photograph by Fred Rath.

MIDWINTER IN A WESTERN MOUNTAIN VILLAGE.

almost saturated. Moreover, grass is easily injured by alternate freezing and thawing of the soil moisture enclosing its roots, but is greatly benefited by a snow cover which persists throughout the winter. In the expansion which accompanies the freezing of moisture in the surface soil the grass roots are torn and heaved out. For this reason pastures are soft in the spring. Lawns and pastures are improved by spring rolling, which presses the roots back into the soil, forming a firm sward. Loosely packed snow is an ideal winter cover for all kinds of grasses. However, if the snow is solidified to ice by frequent winter thaws and subsequent freezing, the roots may be smothered.

SNOW AND WINTER WHEAT.

The beneficial effect of snow is perhaps more readily apparent in the case of winter wheat than in any other crop. Wheat is normally a winter annual, and climate is its most important control. It requires a temperature of about 40° F. to germinate, and while it does not grow at a lower temperature, the plants inhale oxygen and exhale carbonic-acid gas throughout the winter. Cool weather and considerable moisture are required during its early growth. The weather conditions prevailing during the winter months determine its density of growth, and therefore its yield. The plumpness, quality, and color of the grain are determined by the warmer and drier part of the year, when the crop ripens. The importance of snow in the early growth of winter wheat is paramount in regions where the winters are severe. Snow acts as a protective cover against temperature extremes, wind and evaporation; it permits the penetration of light and the respiration of the plant tissues; it supplies the necessary winter moisture; and prevents the tearing and the heaving out of the roots by the alternate freezing and thawing of the soil.

More than two thirds of the winter-wheat acreage in the whole United States is included within the eight states of Kansas, Nebraska, Oklahoma, Missouri, Illinois, Indiana, Ohio and Pennsylvania. In this belt the winters, though moderately severe, usually bring sufficient snow to protect the crop. On the other hand, more than five sixths of the spring-wheat acreage of the country is included within the three states of North Dakota, South Dakota and Minnesota. In this belt winter wheat is not produced on a large scale, principally because ordinarily there is insufficient snow to protect such a crop during the severely cold periods which occur almost every winter.

Photograph by Fred Rath.

IN A REGION OF EXCESSIVE SNOWFALL.

Photograph by Fred Rath.

DWELLINGS ENSHROUDED WITH SNOW.

SUMMARY.

To the farmer the benefits derived from snow far outweigh the disadvantages. As it falls, the density of snow is about one tenth that of rain, but upon lying on the ground it soon acquires a density of about three or four tenths that of water. Under certain conditions it may solidify to the consistency of ice. As a blanket or covering, snow on the ground checks winter killing. It protects vegetation from extreme temperatures, from excessive evaporation, and from destructive winds, at the same time permitting the penetration of some sunlight, and

Photograph by Fred Rath.

RAILROADING UNDER DIFFICULTIES IN THE WESTERN MOUNTAINS.

allowing uninterrupted respiration of plant tissue. On twigs and buds it conserves cellular moisture which otherwise might be sacrificed at too rapid a rate during sudden changes of temperature. It mellows the soil, replenishes the ground moisture, checks the run-off from winter rains, furnishes most of the water used for irrigation and power purposes, provides an easy means of transportation, and prevents destructive prairie and forest fires. Grass is benefited by abundant snows, and winter wheat is largely dependent upon it for its success. All in all, the recurring snows of winter form one of our most important agricultural resources.

THE B.A. DEGREE IN AMERICA

By Professor A. G. KELLER

YALE UNIVERSITY

IT requires no very great hardihood to assert that the B.A. degree, in this country, has been cheapened to the verge of meaninglessness. The degree has been so lavishly conferred, and for such a variety of accomplishment, that the letters after a man's name mean nothing of any importance—unless, perchance, they are followed by a parenthesis enclosing the name of the conferring institution. Even then, that for which they stand, let the institution be of the very best we have, is not crystal-clear.

And there is not much stress, despite the efforts of the Carnegie Foundation, in the direction of improvement. Engineering degrees, and the M.D., tend to keep themselves up, because they touch more intimately and vitally upon definite and concrete human interests. The bridge breaks down; the patients die—here is a sort of inevitable test that checks up results and imposes stress. Results are verifiable. But the B.A. is far removed from such tests—farther, perhaps, than any other degree in course. People have nothing definite that they expect from a B.A., whereby they can judge whether any standard has been reached or not. Nor yet has any college known to the writer a set policy in regard to the degree, so that outsiders, on examining its product, can decide whether it has succeeded in its business or not.

I am not about to try to prove the above assertions. I take them to be self-evident to any one who has thought, or chooses to reflect, upon the situation. I wish, rather, to put a query.

Suppose that an endowed college sets itself the question of making a B.A. course which will stand for something so valuable that it will be glad to have its special guarantee-mark in the parenthesis after the letters—so that it will be as jealous of that mark as a high-class firm is of its trade-mark. Suppose it says: "The 'B.A. (Weissnichtwo)' shall stand for quality." Suppose, that is, that this college wants to adopt a definite policy with respect to the B.A. degree. What shall it do?

There is one very simple and easy answer: get all good teachers, and no poor ones, and sit tight. But this can not be done. Most colleges have a number of poor teachers—whom almost any one would regard as such—attached irretrievably to the faculty; and even if all the poor ones would conveniently resign, still their places could not be filled with good ones. The market doesn't hold enough of them. And, of course, there would be at once a difference of judgment, except in the extreme cases, as to what a teacher should be. To this latter point I shall return. For now, all that can be done as an approach to this counsel of millennial perfection is to make no future whimsical or snap-appointments—to be fastidious to the last degree, according to what lights and conscience we have, in the selection of members, and particularly permanent members, of a faculty. Also there should be such discipline in a faculty that inefficient or conscienceless members should be under pressure to do the best they could. If, even as faculties are now constituted, every one did the best that was in him, the case would not be anywhere nearly so bad as it is. This too may seem to be a utopian suggestion. But it helps to set the case before us. Let us now return to our query, modifying it to read: What *can* a college do in the construction of a B.A. policy?

No college can pluck figs from thistles; nor yet can it, however ineffectual its offerings, make thistles out of figs. The sort of students that come to it represent a constant element in its showing and destiny. Nothing worth while in the way of a system or policy is possible until punctilious account is taken of the material to which the B.A. process is to be applied. This is one of those perfectly obvious things that some professors chronically ignore, thus bringing a connotation into the term "academic" that is far from flattering.

In the case before us, this constant is the young American of eighteen to twenty-two, or thereabouts, who comes to our colleges. It seems almost a triviality to say that he is the product of his social environment, and that he can not be made otherwise without first altering that environment—certainly not by yearning over him or vituperating him because he is not like the English, French or German lads. Of course he can be treated in a course so that he will avoid that course, as is demonstrated within every college by certain teachers who gradually clear their courses of undergraduates. From any sane college standpoint, such "instruction" can not be approved. No artificer amounts to much who can not or does not take the trouble to know his materials.

What are the outstanding qualities of this human material? Said an eminent scholar of foreign birth and training, regretting the very course of unremitting attention to study in boyhood which had perhaps made him what he was—upon which, at any rate, an American colleague was commenting, to the disadvantage of American methods: "Yes. But I had no youth. I had no youth." Perhaps this remark made some impression upon the colleague. I do not know. But it offers us a starting-point from which to envisage the American lad. He is having his youth. It makes of him this and that which is revolting to an elderly soul. It is hard sometimes to have patience, even if one has not forgotten his own youth. But, after all, what a wonderful thing youth is, as it recedes from one who has lived it with gusto! Would he have it abolished in favor of a precocious seriousness of maturity? It should be listed as an evidence of kindly design in the universe that, in this country at least, that can not be done. In any case, here is a constant factor, to be reckoned with, molded somewhat if desirable and possible, but not inveighed against.

One of the chief complaints about the student is that he does not know, early in his course, what he is going to do when he leaves college. If he did, he could then specialize and quit "trying," ingenuously, or disingenuously, this and that. Well, most of them do not, with telescopic or prophetic eye, view the vista of their futures. Their life-status, in America, is not settled soon enough. There are no cut-and-dried careers to which they are, as it were, preordained. So, too, they are not set off into life-status or class; it was partly to get rid of such Old-World inflexibility that people have migrated to this country. We have no "careers" for which an undergraduate, studying non-professional branches, can fit himself. In other words, the social environment in the United States is such as not to call for early specialization in a regular college, and so it does not occur. There are professional schools for that. And even these are coming latterly to demand an antecedent degree of the B.A. order, as something, vague and uncertain, perhaps, but yet indispensable before strict specialization. The directors of such professional schools—which are the most noted ones—seem to see something useful in the colleges, even as they are. What they want, of course, is a clientage of liberally educated men; if a doctor or a lawyer knows only medicine or law, he is at a discount in these days. The doctor has an increasingly significant social function. Even the soldier, as the recent changes in the West Point curriculum indicate, ought to know some English and history.

As a matter of fact, a very large proportion of college graduates go into "business." Now there is no form of specialization for this career except in a business college. Academic courses in economics are not meant to teach a man how to be a bank-teller or how to buck the stock-market. If professors could teach business, they would be likely to show more evidence of having practised it, on the side, instead of constituting a chosen mark for promoters of all sorts of doubtful ventures. What the business-man-to-be wants out of college is a cultivated, adaptable mind and widened interests, so that there will be something in his life besides business. He needs a liberal education. Plenty of men in college know that they are going in with their fathers, or they have positions otherwise in view; but they do not want to specialize, or they would not be in college. No matter what they came there for, it was not to become business specialists, or any other sort of specialists; and they constitute a proportion that has steadily grown ever since the time when going to college and doing pretty well generally meant entrance into the ministry.

Here are some facts about students, as they are. Anybody who knows the student knows they are true; and any one who does not know him, as he is, not as a figment of a prepossessed mind, has no business to be talking about the matter at all. It is a detriment to education when such men get into positions which seem to lend them weight in counsel, so that they can impress outsiders, oppress their colleagues, and at length depress the reputation of all education by attaching to it, again, as their talk is seen to be futile, the connotation which "academic" has come to bear.

The "liberal education" of which I have spoken is not specialization. It is selection. It is a process of "discovery of mind," as one efficient teacher phrases it. This discovery is consummated by "exposing" the as yet unoriented, or even unformed mind, to certain influences. The youthful mind does not take to this process as a duck to water, by any means. A veteran teacher once remarked that he had never ceased to marvel at the infinite capacity of the human mind to resist the introduction of knowledge. Hence the need of "school-mastering," where that means effort in the opening of minds and the rendering of them sensitive, and in the imposition of discipline. If the education is to be a "liberal" one, this "exposure," in many directions and to a variety of intellectual influences, must be accomplished, though it has to be forced. No matter what a student comes to college for, this "exposure" should take place, and this "discovery of mind" should be accomplished—or the student should leave college. It is freely granted that the life among one's fellows, at college, possesses educational value of the highest order; very likely the athletics and the rest of the "extra-curriculum activities" have their sort of educational value. But the faculty can not take cognizance of these except to exult over or regret their presence. The B.A. degree stands for things of the curriculum. In any respectable college the passing of the courses, together with the maintenance of a certain conventionality of behavior, is the *sine qua non* for the B.A. degree. Considering the nature of the student, what should the B.A. stand for, intellectually? What should the curriculum of studies be? What is a "liberal education," in these days and in this country?

Education is the transfer of knowledge, rules of living, discipline, etc., which makes the young into fit members of society—fit, that is, to take the places of the passing generation. Being that, it is different in different societies—Zulu, Afghan, American, English, German. All schools aim at this; the graded schools try to inculcate what they consider the absolute essentials, for those who can not go very far. The high schools aim at a fuller preparation for life in the local society. And then come the colleges whose product is, or was once, at least, supposed to constitute a class competent to grapple, with knowledge, discernment, and trained and disciplined mind, with any and all aspects of social life. We know that this reputation was never deserved; but at least the college graduate was supposed to have had the chance, whatever he did with it, of making the acquaintance of all forms of knowledge. He was a man who had had opportunities beyond the common range of men for knowing about the questions that have always engaged the interest of man. He had had the chance to know what was worth knowing.

Not so very long ago the stock of human knowledge was much smaller than it is now, and the idea of what was worth knowing was a traditional matter. Both of these facts contributed to a prescribed course of study. Rightly or wrongly the college degree meant something definite: Latin, Greek, mathematics, metaphysics, etc. Every one had to take pretty much the same course; and he had to study certain subjects, whether he wanted to or not, or he might leave college. If any one wanted the B.A., he could present certain fixed prerequisites and pursue study on lines laid down. He could take it or leave it; and there was no control exercised over the college by the lower schools. There were numerous advantages in all this. At least the B.A. course had the dignity of its convictions.

But it was not adaptable. There was too little room for variation and new selection, with consequent adjustment to environment. And so the old required college course came to be out of joint with the times. Its inertia of tradition prevented it from seeing any good in the newer disciplines. Its self-sufficiency stirred such powerful opposition and criticism as is typified in Herbert Spencer's classic work on education. The resistance it offered caused the gathering forces of the new time to carry the college course out of the hands of these who had been its natural directors virtually into the hands of the students themselves. The elective system secured freedom from tradition; but this freedom was not that sole kind of liberty that ever benefited the race—liberty under law—but ran out into license and abuse. Doubtless the reaction was perfectly normal, in view of the entrenched conservatism of the old curriculum; those in charge of the colleges, who resisted the new, brought all their woes upon themselves. But it was entirely irrational, and cheapened the college and its degree, to leave the course of study to the untrained and often whimsical (when it was not a super-expert) choice of a lot of boys.

It was not that the old course was a required one that brought on its collapse under assault; it was the nature of the requirements, and of the exclusions. New forms of knowledge were on the increase, and, in particular, science was coming to be the feature of the age. If education was going to fit the young to live in the society of the time, it could not stick to the old course and look with contempt upon the characteristic intellectual activity of the epoch. By trying to do this, it proved itself maladaptable and was selected away. This was inevitable; the old education was suffering from a sort of "spinescence" and could no longer adjust; and so the board had to be swept clean, for a new deal.

No cataclysm of this order can occur without loss of much that is good. As I have intimated, we now see that the old system had its parts. We can never go back to it again—*Was vergangen kommt nie wieder*—but there is no reason why we can not, now the surge of the reaction against it is past, and it is dead forever, reintroduce some of its best features.

I have said that the old required course did not fall because of the requirement, but because of the course. The element of requirement was swept away along with the course, in the rush of reaction and of resentment. Then came the confusion of the two; requirement of anything became anathema, and freedom was the watchword all along the lines. The elective system reached clear into the elementary schools, as an inundation, having once risen to surmount its first barriers, goes coursing up the country toward the foothills. But sensible people are now coming to see the folly of such extremes, and to awaken to the fact that the college course, like any other course of learning, should be laid down by men of experience and perspective, not by boys who lack both. If those who have tried to direct the studies of the youth had not ignored the nature of the material with which they had to deal, as certain savants whom I have noticed still wish to do, the axiom that any course of study, whatever it may be, should be required (and should be so difficult as not to be chosen voluntarily by the ne'er-do-well) in order to be effective, would long ago have been generally admitted.

I believe firmly in a required course of study, therefore; though I premise that it is to be laid down by men of experience with students of all types, and who have attained a perspective, not only of studies, but of the life of the society into which the students are to be *per gradus* inducted—" graduated." First of all, therefore, I think that a college wishing to adopt a policy regarding the B.A. degree, should move straight toward a required course. If the student insists upon choosing, let him choose between colleges—there will always be some that allow him " freedom." But having chosen to try for our sort of B.A., which we are striving to make distinctive and distinguished, let him plan to do but little more choosing. We will take the responsibility along with the power, and stand or fall by our results. Of course this takes some nerve, and means that we bid defiance to the prevalent cult of numbers. We may even become poorer, for a time—though, if we carry out our plan we shall presently have candidates, as one man put it, " yammering at our gates."

I said that the student should do little more choosing. He should do none that would allow him to evade a certain " irreducible minimum " of requirement. Now, what will this irreducible minimum be? Naturally, the very essence of essentials. In a word, it will include what a thoughtful mature graduate is glad he had, and does not see how he could have spared, plus what he regrets that he did not have, in his own college course. Putting together the experiences of such men, experiences of which I know, I find that a collegian should make the acquaintance of all of the several characteristic disciplines included in the curriculum of any college of the better sort. One man I know, reared under the old régime and rebelling in no pronounced way against it, graduated without knowing any natural science—knowing no astronomy, chemistry, biology, physiology, embryology, geology, or botany. He had no course treating of the greatest single factor in modern scientific thought, Darwinian evolution. I am speaking only of disciplines to which he was not "exposed" at all. There were some courses which he took that were rendered useless to him because taught so poorly as to be repellent, or because they were unsystematic, or (even at that time) arranged for the budding specialist. In a number of lines, therefore, including some in which he had courses, he was not sent out of college ready to understand, as a liberally educated man should, many of the most significant things in the life of the society within which he was to live and labor. In certain lines he has had to acquire, by considerable exertion, the elements of sciences related to his own special work and necessary to him. With all these hiatuses in his fit, he was not a liberally educated man. He will never be that now, for life seizes one and works him and wearies him, and the power of acquisition, and the time for it, fail.

Others whom I know pursued science more especially, in the time they could win out of the old classical schedule, and do not show the painful lack of it indicated above; but they have a similar ignorance of modern language, let us say, or history, or literature. They feel these lacks and have as strenuously labored somehow to make them up, as my other friend did in the matter of science. They were not liberally educated, because they had had little but science; he, because he had had almost no science.

It is a common saying of the advocate of specialization that any defect incurred by devoting attention almost solely to one thing will be automatically remedied by the youthful specialist, who has thus learned application and seriousness of purpose. I do not know where the evidence for such a view is to be found. I recall cases used (prophetically) in point, but, viewed after the act, they did not pan out. As a matter of fact, such a specialist will remain narrow unless he is an extraordinary personality who will react against the unwisdom of his course and see its straitening effect. As for the ordinary man, he will never do this, but will live on to constitute one of that pitiful band of the half-educated who think they know it all, or will be one of those who feel all their lives the lack of a rounded equipment. There is no time later to get these things up; a more advanced age rebels against the drudgery; and no amount of mere reading can take the place of a skilful introduction and guidance through the elements. Few will begin Greek with the excellent Balbus at seventy, or even late in middle life, as Huxley did. These things are like the diseases of children: taking them betimes is best; with adults they go hard.

Returning then to the idea of general "exposure" of the mind to cultural influences as represented in college courses, it is understood that we want all the influences, not one alone, to "take." Let one predominate after a while, if fate wills it; but see to it that there is a proper exposure to all. For one thing, you can not be sure which is the real infection till all are conscientiously tried. One influence, coming a little later, may easily be prepotent over another which looks to be the real and lasting thing until the all-compelling factor enters the field. Frequently it is a subject not encountered till senior year that proves to be the really engrossing attraction. Every such possibility should have had its chance before college is over. By that time the conditions for an intellectual orientation should all have been met, and even the totally "non-specializing" student should have selected his intellectual hobby—so blessed a thing to fall back on, "mid this dance of plastic circumstance." A sane choice of intellectual interest can not be made on the basis of mere whim, fancy, or vague yearning. I can recall a graduate student whose first idea was to write a thesis on the relation of God to the universe; but who, advised to look about a while first and study things, ended by producing an excellent dissertation upon the metal-industry of a small eastern town.

It will be observed that we are working around to the conception of the liberally educated man as one who knows enough about all the different major intellectual disciplines to have developed an intelligent special interest in one or more of them. If a student is obliged to become really acquainted with the essentials and methods of a variety of disciplines, he is almost sure to develop a fondness for some one of them. There are not a few busy men who take pride and pleasure in pursuing as they can some line of intellectual activity utterly disconnected with mere business; and this keeps them interested and interesting. Such men reflect great credit upon the college they attended; and they live happier lives. But this even semi-specialization is only a by-product of the B.A. policy here advocated, which would, as its paramount function, hold every student to a required course including the elements and essentials of all the major branches of knowledge or mind-cultivation taught in the better colleges. Let us get down nearer to particularization as to this policy, which aims to turn out well-rounded men rather than specialists or even hobbyists.

It goes without the saying that no man is well rounded who is graduated ignorant of science and scientific method; or without development on the side of the literary, or the esthetic in general. I think it would generally be admitted that the graduate should be able to read freely some language beside his own. Dispute might rise as further attempt to particularize is made. Somebody might object that one need not take both physics and chemistry, both geology and biology, both an ancient and a modern language. I suppose, however, that no one would deny that it would be better if all of these could be gotten. If, now, we scan the list of departments or subdepartments represented in the catalogue of some good college, we are surveying a classification of intellectual disciplines—a classification for the most part automatically evolved, of disciplines regarded as sufficiently typical in content and method to be set off one from another. Let us see whether such a classification, developed for ends quite other than those of this essay, can aid the present inquiry at all.

In general, there are about a dozen categories that might be considered as representing major divisions of human knowledge as taught to undergraduates: ancient language, modern language, English, mathematics, physics, chemistry, biology, geology, psychology, history, philosophy, economics, sociology. Suppose a man of twenty-two to be familiar with the general content and method of the above disciplines; would he not be a liberally educated man? Would he have the regrets at the hiatuses in his education of which I have spoken?

"No!" roars the specialist-lover, "he would not be educated! He would have a smattering of a lot of things, and really understand no one of them! Out upon him for a shallow taster!" Well, even so, would he not be better off, in his claim to be liberally educated, in his right to the B.A., than a man who had taken a strictly special course, and to whose amœba-saturated head any thought, say, of the essential nature and the evolution of human society was foreign? To whom the names of Homer and Goethe, and Caesar and Bismarck, were mere vocables?

But let us pass this instant and *ex parte* objection by for the moment, in order to get clear upon two preliminary matters, one of which conditions the other. First, is such a scheme practicable? By a simple calculation it is seen that if each discipline cited above were allowed a three-hour course for a year in which to treat the essentials of its being, the sum of the hours would be thirty-nine (out of the usual sixty required for the B.A.). This sum could be reduced somewhat if "exposure" had already taken place—say, by four years of Latin—before coming to college; but it would also have to be increased somewhat in the case of certain disciplines begun later or covering much ground, as, for example, the social sciences or history. Forty-five hours at the outside, that is, three-fourths of the college course, ought to do the business for any one, leaving fifteen for following up certain disciplines, to attain a more intensive knowledge of them. A boy well-prepared or "exposed" at entrance would automatically, and properly, win a larger scope of election; for he would have much more than fifteen hours free. The essentials acquired, there might then be some choice, though it should not extend beyond going on with some stock course deliberately laid down by the department in question as the next vital step in acquiring the next most important things. Rambling should cease, under this system.

But I hasten to the objection now for some seconds on the lips of some readers. "From our elementary courses the student can not get the essentials or the perspective." This is true. The nature of many elementary courses, as now given, would have to be changed. Some departments always look at the elementary course as the first step toward making a specialist, and put forth no effort to get the essentials of the discipline before the student; he will gradually, doubtless—at least, it is to be hoped—soak them in as he goes on in his specializing. This attitude seems highly unwise if it is deliberate, and inexcusable if it merely represents laziness or lack of interest in beginners—a lack generally conspicuous in the specialization-champion. Nothing impresses youth so much as catching glimpses of vistas and perspectives, as he works through a tough undergrowth. It gets his interest aroused; and that is good, even for the future specialist. But we have seen that most college students have no idea of becoming specialists. Hence the conduct of an elementary course on that assumption is a basic error. A change here would be, in any case, an advantageous adjustment to actual conditions.

And then there are other elementary courses which are loosely constructed, and in connection with which there has been no attempt at all to get down to essentials—not because the idea here is specialization, but because there has been no pressure on anybody to determine what the essentials are.

Who can deny that it would be a blessing for any department to have to take thought and be resolved as to what essentials in its line are? To "get down to brass tacks"? To clear decks for real action? Courses, as well as departmental schedules, get cluttered up with curios, antiques, and bric-à-brac, whose function is chiefly to obstruct movement and collect dust. The "irreducible minimum" to which I have alluded is what is left when these are cleared away; and it is just what the student most needs. He can be a liberally educated man if he has not read the "Castle of Otranto," but not so if he is innocent of acquaintance with "Hamlet," or "Paradise Lost," or "The Idylls of the King," and can not write clear, idiomatic English. He may be able to calculate the sort of sound waves emitted by an organ-pipe, but if he does not know how a barometer works, his physics has failed him. He may have dissected dozens of frogs, but if he does not know his Darwin and his Huxley, he is not (biologically) liberally educated.

The elementary course, required of everybody, should be a candid answer to the question: What shall here be given that the student may see the characteristic sphere in the world of learning and living ocupied by this subject?

I hear the phrase "information course" echoing back to me from one of my earlier paragraphs. But what must come first; which is more elemental, even if also more elementary: facts, or syntheses and methods? Said an elderly lady, reflecting upon her schooling:[1] "I have sometimes thought that historic research would be easier for me if sometimes I knew what men did before I was forced to understand why they did it." It is the fact that is primordial, and upon it mental operations spend themselves. Many courses in economics fail because the students do not know the economic facts—say, the difference between a stock and a bond—upon which the structure of theory rises. I maintain that it is no aspersion upon a college course that it is "informational," provided the information is true and to the point. What the beginner needs, whether he is going to specialize or not, is sets of data, classified and interpreted according to the accepted theories of the discipline in question. The theory-end, admittedly, has to be in the main dogmatic, ignoring exceptions for the time; for the crucial desideratum is a foothold, a *point d'appui*. But the American student is not docile to the extent of following blindly wherever he is led. He is strongly practical, like the nation that nurtured him. He must needs see the relation of what he is doing

[1] Winifred Kirkland, "An Educational Fantasy," *Atlantic Monthly* for August, 1915, p. 237.

to human life and interests. The great figures in the teaching world have always related studies to life. If such a relation can not be compassed, it means either that the study is an unearthly phantasm or the teacher is a misfit or is at fault. Much that goes under the designation "information" is really illustration, calculated to fix a point or set of points by relating it or them to tangible facts, previously known or unknown, as anchors to hold the floating synthesis within reach. Much so-called "information" is pure exposition; and not seldom the contempt poured upon it is a reflex of envy of the results secured by the expositor skilled in his function.

The conception of a college course which I have sketched, in its essentials, demands the skilled expositor above everything else. For it proposes to stir the interest of all students and there is only one possible way to do that. Great names in the world of scholars mean nothing to the average college man; they never come to college to study under a great scholar, so far as my experience goes. In my day, at Yale, nobody had any idea that Gibbs was a great figure; and all we knew of Whitney was that he made the German grammar and dictionary, and so must be a very learned man. Seymour too must be a great scholar, we thought, for did he not write that First Three Books of the Iliad! Text-book writers do more to advertise a college among school-boys than any other class of professors. What does the average undergraduate know of the research doings of a professor, or what does he care?

But above all is the exposition. "When you go to college," says an older brother to a younger, "take X's course in Y-ology. Don't miss it. It's an eye-opener. He's hard, but he's got it." "What has X written?" queries the casually listening father, "Has he a national reputation?" "Oh, I don't know about that," is the answer. "I suppose he has. We read a book of his—I've forgotten the title. But he certainly can get it across." And the father knows that is so, for the solicitous eye of the parent, dissembled though his scrutiny may be, has discerned the unmistakable signs of something that has somehow been "got across."

This is no place to go into the qualities of the teacher except to say that he regularly has the knowledge of student-nature—he knows his materials—and the eye for essentials. He does not hope to get in much more than these, and he enfilades and cross-fires with them relentlessly. Such have been all the great expositors and mind-openers whom I have known. And, since a required system naturally evokes some opposition, it would be particularly necessary for a college adopting that system to emphasize these qualities in appointments.

Another essential for the adoption of any such system would be the courage, not only to introduce it, but to carry it through. One of the means now advocated for improving the college degree consists in abandoning the majority of each class to its fate, letting them slide through as they will, on the analogy, or in imitation of the English "pass-men," and concentrating all attention upon the few "honors-men." The proposal of such a plan seems to some of us un-American, or, if a chauvinistic connotation clings to that term, chimerical. It is a plan that would be maladaptable to American conditions. But, apart from this, it is no way to lift the body of students to a more scholarly level; and I maintain that the American college is bound, even by the very purpose of its endowment, to aim at the body of students. Funds were not given to enable a group of lofty souls to do what they like to do in life; they were meant for the students, and, through them, for the nation. The college is the thing endowed, not the faculty.

The plan developed above would demand courage—the courage to impose a discipline over all which would issue in a considerable mortality among some—those who could not or would not fall in with requirements. Many men would have to take five years to complete the course, and many would be dropped. The plan, as distinguished from the "pass-and-honors" one, would be, not to cause the plant to grow by attaching elastics to the topmost shoots, but by going in with a pruning-hook nearer the roots.

I may conclude by enumerating briefly several of the subsidiary advantages of a course such as I have suggested. First of all, it would help to settle the vexed question of entrance-requirements. The issue would be left bare and stark: what does the college demand in order to have a man prepared to go on for its style of B.A.? If he can present qualifications, well and good; if not, there are other colleges. Next, the congested time-table, with its courses bunched in the forenoons from Monday to Friday, could be spread out into Saturday and the afternoons. No longer could an instructor's course be crippled, as it now is, by placing it on Saturday morning. And for the student there would be no more cases of four exercises or more, nor yet three or four two-hour examinations, on one day. The stress against exodus over the week-end would be strengthened, as also would that against participation in too many extra-curriculum activities—against which even the students protest.

There would not be time, if getting the degree were not to take over four years.

Departments could and must concentrate and strengthen their offerings of courses; the outlying ones must perforce decrease. This would save a great deal of trouble and money for the college.

The expense and irritation connected with making up student schedules would be lessened, and there would be no more lop-sided lists of choices, whereby a student may "specialize" unwisely or overwisely. Irregularities of attendance could be more readily dealt with, and the teachers of all departments better organized to cooperate and march together. At least they could know what their students had already had, and thus be enabled to avoid repetition and to have some idea of what there was to build on. The work of instructors could be tested up; in fact, they would be subjected to a sort of natural selection, and fewer plausible excuses could be found for failures.

The reader who is familiar with the group of irregularities known as the "abuses of the elective system" will see that they could not persist under a "new" required system. There were abuses of the "old" required system, too, but they were less than those that followed upon the lodging, in student choice, of power for determining college policy. A great many of the ills under the old required course were, I repeat, due to the course more than to the element of requirement. There will doubtless be new evils and maladjustments, but these could be dealt with, provided the general policy rested upon the facts, and on the principles derivable from knowledge of them.

And the college that offered a B.A. course of this order would stand some chance of escaping the impending fate of a college in a university: of becoming a mere feeder for the professional schools.

EVIDENCES OF FULL MATURITY AND EARLY DECLINE[1]

By J. MADISON TAYLOR, M.D.

PROFESSOR OF APPLIED THERAPEUTICS, TEMPLE UNIVERSITY, MEDICAL DEPARTMENT

AT the apex of maturity we become aware of an increasing contentment, a welcome feeling that, no matter what happens, we are better able to meet events with precision and judgment. During youth and early adulthood often there obtrudes an undertone of anxiety lest we have omitted or forgotten to do some tasks we ought to have done and didn't. During maturity arises an easement, the natural fruition of fully developed powers, the sum total of training and adaptative measures. We have met and overcome such a multitude of troubles, the onset of another one no longer makes afraid.

Sleep becomes now more tranquil and refreshing, though perhaps not so long nor so deep; action is more deliberate, there is less sense of hurry, of urgency to duties or obligations or indeed to gratifications of sense. Digestion improves in proportion as more time is spent at the table and less is stolen from post-prandial amenities. As a keen young man or a bustling young woman, eager for amusement, there were restless surgings to and fro from sheer prodigality of impulse. The act of feeding thus came to be regarded as merely a negligible incident and hence nutrition suffered. The maturer, more deliberate person tends to become rubicund, to take on weight or at least not to squander it. Accumulation of flesh at this time is natural enough within certain limits of safety. Beyond those bounds, those normal variants, obesity gives evidence of disease, that anabolism is out-running katabolism. Perils begin from this point which may lead to any one of a multitude of destructive happenings.

Mental processes of maturity differ from those of ardent young adulthood chiefly in a relative sedateness as contrasted with adolescent eagerness and exuberance. A calm assuredness now obtains, based on experience, poise; a welcome subsidence comes of early vehemence or overenthusiasm. Initia-

[1] Dealing chiefly with mental (psychophysical) phenomena. A previous paper on the subject will be found in the issue of THE SCIENTIFIC MONTHLY for November, 1917.

tive is still abundant enough, so is confidence and ardor, tempered, however, by an amplitude of contrasts, experiences and discriminative or selective proficiencies. Instead of an idealized enlightenment there comes a product of associations, a familiarity with cognate facts and circumstances leading to justifiable inferences.

Precision in assembling materials for conclusions and in their orderly arrangement constitutes a full equivalent of former lavishness in gathering data. Youthful percepts are almost limitless in plenitude and variety. The imagery of adolescent prepotencies becomes merged in maturity into a clearer and soberer vision of things as they are.

The man of many successes, as the meridian passes, readily comes to overvalue his own opinions; he tends to form conclusions more in accord with personal limitations, his prejudices, with the point of view of his habitual angle of approach, rather than that warranted by the facts. He may be, and usually is, less ready to change and modify than would a younger one upon presentation of adequate evidence.

In the psycho-physical sphere that which can now be most safely counted on is the measure and degree of fruition attainable through favorable environment, through liberalized variety, through healthful and stimulating mental and moral influences. The mind exerts paramount effects on both development and on survival values, hence the significance of having attained right points of view and disposition during the plastic years. Thus a serene temperament is achieved.

When the body degenerates and declines there is nothing left but the husk from which the spirit fades till it disappears. Whatever view one may hold as to the ultimate fate of the vital spark, it is obviously something with points of similarity to the springs of action in survival energies. We picture our future in accord with the best teachings; the more beautiful and reasonable manifestations of dynamics, the better.

To do justice to the subject of mental characteristics which distinguish maturity would involve a survey of general psychology beyond that which is permissible here. All that can now be offered are a few memoranda of those mental peculiarities displayed in maturity which shadow forth the beginnings of senescence.

In certain individuals the mind remains soundly integrated till the end of a long life, so clear, the memory so retentive, the perception and judgment so keen, that they enjoy the appreciation of their fellows till well into the eighth or ninth decades.

Through such exemplars we learn that senile mental decrepitude is not inevitable under fairly favorable conditions: only a normal decadence, *i. e.*, a series of normal phenomena of devolution varying in kind, but little or none in degree. Abnormal physical changes accompanying old age, on the contrary, may be of the widest latitude. Indeed, energies and integrities of the mind may, and often do, far outlive those of the body.

It should be remembered that some mental phases of overripeness are merely the result of lax methods of thinking, of inattention, of defects or neglects of memory, of faulty habits, and not due to morbid alterations in structure. If, or when, unlovely mental peculiarities persist, become pronounced features, they may indicate gradual retrograde cell changes. These may not increase for many years.

Such of the changes as do occur in the mind and temperament as a part of early senescence are often enough mere exaggerations of long-existing inherent peculiarities, those which have grown up in one by reason of the preponderance of original trends or have not been held under adequate subjection.

The physical changes in senescence are gross and obvious, of little importance, especially in the higher walks of life where physical decrepitude is of a far less seriousness than mental. The state most worth striving for is to keep both mental and physical fitness on a par; to gain this end they must be constantly and freely used.

Mental and moral impairments are, fortunately, not inevitable till the last call is sounded. Indeed it is a blessing that defections in the mental and moral domain are not inevitable. After all, it is the manhood, the personality, which tells, rather than those threatened inroads of structural decadence which we desire and strive to escape.

Of the mental changes characteristic of later maturity, some are of towering significance and others matters of indifference. Variations during the high tide of maturity are wide in accordance with the life one has led, and especially the sort of mental occupation followed. Mental changes, being of widest scope as contrasted with the limited sphere of physical alterations, can only be mentioned in so brief a review of the subject.

The distinguishing characteristics of the mature mind are poise, deliberation, economy of effort with largest output of judgment. To be sure, it is to the old man that the laurel crown of wisdom was given in Rome—senes—senator—the highest body of legislators.

The earliest retrograde mental changes are due chiefly to wandering of the attention, loss of capacity to fix and hold it, to concentrate. The exceptions are when individual comfort is concerned.

As old age progresses these mental features are those of decline in capacity, in grasp, in coordination. Some, indeed a large part of senescent mental abnormality, is due to fatigue reactions from over-strained attention. This is far more likely to be the product of exhaustion from monotony, wearisome routine than from effort. Impairment of mental efficiency leads to dissatisfaction, distress; and the worst effects are from protracted anxieties, from exhaustion which follows diffusion of thought, therefore of clear percepts, and hence "poverty of memory pictures, the one precious possession of the aged."

Attention being unrelieved, it wanders or spreads over one group of objects and loses sight of others. Unrest follows and a habit of onesidedness in the outlook on life. Absorption in one line of mental pursuit, such as of science or art, becomes so fascinating, so confining, that a man may become indefinitely happy in one narrow line of pursuit, therefore he grows indifferent to surroundings.

This narrowing of the personality, this shut-in-ness should not be allowed to become a mere selfish indulgence and disregard of others' opinions and feelings; it may lead to petty tastes, to trivialities, to whims, to vanity into which all of us are tempted to fall.

What, indeed, is growing old? Old age is one thing (senility), and the process of growing old (senescence) is another. Old age implies length of days, accumulations of years, the inexorable process of chronologic advance. Growing old structurally is a variable state: Some do so more slowly and others more rapidly, in accord with varying conditions of inheritance and also in manner of life, favorable or unfavorable.

Variants occur due to causes inherent or acquired; also differ in different individuals, in families and in races. Old age implies mere progress of time; senility indicates deteriorations (abnormalities) in structure and hence also in function.

Senility is due to deterioration in somatic (body) structures and is, for the most part, caused by excessive accumulations of self-formed poisons (above what the eliminating machinery can get rid of) and to a few poisons from without, *e. g.*, alcohol, tobacco, tea, coffee, lead, mercury and other foreign or valueless substances to which mankind is exposed.

Senile changes, limiting functional integrity, may be grouped under the general caption of impairments in elasticity, in plasticity; the old cells become too stable, too rigid, too static. Hence the maintenance of elasticity, so far as this is possible, makes for efficiency in structures and the postponement of devitalization.

The problem before each one of us is how to attain old age while continuing to be able to render the best service with the least cost in effort, in adverse conditions, and in distress. Hence the factors are not only physical, but also economic and social or sociologic.

The aged are notoriously conservative, accepting novel ideas or suggestions with reluctance or flat denial. Parsimoniousness alternates with misanthropy. Self-restraint, in short, is waning, and may be shown in both ludicrous and pathetic directions. Temptations aforetime readily resisted now overcome former conscious control.

When the reproductive powers have ceased, capacities for affection subside. All actions or thoughts correlated with sex impulses become changed. Yet old men occasionally commit absurd or dangerous follies through sex instinct, becoming suddenly impulsive, imperative, despotic.

> The best average barometer of mental failure is memory in all its varieties—only an advance guard of an invading army that is sooner or later to devastate the brain. (Clouston.)

Attention can then no longer be sustained, is readily fatigued; mental and physical energies are diminishing. Imagination no longer colors and illumines thought. Enthusiasms fade away, as does adaptability to change and ideation.

> The old have no faith in the young. (H. M. Friedmann.)

Old persons display a tendency to overeat, in spite of the maxim that "one should descend out of life as he ascended into it, even unto a child's diet." Feeding is the one remaining pleasure, and among old people in special "homes" or asylums are found wonderful trenchermen who survive amazingly so long as they live in that atmosphere of undisturbed tranquillity.

The craving for rest and quietude in the aged is of organic origin. It permits of a systematic and orderly arrangement and storing of facts and makes for excellent mental products in those whose energies are well sustained. Particularly valuable are the thoughts, opinions and conclusions of old age when earlier training was along well-defined lines of science or philosophy or art. The greater mental detachment accentuates judicial poise; enthusiasms are then in abeyance or gone, hence conclusions are more in accord with underlying truths.

Intellectuality is shown at the best in many aged persons. Mental force depends on the kind of constitution possessed plus the nature and quality of early training. Indeed, no greater pleasures can be enjoyed in the twilight of life than a sustained interest in one's early absorbing occupations. Of course only certain aspects of these can be carried to legitimate fruition. It is always possible for some one or other department, direction or phase of knowledge or activities to be continued or elaborated.

Age being a purely relative term in all but the chronologic or legal sense, there can be no period fixed for its characteristic phenomena to begin. Modifying conditions are such as reside in individual makeup, environment, points of view, training, habits, tastes, prejudices, physical fitness and qualities of energizing.

The redeeming features of old age are that one is (then) freed from the demands of former youthful passions, emotions and sentiments—if, indeed, such freedom is worth while. The old have, besides the relative advantage of immunity to certain diseases, such as the eruptive fevers, typhoid and phthisis; the old tissues do not seem to be good media for these disease agencies. On the other hand, they are very prone to pneumonic infections and erysipelas, which carry away most aged folk. (H. M. Friedmann, *op. cit.*)

The phenomena of aging—growing old—are normal, but so frequently are they obscured by abnormalities that the impression obtains that old age is a disease. Professor Ribot (editorial *N. Y. Med. Jour.*, Sept. 26, 1908) points out the contrasts admirably thus:

In pathologic death in late age, the general cells cease to retain their powers of rejuvenation by means of external influences (bacteria, toxins, etc.) and the part ceases to perform its function. Physiologic death is, in the main, the result of failure of the brain and central nervous system to function.

Natural death in senility is therefore a consequence of anatomical, together with functional changes in the component factors of the body, partly of the cells and partly of the intermediate substances. These changes in death are not the result of external influences (such as, *e. g.*, of too much or of improper food, of disease-producing influences, toxins, etc.), but they are necessary sequels to the chemical expiration of the phenomena of life.

In the cells are formed clinkers so to speak, deposits which are products of metabolism, bringing about atrophy of the bioplasm. The intermediate substances, which are not living matter in the real sense of the word, commence to relax generally in their more or less mechanical functions, thus damaging the circulatory apparatus. This process is of detriment to the cells, the atrophy of which is thereby increased.

Diseases of senility, especially arterial degenerations, favor the accomplishment of old-age changes and conditions, but they are not integral parts of old-age conditions; they are merely complications. Old age is *per se* normal; is free from diseased conditions. Especially responsible for natural death in old age are the ganglion cells, which have always the same elements. Hence physiologic death in the aged is thus more or less of a brain death.

Résumé of Mental Phenomena of Beginning Old Age, Normal Senescence

The mental phenomena of senescence are exaggerations of those of over-maturity.

We may take comfort, however, in the well-demonstrated fact that in one of vigorous constitution the brain and its functions are also pretty certain to be and remain sound till the final fading away of forces.

The mind and all the finer faculties grow dulled in the elderly. Permitted to live in an atmosphere of comfort and peaceful routine, they are serene enough and may continue so indefinitely. Interruptions, invasions of their tranquillity are resented. Contradictions or other oppositions shock their equipoise, jolt an equanimity now readily disturbed; they thereupon display peevishness, irritability of temper, irascibility or petulance. Likewise a tendency to commit diverse follies of impulse is noticeable, to exhibit puerile ambitions and vanities, boastfulness, assertiveness, jealousies, misanthropy, coldness of disposition, indifference to family and communal ties, duties and responsibilities.

A much greater stimulus is needed to arouse sense perception in the old; responses to sensory impacts are slower, more inadequate.

The tissues involved are losing their impressions, also their capacity for impressionability. Reflex action becomes more sluggish and weaker. Instinctive acts grow fewer.

Irritability is diminished, is noticeable in all acts; the power of originating action independent of stimulation (or irritation) becomes weaker in the aged, whereas it is prompt in the young.

The regulating centers are weakened, irresponsive, though oftentimes over-sensitive to disturbances.

The acts of the aged result more from conscious purpose, from careful reason, and from habit, or they follow only upon strong irritation.

Instinct has subsided, is replaced by experience and prejudice.

Inadequate repair follows injury in the condition of growing old, especially in the more highly differentiated structures,

—the more sensitive ones, notably whose functions require for right action large supplies of blood, such as the ductless glands, the spleen, the adrenals, the brain, nerves, marrow and muscles.

Memory becomes impaired because mental perceptions have become weakened, therefore only powerful stimuli make impressions; those most affecting the individual are retained and reproduced. Hence a strong effort must be then made to recall recent events or circumstances, whereas the earlier ones are readily reproduced.

The child demands to know "why," opens up objects, pulls apart, observes the component cells and structures. The senile mind is better fitted to construct, or especially to reconstruct.

The aged mind becomes narrowed in its outlook to those subjects which concern self and especially on matters bearing on self-preservation.

Youth wants to know; age wants to be. (Nascher.)

In crowding years one is haunted by a fear of death in spite of all the offered consolations of religion and philosophy. The emotions of those passing down into the valley lose their equipoise in proportion as reasoning powers fail and mental balance lessens.

The onset of climacteric limitations in both sexes is marked by mental changes in the point of view. The temperament veers; the angle from which one views life, as the shadows grow long, is altered. Men are more hopeful for the time and after the "change of life sink into relative apathy or gloom."

In women their innate vanity supports them in great measure to keep up appearances; also their religious feelings, their optimism and their faith in the power of things unseen, supports them to maintain a cheerful front and a good appearance.

Among the mental manifestations of senility are:

Impairment of memory; of capacity to perceive, to observe; and to fix attention on current happenings. The mind wanders, veers about, drifts.

Interest in surroundings diminishes except as the individual comfort is concerned.

Doubts are readily entertained; new ideas are challenged. Conscience becomes blunted increasingly as old age advances.

Automatic acts replace the more volitional ones, *i. e.*, habit paths in motor and psychomotor mechanisms become relied on to the exclusion of the failing initiative. This increases as time progresses.

At first, in early childhood, all motor acts are the products of initiative, of will; then these acts become automatic, habitual, merge into instincts, and, as they fade, mere automatisms remain.

As age advances the phenomena of animal life gradually subside, actions become fewer and fewer and less and less controlled by will. Man retires more and more into himself, or the shell of his self; becomes isolated, is shut out bit by bit, from his surroundings and becomes absorbed in his own personal doings or survival.

In these insignia are shown the tendencies of the man, how he is influenced and narrowed by social and domestic considerations rather than the cultural effects of age, in short how "an individual reacts to the deterrent effects of aging processes and submits to become a marionette, responsive to fewer strings."

If only lower ideals are exerted, a man or woman drifts along the path of least resistance.

All this breeds increasing littleness, selfishness, which may become most disfiguring, unlovely.

The way to remain essentially young and also retain the appearance of youth is to "cultivate variability," (Boris Sidis) widen the point of view, to expand the interests. It is desirable to resist as long as possible the lowering of the curtain, "playing the rôle of the solitary unit."

Vastly more important than to pursue over-eager measures contributing to lengthening days is to keep in touch with affairs, maintain warm relationships with environment, domestic, social and especially national.

Old age has natural affinities for childhood and youth. A young life as a companion is the best tonic. To make oneself loveable is the most important aim. Cheerfulness is the key—to keep trying to reach out and affect other personalities. Old age laments becoming useless; yet one can never tell how far one's influence extends.

Growing old ungracefully is thus described by Elliot Gregory:

> There comes, we are told, a crucial moment, "a tide" in all lives, that, taken at the flood, leads on to fortune. An assertion, by the bye, which is open to doubt. What does come to every one is an hour fraught with warning, which, if unheeded, leads on to folly. This fateful date coincides for the most of us with the discovery that we are turning gray, or that the "crow's feet" on our temples are becoming visible realities. The unpleasant question then presents itself: Are we to slip meekly into middle age, or are arms to be taken up against our insidious enemy, and the rest of life become a losing battle, fought inch by inch?

In other days it was the men who struggled the hardest against their fate. Up to this century, the male had always been the ornamental member of the family. Cæsar, we read, coveted a laurel crown principally because it would help to conceal his baldness. The wigs of the Grand Monarque are historical. It is characteristic of the time that the latter's attempts at rejuvenation should have been taken as a matter of course, while a few years later poor Madame de Pompadour's artifices to retain her fleeting youth were laughed at and decried.

The situation to-day is reversed. The battle, given up by the men—who now accept their fate with equanimity—is being waged by their better halves with a vigor heretofore unknown. So general has this mania to retain youthfulness become that if asked what one weakness was most characteristic of modern women, what peculiarity marked them as different from their sisters in other centuries, I should unhesitatingly answer, "The desire to look younger than their years."

. . . The men or women who do not look their age are rare. In each generation there are exceptions, people who, from one cause or another—generally an excellent constitution—succeed in producing the illusion of youth for a few years after youth itself has flown.

The desire to remain attractive as long as possible is not only a reasonable but a commendable ambition. Unfortunately the stupid means most of our matrons adopt to accomplish this end produce exactly the opposite result.

One sign of deficient taste in our day is this failure to perceive that every age has a charm of its own which can be enhanced by appropriate surroundings, but is lost when placed in an incongruous setting. It saddens a lover of the beautiful to see matrons going so far astray in their desire to please as to pose for young women when they no longer can look the part.

Holmes, in "My Maiden Aunt," asks plaintively:

Why will she train that wintry curl in such a springlike way?

Few matrons stop to think for themselves, or they would realize that by appearing in the same attire as their daughters they challenge a comparison which can only be to their disadvantage, and should be if possible avoided.

There are still, it is to be hoped, many such lovable women in our land, but at times I look about me with dismay, and wonder who is to take their places when they are gone. Are there to be no more "old ladies"?

I am grateful to Dr. H. M. Friedmann, Dr. Robert Saunby, Prof. Charles Sedgwick Minot and Dr. I. L. Nascher, whose contributions to the subject of advancing age and its treatment are filled with valuable points.

CHEMISTRY IN MEDICINE IN THE FIFTEENTH CENTURY

By PROFESSOR JOHN MAXSON STILLMAN

STANFORD UNIVERSITY

THERE lies before the writer a stately folio, printed in Strassburg in Alsace in the year fifteen hundred, not written in the conventional Latin of the scholars of the period, but in the German language. It is a work not unknown to historians of pharmacology and medicine, but the significance of the movement it represents and the influence of its publication upon the development of chemistry and of materia medica seem not to have received the appreciation it deserves. The title of the work, translated, reads: "The Book of the Art of Distilling Simples, by Hieronymous Brunschwygk, a native and surgeon (Wundartzot) of the imperial free City of Strassburg."

The book is noted as one of the earliest printed books giving circumstantial descriptions, with many illustrative wood-cuts, of the apparatus and methods of distillation in vogue with the chemists of the fifteenth century. It is also noted among the early herbals on account of its many descriptions of medicinal herbs with illustrative wood-cuts.

The first division of the book is devoted to descriptions of the construction of furnaces and of the various forms of stills, retorts, receivers, condensers, etc., and of the various methods of distilling: by direct fire, from water bath, by the sun's heat, by the use of the gentle heat of fermenting horse-manure, etc. It is interesting to note that as with still earlier authors on distillation, there is included under this head the distillation "*per filtrum,*" which consisted in siphoning, by means of a felt cloth, the liquid from one vessel to another placed at a lower level. This process is then not really distillation, but is what we now call "*filtration.*"

Especial emphasis is laid upon the distillation and preservation of "waters" distilled by these various methods from medicinal herbs or from other substances which the pharmacology of the time recognized as of remedial value.

The second division of the work is devoted to the description of many plants and other medicinal agents, alphabetically arranged, with wood-cuts illustrating them, directions as to the parts to be subjected to distillation, the time or season for their preparation, and the complaints which the distilled waters are supposed to benefit with the doses for their application.

A single example will best serve to illustrate the character of these descriptions.

Mulberry water, by the Greeks called *Mora,* by the Arabians, *hoc,* and by the Latins, *Moracelsi,* and by the Germans, *Mulber,* is a tree well known to many. The best part, and the season, is the fruit or berry when perfectly ripe, but not near its falling.

A. Mulberry water, drunk three or four times a day, two or three ounces each time, and also well gargled, dispels the complaint of the throat called quinsy.

B. Mulberry water when drunk every morning, noon and night, for five or six days about four ounces each time, dispels ailments of the chest and stomach and softens and expels excreta.

C. Mulberry water drunk as above directed is good if one has fallen and has coagulated blood, which it scatters and dispels.

D. Mulberry water drunk as above directed is also good for a cough and expands the chest.

E. Mulberry water reduces the veins when rubbed with it and pressed with it (varicose veins?).

F. Mulberry water, when not quite ripe or when ripe is good for the eyes when introduced into them or when they are bathed with it.

G. Mulberry water from unripe mulberries is a principal water for the palate and epiglottis, especially if one gargles well with it three or four times a day, about three ounces each time, for it takes away all rawness and heat from the throat, as I have often observed.

The list of waters similarly described which makes up the greater part of the bulky volume includes distillates from many common plants and herbs, but is by no means confined to these —for the list includes waters distilled from many other substances then accepted by medical authorities as possessing curative powers:—oxen-blood, ants, frogs, frogs' eggs, flies, and many other substances the like of which are now only to be found in the traditional pharmacopeia of China.

The book concludes with a formality characteristic of the period:

Herewith is completed the book called the book of the art of distilling simples, by Jeronimus Brunschwyg* surgeon of the imperial free city of Strassburg, and printed by the highly respected Johann Grüninger at Strassburg on the eighth day of May, as one counts from the birth of Christ fifteen hundred. Praise be to God.

The distilled waters of Brunschwygk have left but little trace in the pharmacology of to-day, yet, foreign to modern practise as these remedies are, it is manifest that his work or the practise which it represented exerted a very considerable influence on the popular medicine of the time. The work of which the above is the first edition passed through at least nine editions. It was followed (1512) by another work by the same author on the distillation of composita, extending the system beyond the single substances or simples to more or less complex mixtures, and this work also passed through several editions. Imitations, translations and works by later writers extended the literature of distilled medicines to a very considerable volume, evidencing a very prominent popular vogue of these distillates or filtrates instead of the system of powders, syrups and decoctions which the traditional ancient and university authorities recognized.

So far as the writer has been able to ascertain, the book of Brunschwygk is the first book which presents a system of remedies based upon distilled (or in some cases filtered) waters from the numerous and varied substances familiar to the medical practise of the time.

In this respect it marks a distinct departure from the scholastic medicine of the middle ages, and was without doubt an important agent in the influences operative in breaking down the walls of scholastic conservatism in medicine, and in initiating the revolutionary movement which culminated a century or more later in opening the way to the union of chemistry and medicine.

The author of the Book of Distillation makes no claim to originality in introducing this system of medicines, nor is it probable that his book is other than a formulation of practises in use in a certain group of medical practitioners and especially of a notable group or guild of Strassburg surgeons which attained a very considerable prestige and of which Brunschwygk was the most noted in his time.

The Book of Distillation of Simples, in its general plan of arrangement, except for the part on distillation methods and apparatus, was modeled on the earlier Herbals. These were illustrated descriptions of plants, intended for the more accu-

* Our author is not particular about the spelling of his name. It is spelled in three different ways in this book.

rate identification of medicinal material, and also included synopses of the virtues of the plants and their application in medicine. The distinct departure of this book from its predecessors lay in the idea of applying the processes of chemistry to the separation of the supposed active principles from these raw materials. The traditional method of utilizing the remedial substances—the method sanctioned by the authority of the Greek and Arabian authors whose teachings were the accepted dogmas of the learned doctors of medicine—was as powders, decoctions, syrups or plasters. The idea of separating a purified principle by distillation or in some cases by solution and filtration was from the point of view of the medical faculties heretical and a phase of ignorant charlatanism.

The theoretic basis of this new medical practise is doubtless to be found in the neo-platonic theories of nature, which under the leadership of the Florentine Academy exerted a strong influence at this period and was at variance with the traditional Aristotelianism of the schools. One phase of this philosophy recognized in all things animate and inanimate a soul or spirit which represented the essential principle as separate from the grosser materials of its body. The then familiar knowledge of the obtaining of alcohol—the "spirits of wine"—and the method of distilling essential oils and perfumed waters, already developed to some extent by the Arabian chemists, served to give a substantial experimental illustration of the theory. By these processes from the gross and perishable raw substances a purified "spirit" or "essence" was obtained. It was in all probability the extension of these ideas to the domain of medicines which gave rise to the practises of the Strassburg surgeons and their fellows or followers.

However analogical and unscientific may have been the reasoning upon which the "distilled waters" school of practitioners, and however little permanent place the medicines of Brunschwygk's pharmacology have found in modern medicine, it is not to be denied that there was contained in their method the assumption of a fact of importance, that it is possible to extract by chemical methods from many substances a pure principle more efficacious than the crude material from which it is obtained. And it is also true that the historical importance of the movement inaugurated or first formulated by Brunschwygk is not to be measured either by the correctness of its theoretical foundation or by its permanent contributions to medical practise, but by its influence upon its own epoch and the relation of that influence to the future development of the science. The nature of this influence then is the important consideration here.

Students of the history of chemistry and of medicine recognize the sixteenth century as the rise of the period of "Iatrochemistry" or the application of chemistry and chemical points of view to medicine and pharmacology. Modern historians of medicine generally credit the inauguration of this revolutionary movement to the influence of Paracelsus and his disciples and followers, Crollius, Van Helmont, Thölde (Basilius Valentinus), Glauber and others; and justly so, for the life-long battle of Paracelsus against the medieval slavery to traditional authorities, for open minds to new experiments and observation, and for the recognition of chemistry as a pillar of medical science, was determinative of a new impetus to chemical science and of a breach in the medical profession which eventually won for chemistry its recognition as an essential factor in medical theory and practise.

Without in any way disparaging or minimizing this influence of Paracelsus, it nevertheless seems fairly certain that the influence of the school of chemical physicians represented by Brunschwygk was important in supplying Paracelsus with no inconsiderable part of the basis and the inspiration for his campaign.

Brunschwygk was born at Strassburg about 1450 and died there about 1534. Paracelsus, born 1493, had studied chemistry in the laboratories of the mines of southern Germany and Austria. In 1526 it is recorded that Paracelsus was himself granted citizenship (Burgrecht) in Strassburg and assigned to the guild of "Lucerne" to which the surgeons (Wundärtzte) also belonged. It was in the same year that he began his war against the conventional medicine of the faculties at the University of Basel. It is to be remembered that the Book of Distilling Simples first printed in 1500 had passed through several editions before Paracelsus was assigned to the guild of surgeons. Though Paracelsus makes no reference in his works to Brunschwygk or his book, there are many passages in his works which show him to be more or less familiar with the practises and theory which underlie the work of Brunschwygk.

For instance, speaking of Simples, he says:

> The virtue in a simple is one and not divided into three, four, five, etc., and a simple needs only chemistry ("Alchemia"), which is nothing different than with the miner or metallurgist, it consists in extracting, not in compounding, it consists in recognizing what is contained in it, not in mixtures and patchwork.

So again referring to chemistry (Alchemia) he says:

If in this (art) the physician is not in the highest degree skilled and experienced his art is all in vain. For nature is so subtle and keen in her affairs, that she cannot be used without great skill. For she yields nothing to us that is perfected in its place (occurrence) but man must perfect it. This perfection is called alchemy.

To such as the author of the distillation book the following passage from Paracelsus, "De Natura Rerum," seems very definitely to refer:

The separation of those things that grow from the earth and are easily combustible, as all fruits, herbs, flowers, leaves, grass, roots, wood, etc., takes place in many ways. Thus by distillation is separated from them, first, the phelgm,[1] then the mercury[2] and the oily parts, third, its resin, fourth, its sulphur,[3] and fifth, its salt.[4] When this separation has taken place by chemical art, there are found many splendid and powerful remedies for internal and external use.

But because the laziness of the reputed physicians has so obtained the upper hand and their art serves only for display, I am not surprised that such preparations are quite ignored and that charcoal remains cheap. As to this I will say that if the smith could work his metals without the use of fire, as these so-called physicians prepare their medicines without fire, there would be danger indeed that the charcoal burners would all be ruined and compelled to flee.

But I praise the spagyric (*i. e.*, chemical) physicians for they do not consort with loafers, or go about gorgeous with satins, silks, and velvets,—gold rings on their fingers, silver daggers hanging at their sides and white gloves on their hands, but they tend their work at the fire patiently day and night. They do not go promenading, but seek their recreation in the laboratory, wear plain leathern dress, and aprons of hide upon which to wipe their hands, thrust their fingers amongst the coals, into dirt and rubbish and not into golden rings. They are sooty and dirty like the smiths and charcoal burners, and hence make little show, make not many words and gossip with their patients, do not highly praise their own medicines, for they well know that the work should praise the master, not the master his work. They well know that words and chatter do not help the sick nor cure them. Therefore, they let such things alone and busy themselves with working at their fires and learning the steps of alchemy (chemistry).

From these and other expressions it seems fairly to be inferred that Paracelsus was cognizant of and sympathetic with the ideas and practise of the distillers of simples.

It is true that the application of chemistry to medicine as visualized by Paracelsus transcended in extent the distilled waters from the conventional remedies of Brunschwygk, and his own practise extended to the use of inorganic salts and com-

[1] Meaning the watery distillate.

[2] With Paracelsus this includes volatile or gaseous products.

[3] That which burns.

[4] The ash or fixed residue.

pounds of metals which would perhaps have been as abhorrent to the chemical physicians of the Strassburg school as they were to the medical faculties themselves. But it may well be true that a large part of the impetus to his campaign was derived from the Strassburg surgeons, and that his own experiences in the chemistry of the mines and the homely remedies of the mining regions supplemented and extended his ideas as to the utilization of chemistry in medicine.

That Paracelsus had knowledge of the Herbals and had a certain contempt for the various claims for the virtues of the remedies therein described is evident from a passage which applies equally well perhaps to the Brunschwygk pharmacology as to its predecessors:

> Open one of these Herbals and you will there find how one herb has fifty or a hundred virtues, and open their books of recipes and you will find forty or fifty such herbs in one recipe against one disease.

A better understanding of the significance of the origin of this school of medicine in the guild of surgeons may be obtained if we recall the relation of these to the medical profession in the period which we are considering.

Even under the Roman Empire the occupations of physician and surgeon were separate, as was also the business of collecting, preparing and selling of drugs and medicines.

In the early Renaissance, and throughout the period of the distillation books, the doctors of medicine were very conventionally and generally very superficially trained by lectures or readings in the dogmatic theory and practise of traditional authorities. Their knowledge of physiology and of anatomy was in general slight. Independent observation and experiment were practically inhibited by their oaths of allegiance to traditional authority and by professional caste pride. Custom also dictated that the physician was not to lay hands upon his patient in the way of any operations. In case bleeding or leeching was considered necessary, the barber was called in, in more grave operations—fractures, amputations or internal operations—the surgeon was called upon. It developed that, generally speaking, the doctors of medicine became more and more rigid in their adherence to the dogmatic medical theories, and less and less capable of progressive development.

The surgeons, on the other hand, were in general not men of traditional learning nor necessarily trained in the Latin of the scholarly classes. They learned their art by apprenticeship under older surgeons, and sometimes also in special schools for surgeons. They were not "*doctors*" but "masters" (magister). Theirs was a skilled trade, not a profession. In the wars it was the surgeon who accompanied the troops to dress their wounds and to care for their health. The surgeons were very often also appointed as city physicians (Stadt-Artzte) to care for the health of the poor who could not well afford the high fees of the regular doctors nor to pay the prices for their often costly prescriptions of rare and far-fetched medicines.

The surgeons, therefore, very naturally develcped a medical practise less founded on scholastic traditions than upon their own experience with popular and homely remedies, though naturally also greatly influenced by the traditional practise of the scholarly physicians. Their practise tended more to an empiricism which, however unscientifically founded, yet had the advantage that it was not bound by the traditions of authority which limited the regular school, and was more open to the reception of new and progressive ideas. The surgeons also, by the nature of their experience in the performing and care of serious operations and their care of the poor, acquired a better knowledge of anatomy than the doctors.

It is not surprising, therefore, that as early as the twelfth and thirteenth centuries in Italy, the thirteenth and fourteenth centuries in France, and soon after in Germany, the surgeons became recognized as a strong and influential group, and that even as medical practitioners were often strong competitors of the regular physicians for popular favor. The names of Lanfranchi, Mondeville, de Chauliac, in France in the thirteenth and fourteenth centuries, and of Brunschwygk and Von Gersdorff in Strassburg, are illustrations of surgeons who attained distinguished eminence. Brunschwygk himself was the author of a work on surgery, apparently the first printed treatise by a German surgeon, first printed in 1497 in Strassburg and passing rapidly through many editions.

The surgeons of the period were then also medical practitioners with a very considerable following among the people, however discredited by the learned classes. But because they were not bound by allegiance to recognized authorities whose teachings were held as almost sacred by the university doctors, they were more open to new ideas and better able to profit by the results of their own experience. Thus their influence grew with the advance in knowledge more rapidly than did the influence of the conservative physicians.

Hence it is that the surgeons were the ones who first took cognizance of the development of chemical methods and phenomena and endeavored to apply these methods to the purification and preparation of medicines. And as above suggested it is probable that the neoplatonic idea of the existence in every medicinal substance of a pure essence or "spirit" which was the active remedial agent, was the origin of this first attempt to apply chemistry to the practise of medicine. The author of the "Liber Destillandi" himself explains that the distillation of his "waters" is for the purpose of separating the active agents from the impurities which complicate or interfere with their action. To what extent the methods and practices of the Strassburg school represented by Brunschwygk prevailed in other localities at the time is not known to the present writer, but from the fact that the distillation books of Brunschwygk and others enjoyed such an extensive popularity as is evidenced by their many editions and translations, it is evident that their influence was not insignificant. That Paracelsus a quarter of a century after the publication of this first edition of the "Liber Destillandi" evidently was to some extent inspired by this movement in inaugurating his campaign for the union of chemistry and medicine, seems fairly to indicate the important place of this early phase of chemical medicine in the history of the application of chemical experience to medical development.

Brunschwygk's "Liber Destillandi" appears to be the first published systematic attempt to graft upon the practise of medicine the methods and the theories developed by the early chemists. Though that attempt contributed little of permanent value, it very manifestly assisted in inaugurating the movement for the union of chemistry and medicine which by the campaign of Paracelsus and his disciples developed into a revolutionary movement both in chemistry and in medicine, a movement which since has been continuous and of ever-increasing importance.

METEOROLOGY AND THE NATIONAL WELFARE

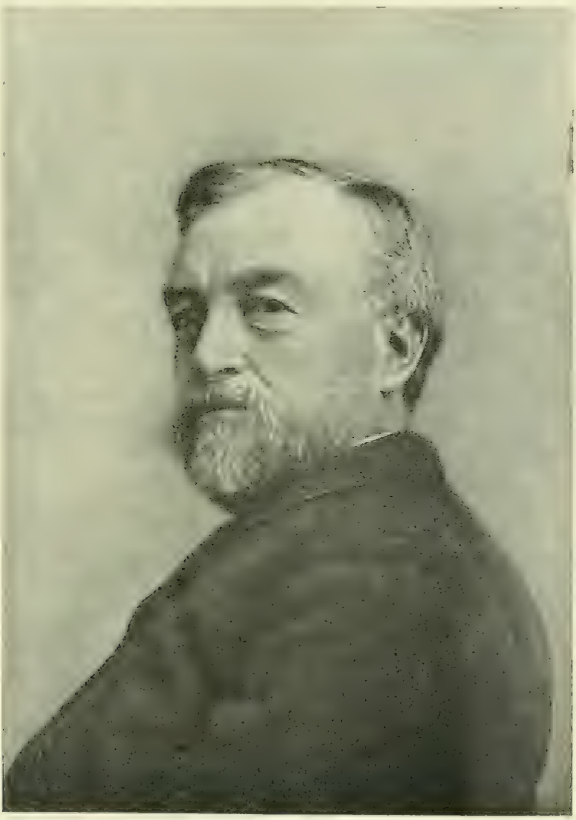
By ALEXANDER McADIE

A. LAWRENCE ROTCH PROFESSOR OF METEOROLOGY, HARVARD UNIVERSITY

THERE are some who maintain with cheerful optimism that a stirring of the pool is beneficial for nations as well as individuals. For there seem to be results which the untroubled waters never give. In the present world-wide war surely we have had a stirring sufficiently vigorous to satisfy all anticipations, and it only remains to look for the great good which should follow according to the premise. Certainly there have been great economic, social and political consequences. Among others we may cite the limitation in the use of vodka in Russia, the restricted use of liquors and stimulants in general, the suspension of distillation of spirituous beverages in the United States, the regeneration of Russia politically, the spread of democratic ideas, the exploitation of Africa, the development of under-sea craft and submersibles, and standing out most conspicuous of all, in meteorology, the conquest of the air. Without question the great war has given a stimulus to the art of flight and the construction of air-runners which twenty years of peace might not have equalled. There is no doubt now in the mind of the public as to the future use of the air in the transportation of mail and fast freight. And this present mastery of the air, the medium in which we move, is the greatest advance yet made in the long campaign in which men have sought to rise from earth and rival the birds.

Twenty centuries have passed since men began to speculate concerning the nature of air. Practically there was no advance until a Florentine experimenter (he had had the benefit of a few months' acquaintance with Galileo) turned a tube of mercury upside down in a bowl of mercury. That simple experiment demonstrated that a balance could be maintained between the column of mercury *in vacuo* and something outside, that something being the atmosphere. The master himself died without comprehending the law of aerostatic pressure. It seems simple enough now and every schoolboy understands it, but previous to the middle of the seventeenth century no one knew that human beings walk around at the bottom of a sea of air which presses upon every square centimeter of their bodies with a force equivalent to 34.5 grams, or if we can not free ourselves from the old English units, with a force equivalent to 14.7 pounds per square inch. It required the composite genius of Torricelli the Florentine, Pascal the Parisian, von Guericke the burgomaster of Magdeburg, and Boyle the Dorsetshire squire, to make plain to men this simplest of facts, namely, that the air in which we move and live and have our being is a physical substance which can be weighed and compressed. It was not until the latter part of the eighteenth century that Cavendish, the most solitary figure in science, announced the chemical composition of atmospheric air. But not until the first decade of our own, the twentieth century, did it occur to men to make use of the inertia of the air. And this, Professor Langley and the Wright brothers did.

The airplane is simply a skimming plane taking advantage



PROFESSOR S. P. LANGLEY

of the inertia of air at rest. But there is also the inertia of air masses in motion and as yet full advantage of this has not been taken. In the mass motion of air there is a vast store of energy as yet not utilized by man.

Strangely enough, nature did not provide man with any special sense organism whereby changes in air motion could be instantly detected. He only realizes changes due to pressure, when he climbs or is carried to a great height. As for temperature, the average man thinks he is responsive, but in reality always confuses the effects of heat and humidity.

Langley Aerodrome in Flight over Lake Kenka, June 2, 1914

As for changes in the density of the air, or in its ionization, or electrification and nucleation, mankind is as yet hopelessly in the dark. A few laboratory experiments made with apparatus of great sensitiveness mark the boundaries of all that vast unknown. At present we can only wonder and wait. Even in so near a matter as the changes in the internal energy of a mass of water vapor we are sadly handicapped. We are not in any way directly cognizant of the processes of cloudy condensation. Perhaps if we were we could tell in advance weather changes and say with some certainty when the rain would begin and end. We ought to be able to do these things, and yet even official weather forecasters fall far short of accuracy and, indeed, as the writer has elsewhere said, at present it is the valor of the forecaster rather than the value of the forecast which should be commended.

Leaving these infinitely small excursions and the consequences which follow molecular changes, let us consider briefly the movement of air in bulk or the flow commonly called wind. Watching the motes rise and fall in a dusty atmosphere illuminated by a sunbeam, we have all of us tried to puzzle out the causes of the circulation. It seems as if there were neither regularity nor order in the scurrying of the motes, and yet we know that the circulation must depend upon convectional currents and heat difference. Similarly, in plotting the winds of the globe, which at first glance seem to be equally complicated,

PROFESSOR WILLIAM FERREL

one feels that there must be great currents or streams of air due to convection caused by differences in temperature. We do find that there are some great wind systems and the air apparently streams with much steadiness in certain directions. It is not known how early the name Trade was applied to the winds of tropical latitudes. The navigators of the seventeenth century knew of these steady streams and utilized them in exploration and for commerce. The word "trade" had no reference to commerce, but meant persistence. The northeast Trades were the best known. Halley in 1686, Hadley in 1735, Maury in 1855 and Ferrel in 1889 tried to explain the origin of these winds. The early explanation that air moving from north to south (the directions being reversed in the southern hemisphere) passed to regions of constantly increasing rotational velocity and so would lag behind and seem to have an east component, that is, flow toward the west, satisfied the navigators of the seventeenth century, but did not appear valid to Halley, who knew of calm belts near the equator, monsoon winds in the Indian Ocean and southwest winds off the coast of Guinea. He thought that the flow westward might be in some way connected with the apparent diurnal movement of the sun from east to west. Hadley saw that if the march of the sun were a true explanation, then air should flow in from all sides toward the equator, and the flow toward the east be as vigorous as in the opposite direction. He set forth the deflection of north and south winds, not understanding that east and west winds could also be deflected. Maury plotted the winds and in the main followed Hadley. Making free use of a symmetrical or balanced circulation, he indicated the winds and pressure belts of the higher latitudes, misleading Ferrel, who laid stress upon the deflective effect of the earth's rotation and the necessary outflow from belts of high pressure in the latitude of 30° North and South, and also certain polar "lows." All the theories rest upon an assumed heating of equatorial parts and a surface flow of air from the poles toward the equator. In return there must be an upper current from the equator poleward. All these meteorologists fell into the very natural error of taking it for granted that warming the surface air necessarily caused uplift and motion. While there may be change in density, it does not follow that there will be change in pressure unless the volume remains constant. The dynamics of air motion is concerned rather with the gravitational fall of a mass of cold air displacing a mass of warm air at a lower level. To further complicate the problem, recent observations as embodied in the

Réseau Mondial for 1911 show that in certain trade-wind latitudes neither the direction nor velocity accords with the hitherto accepted values for such latitudes.

ABBOTT LAWRENCE ROTCH, 1861–1912
FOUNDER OF BLUE HILL OBSERVATORY

But rather more important than the trades, so far as the commerce of the world is concerned, are the prevailing westerlies, as they are called, meaning the flow of surface air from west to east in temperate latitudes. These winds along the California coast are often erroneously called trade winds. There is no satisfactory explanation of these winds. Taken in connection with commerce, crops and transportation they are easily the most important of the planetary circulations, and there can be no doubt but that a fuller knowledge of their origin and action would be of much value in our national welfare. It is already apparent that air routes for mail and fast passenger service must be determined by the frequency, intensity and duration of these great aerial currents.

We pass now from these major to what may be caller minor circulations, and come first to the seasonal phenomena known in general as monsoons. The word monsoon itself is from the

Arabic and means season. In connection with these seasonal air flows, the Indian Weather Service has done some valuable work bearing on the relation of these winds to the rainfalls, harvests, droughts and famines of that country. There are certain monsoonal effects noticeable in our known distribution of rainfall, and perhaps if more attention were given to the study of these influences, the accuracy of the forecasts would be improved.

The one great advance in recent years in connection with abnormal seasons was made by Tiesserenc deBort, while studying certain cold winters in northwestern Europe. He gave the name "grand centers of action" to certain areas of high and low pressure which appeared to form and dissipate slowly. These are now better known as hyperbars and infrabars. Displacements of these semi-permanent areas appear to coincide with abnormal seasons. On the Atlantic coast it has been shown by Fassig, Humphreys and others that the movements of the north Atlantic infrabar and the Bermuda hyperbar agree with abnormal seasons. On the Pacific coasts McAdie and Okada have successfully used the displacements of the Aleutian infrabar and the continental hyperbars, for forecasting. In a recent study of the flow of the surface air on the north Atlantic seaboard the writer has shown, using the records of the Blue Hill Observatory for a period of 31 years, that in a warm winter month there is an increase in the south and southwest winds and conversely in a cold winter month an increase in duration of north and northwest winds amounting to nearly 10 per cent. of a normal circulation. The temperature appears to be directly determined by the surface wind. Now the conditions favoring a cold winter month seem to be synchronous with a displacement eastward of the ocean infrabar. On the other hand, a strengthening of the Bermuda hyperbar is accompanied by the prevalence of southerly wind and higher temperature. Again, the matter of droughts in the spring is of great importance; and we find that a dry period at this time of the year is unmistakably associated with a marked increase in the duration of west and northwest winds. Evidently the inflow of moisture-laden air from the sea is lessened, and as both vertical and horizontal circulations are less vigorous than usual, there is less condensation, fewer clouds and an absence of both rain and snow. During a wet spring the north Atlantic infrabar is apparently displaced westward and the Bermuda hyperbar intensified. The surface flow from south to north is accelerated, the alternation of cyclone and anti-cyclone becomes more fre quent and apparently the dynamic compression of the air is more marked than in dry periods. Here then we begin to lay the foundation for accurate seasonal forecasts, a matter of great importance, in connection with crop yields and national prosperity.

We come next to the individual disturbances known as cyclones and anti-cyclones and the special types of tropical origin called hurricanes, typhoons and baguios. The term cyclone was first used by Piddington, who also proposed the term cyclonology for the new science of storm movement. Typhoon is from the Chinese, meaning violent wind, and baguio is from the Philippine town near Manila. The fact that the air flow in storms is

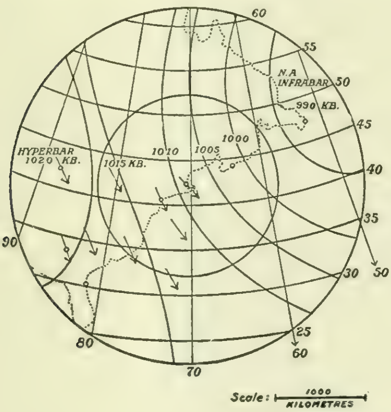


FIG. 1. THE SURFACE AIR FLOW DURING A DRY SPRING. Note: A kilobar (KB) is 1/1000 of a standard atmosphere.

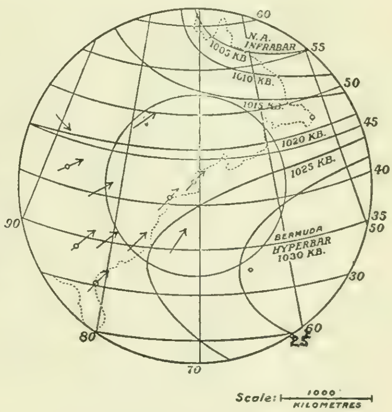


FIG. 2. THE SURFACE AIR FLOW DURING A WET SPRING.

not straight but curved was definitely determined about the middle of the nineteenth century. True there is a paper in the *Philosophical Transactions* for 1698 by Langford describing a West Indian hurricane as a whirlwind and some later references, including one in which Franklin mentions the fact that the air may have traveled many miles in a northeast storm; but it is doubtful if there was any clear concept of the rotational character of a storm at the close of the eighteenth century. Franklin did, however, set forth the fact that storms had a progressive movement, or, in other words, that there was a storm track from Virginia to New England. In a letter to Jared Eliot, July 16, 1747, after describing a wet summer, Franklin says:

We have frequently along this North American Coast storms from the northeast which flow violently sometimes three or four days. Of these I have had a very singular opinion some years, viz., that though the course of the wind is from the northeast to southwest, yet the course of the storm is from southwest to northeast, that is, the air is in violent commotion in Virginia before it moves in Connecticut and in Connecticut before it moves at Cape Sable, etc.

In another letter to the same correspondent, dated Philadelphia, 13 February, 1750, referring to an eclipse which occurred October 21, 1743, he says:

You desire to know my thoughts about the northwest storms beginning to leeward. Some years since there was an eclipse of the moon at nine o'clock in the evening, which I intended to observe, but before night a storm blew up at northeast and continued violent all night and all next day; the sky thick clouded, dark and rainy so that neither moon nor stars could be seen. The storm did a great deal of damage all along the coast, for we had accounts of it in the newspapers from Boston, Newport, New York, Maryland and Virginia; but what surprised me was to find in the Boston papers an account of an observation of that eclipse made there; for I thought that as the storm was from the northeast it must have begun sooner at Boston that with us, and consequently prevented such observation. I wrote to my brother about it and he informed me that the eclipse was over there an hour before the storm began.

Colonel Capper; Captain Horsburgh; Professor Farrar, of Harvard; W. C. Redfield, a naval architect; Brand, Dove, Reid, Thom, Piddington and Espy established the fact that in the northern hemisphere the motion of rotation was counter clockwise, while in the southern hemisphere it was clockwise. The invention of horn-cards or transparent protractors for anticipating the shift of the wind with the advance of the storm center made it possible for navigators to prepare for the change and take advantage of the shift.

Naturally it was in connection with navigation that this new knowledge found its widest application. Apparently no special use was attempted on land, and as telegraphic communication did not then exist no proposal was made to attempt forecasting. But on the sea it was vital to save ships and many hard and fast rules were laid down for the proper handling of a sailing vessel caught in a rotary storm. As Piddington says:

the navigator was taught first the best chance of avoiding the most violent and dangerous part of a hurricane which is always near the center, next the safest way of managing his vessel, and third the means of profiting by a storm by sailing in a circular course and around, instead of holding to a straight course.

Then came Maury with his "Physical Geography of the Sea." He had the sailor's direct knowledge of the winds.

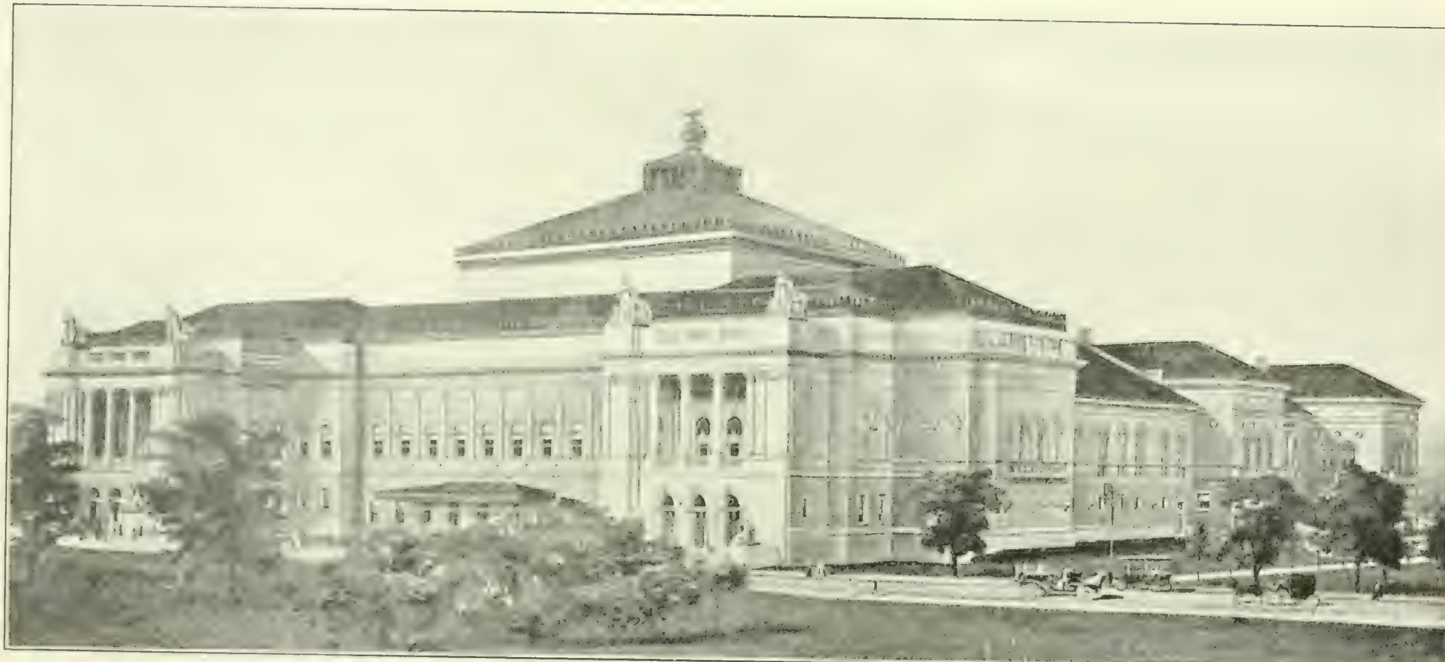
Graphic indeed are the descriptions of the voyages of the high-masted American clipper ships. The very names tell of the aspiration of their builders. The *Flying Cloud,* the *Archer,* the *Wild Pigeon,* the *Trade Wind,* the *Flying Fish* and the *Glory of the Seas* raced around the world. And our admiration is

DR. JOHN JEFFRIES, OF BOSTON, MASS., FIRST TO TRAVEL BY AIR FROM ONE COUNTRY TO ANOTHER SEPARATED BY THE SEA.

aroused not alone for the clever skippers, but also for the cartographer and investigator whose "Wind and Current Charts" were conned over by these navigators and used to advantage in their struggle for the supremacy of the seas. As illustrating the hydrographer's knowledge of the force, set and direction of the winds and currents of the Atlantic, witness the calculation of the run between New York and the crossing of the equator which vessels of certain rig should make, allowing for adverse winds. The figure given was 4,115 miles. By actual count in two cases the figures came out 4,077 and 4,099. This was the era of our national supremacy on the sea; and Maury's work and wonderful charm of presentation aided in no small degree the attainment of this primacy.

Then came the era of official weather services, inaugurated in this country by the Signal Corps of the Army. For half a century the work of official weather bureaus has centered in the synoptic map of surface conditions. It is the mainstay of the forecaster and while it has great value, the limit of its possibilities has been reached, for we may say that practically no great improvement has been made in forty years; and the methods of forecasting to-day are essentially the same as when the map was first used. From the very nature of things a map confined to one level can not indicate what is going on in the air at various levels. About fifteen years ago Bigelow attempted the construction of maps at three levels, sea-level, 3,500 feet and 10,000 feet; but the maps as constructed gave rather assumed conditions than the actual state of affairs. It would seem that the closed isobars of the surface open out into loops in the high levels. The temperature distribution, too, is different from that predicated by Ferrel and set forth generally in meteorological text-books. It is far from being a symmetrical distribution. And this in itself upsets the old theory of cyclonic formation and structure. It had indeed been shown from studies of the mean temperatures in anti-cyclones that the old conceptions were faulty. There was need of high-level data and these have been in part supplied by the ascensions of the past ten years, chiefly by kites and sounding balloons and more recently by pilot balloons. A. Lawrence Rotch and Leon Tiesserenc deBort must be regarded as pioneers in the exploration of the upper air. We need not go into detail regarding their work or the more extended efforts of the International Commission for Scientific Aeronautics. The information is given with some detail in an article by Cave in a recent number of the *Quarterly Journal* of the Royal Meteorological Society and also in a book by the writer on Aerography, recently published.

And now we face the era of airplanes through which will come, we hope, the long-desired synchronous survey at various levels. It is evident that what the hydrographer has done for navigation, the aerographer must accomplish for aviation. He takes his place as cartographer and pathfinder of the atmosphere. The logs of the planes will be assembled and the data systematically plotted for the benefit of aerial commerce. And the nation that controls the air, even more than the nation which has supremacy on the sea, will have the command of transportation and communication. It was an American naval officer who brought home to statesmen the influence of sea power upon national destiny. Captain Mahan might modify his views to-day, owing to the advent of aerial fleets, out-speeding, out-fighting, out-classing the battleships and merchant marine of his time. And our nation has reason to be proud of the important contributions to aerial navigation made by Americans. Maury, Wilkes and Coffin grouped the winds; Rotch issued the first set of charts for aviators and aeronauts, and Dr. John Jeffries was the first to journey by way of the air from one country to another separated by the sea, by a *lighter-than-air* machine, this just one hundred thirty-five years before the era of Zeppelin; and finally Langley, Orville and Wilbur Wright, Maxim, Chanute, Zahn and a host of less well known American engineers, have made flight through the air by *heavier-than-air* machines a matter of daily occurrence. The national air service promises to be the most deadly of the various arms of offense and defense. The air runner is the prospective agency through which all parts of the world shall be made readily accessible. Not only will the now unexplored regions of the earth be mapped, but also the various levels of the atmosphere, particularly in the troposphere, familiarly described as the highways and byways of cloudland. And this new meteorology, airplane meteorology, the science of the structure of the atmosphere, very appropriately carries as its name the significant word, aerography.



The Carnegie Institute, Headquarters of the American Association for the Advancement of Science.

THE PROGRESS OF SCIENCE

THE PITTSBURGH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE seventieth meeting of the American Association for the Advancement of Science was held in Pittsburgh, Pa., beginning on December 28, 1917, and continuing until January 3, 1918. At the opening general session on the evening of the first day, held in the lecture hall of the Carnegie Institute, Dr. C. R. Van Hise, retiring president of the association, gave his address, which had for its title "Some Economic Aspects of the World War."

Dr. Van Hise, distinguished equally as a geologist and for his administrative work as president of the University of Wisconsin, has made a special study of the conservation of national resources and related subjects, having prepared recently for the Food Administration an extensive work entitled "Conservation and Regulation in the United States during the World War." His address before the American Association was an authoritative review of the economic situation which should be widely read. He closes with the statement that, while nothing can compensate for the men lost in the war, he believed it probable "that if, following the war, wise governmental regulation is continued for essential commodities as well as the utilities, the savings of the people may be sufficient to meet the money cost of the war."

The addresses of the chairmen of the sections and of the presidents of the special societies, as well as the papers and discussions, in large measure followed President Van Hise in taking up questions concerned with national efficiency and wartime activities. Thus the physicists held a general-interest session on the relationship of physics to the war, and the botanists one on war problems of botany. The zoologists discussed contributions of zoology to human welfare, the entomologists insects and camp sanitation, and how entomologists can assist in increasing food production. Before the Entomological Society, Dr. Vernon F. Kellogg, of Stanford University, made an address on the biological aspects of the war. The botanists chose as the subject for their symposium "phytopathology in relation to war service"; the section of experimental medicine considered the medical problems of the war, which included an address by Lieutenant George Loewy, of the French Army, on the treatment of war wounds by the Carrel method, illustrated by moving pictures. The section of agriculture discussed factors concerned in the increase of agricultural production. Many other addresses and papers might be quoted showing the importance of the meeting in promoting the applications of science to wartime problems.

The total registration at the office of the permanent secretary was 692, distributed as follows: Pennsylvania 194, New York 84, Ohio 59, District of Columbia 44, Illinois 34, Massachusetts 26, West Virginia 21, Indiana 20, Michigan 18, Wisconsin 15, Maryland, Missouri and Canada 14 each, Iowa and Texas 13 each, New Jersey and Virginia 11 each, California 10, North Carolina 8, Connecticut, Tennessee and Kansas 6 each, Minnesota and Arizona 5 each, New Hampshire, Louisiana

The Carnegie Institute of Technology, in which many of the meetings of the American Association for the Advancement of Science were held.

and Montana 4 each, Maine, Delaware and Kentucky 3 each, Japan, Nebraska, Utah, Oregon and Colorado 2 each, Rhode Island, Georgia, North Dakota, Arkansas and Wyoming 1 each. The interest of the meeting was enhanced by the presence of the following foreigners, who were made honorary associates for the meeting: Lieutenant Georgia Abbetti, of the Italian Military Commission; Lieutenant G. P. Thompson, of the Royal Flying Corps of Great Britain; Captain DeGuiche, of the French Military Commission, and Dr. Shigetaro Kawasaki, chief geologist of Korea.

It was decided to hold the next meeting of the association in Boston, Massachusetts, the meeting to begin on Friday, December 27, 1918. This decision was adopted with the amendment that the committee on policy be given the power to cancel the meeting, or to change the place should this seem to be desirable. It was recommended that St. Louis be chosen for the place of meeting following Boston.

The following officers were elected:

President, John M. Coulter, the University of Chicago;

Vice-presidents as follows:

Section A, Mathematics and Astronomy, George D. Birkhoff, Harvard University;

Section B, Physics, Gordon T. Hull, Dartmouth College;

Section C, Chemistry, Alexander Smith, Columbia University;

Section D, Mechanical Science and Engineering, Ira N. Hollis, Worcester Polytechnic Institute;

Section E, Geology and Geography, David White, U. S. Geological Survey, Washington, D. C.;

Section F, Zoology, Wm. Patten, Dartmouth College;

Section G, Botany, A. F. Blakeslee, Cold Spring Harbor;

Section H, Anthropology and Psychology (no election);

Section I, Social and Economic Science, John Barrett, Washington;

Section K, Physiology and Experimental Medicine, Frederic S. Lee, Columbia University;

Section L, Education, S. A. Courtis, Detroit, Mich.;

Section M, Agriculture, H. P. Armsby, Pennsylvania State College.

WAR-TIME ACTIVITIES OF THE GEOLOGICAL SURVEY

THE activities of the Geological Survey, Department of the Interior, during the fiscal year 1916–17 have been concentrated on investigations connected with military and industrial preparedness, as shown by the Annual Report of the director of the survey. These activities have included the preparation of special reports for the War and Navy Departments and the Council of National Defense, the making of military surveys, the printing of military maps and hydrographic charts, and the contribution of engineer officers to the Reserve Corps.

The survey's investigations of minerals that have assumed special interest because of the war have been both expanded and made more intensive. Special reports giving results already at hand, the product of years of field and office investigation, have been published for the information of the general public or prepared for the immediate use of some official commission, committee or bureau. Geologic field work has been concentrated on deposits of minerals that are essential to the successful prosecution of the war, especially those of which the domestic supply falls short of present demands. Every available oil geologist is at work in petroleum regions where geologic exploration may lead to increased production. Other geologists are engaged in a search for commercial deposits of the "war minerals"—manganese, pyrite, platinum, chromite, tungsten, antimony, potash and nitrate.

The war not only diverted practically all the activities of the topographic branch of the survey to work designed to meet the urgent needs of the war department for military surveys, but led to the commissioning of the majority of the topographers as reserve officers in the Corps of Engineers, United States Army.

A large contribution to the military service is made by the map-printing establishment of the survey. This plant has been available for both confidential and urgent work, and during the year has printed 96 editions of maps for the war department and 906 editions of charts for the navy department. Other lithographic work, some of it very complicated, was in progress at the end of the year.

WORK OF THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

THE annual report of the executive committee of the National Advisory Committee for Aeronautics states that previous to the entrance of the United States into the war the committee had undertaken a census of the production facilities of manufacturers of aircraft and aeronautic engines, which information was made available for use of the Aircraft Production Board at the beginning of its work in April.

In October, 1916, the committee took under consideration the question of the selection of a suitable site for the committee's proposed experimental laboratory. At the suggestion of the War Department this committee inspected several proposed sites and made recommendation to the War Department for the purchase of one of them, which recommendation was accepted by the War Department and the site was purchased. On this field the War Department has allotted to the committee a space suited to the erection of the committee's proposed research laboratories. The committee has designed the first building of the group contemplated and it is now in the course of construction.

SCIENTIFIC ITEMS

WE record with regret the death of Theodore Caldwell Janeway, professor of medicine at the Johns Hopkins University; of Albert Homer Purdue, state geologist of Tennessee; of Joseph Price Remington, dean of the Philadelphia College of Pharmacy; of Hugo Schweitzer, the industrial chemist; of Louis Pope Gratacap, curator of mineralogy in the American Museum of Natural History; of A. M. W. Downing, formerly superintendent of the British *Nautical Almanac*, and of Fritz Daniel Frech, professor of geology and paleontology in the University of Breslau.

M. PAINLEVÉ has been elected president of the Paris Academy of Sciences, succeeding M. d'Arsonval. —In recognition of his contributions to science, Colonel Theodore Roosevelt has been appointed honorary fellow of the American Museum of Natural History, of which his father, Theodore Roosevelt, Sr., was one of the founders and most energetic supporters.

The committee has made progress during the year in the study and investigation of the following problems: Stability as determined by mathematical investigation, air-speed meters, wing sections, aeronautical engine design, radiator design, air-propeller design and efficiency, forms of airplane, radio telegraphy, noncorrosive materials, flat and cambered surfaces, terminal connections, characteristics of constructive materials, and standardization of specifications for materials.

THE SCIENTIFIC MONTHLY

MARCH, 1918

INSECTS AND THE NATIONAL HEALTH

By Professor CHARLES T. BRUES

BUSSEY INSTITUTION, HARVARD UNIVERSITY

AT the present moment, when America is embarking on one of the most stupendous undertakings ever attempted in her history, her resources and her obligations are weighed in the balance as never before. Industrial efficiency is fast responding to the demands made upon it and human efficiency should be increased in every way possible. The latter depends, of course, primarily on bodily food, and upon the security of the moral and physical health of the nation. These together involve a multitude of minor problems, and it is upon only one small aspect of public health that I have attempted to treat in the following pages. It seems peculiarly appropriate to call to public attention the pernicious activities of insects in relation to disease, since they present a problem which can be dealt with, at least to some extent, through individual effort and small community cooperation. The importance of insects as detrimental to public health is well known to professional zoologists, medical men and laymen alike, but is usually emphasized only under the stress of particular circumstances, such as the safety of soldiers in the present war, or of unusual outbreaks of diseases for which insects are directly responsible.

Insect-borne diseases present a constant menace to the world, and aside from the actual toll of lives which they exact, they impair its efficiency by enfeebling the health of its human population. Their direful influence is more pronounced in the tropics, whence it has been most commonly proclaimed, but our own country is by no means exempt, although its cooler climate causes it to be less severely affected.

The following account is by no means complete. Its purpose is only to call attention to some of the more important disease-bearing insects in their relation to health in our own country.

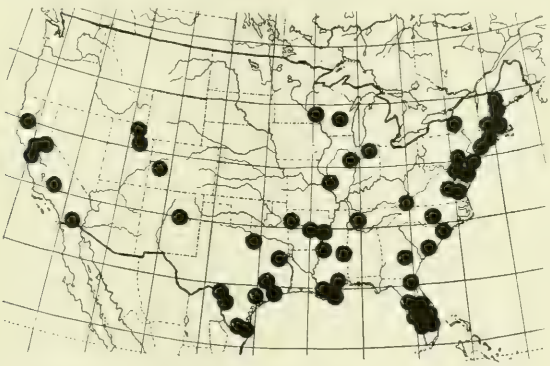
Mosquito-borne Diseases.—No other insects can compete with the mosquitoes as persistent annoyers of man, and none, with the possible exception of the rat-flea, hold over him such power for evil. Practically no parts of the globe that can serve for human existence are free from mosquitoes and large areas from the tropics to the arctic are periodically invaded by them in varying abundance. Even where irrigation has made the "desert blossom like the rose" it has often also produced a crop of mosquitoes to annoy or even afflict with disease the inhabitants of the garden.

On account of their phlebotomic habits, and particularly their hominophilous tastes, mosquitoes have always been heartily detested, even by entomologists, and only their known association with human diseases has brought them to the serious attention of zoologists. With this incentive, however, a vast amount of work has been done by entomologists and medical men and an enormous mass of literature has been produced in less than two decades, bearing on every conceivable aspect of the subject. We now know that mosquitoes are responsible for many deaths, much human misery and great economic loss through their activity as disseminators of malarial fevers, yellow fever, dengue fever, filariasis, etc.

In all of this, several of the more important relations of mosquitoes to public health stand out very clearly. They are: (1) Some very important diseases of man are transmitted by certain specific mosquitoes, the latter being absolutely necessary for the continued existence of these diseases. (2) The disease-bearing mosquitoes are most widely distributed in the tropics, whence they extend into portions of the temperate zones. (3) The range of mosquito-borne diseases is not necessarily coextensive with the distribution of their insect carriers, but is dependent upon other factors as well. (4) Mosquito-borne disease may be combated either by the elimination of the mosquito responsible; by the protection of the population from its bites; by the careful screening of human patients to prevent them from infecting mosquitoes; or by a medical prophylaxis or immunization of the susceptible population. (5) Remedial measures are preferably applied against only the specific mosquitoes responsible, not against mosquitoes in general. The last is primarily a matter of economy, that the most vital needs of the community be first fulfilled; often more willingness on the part of the community is evinced to cooperate in fighting the most annoying or abundant species of mosquitoes rather than the ones most deleterious to the public health.

Of these methods, the first has proved the most generally

MAP 1. DISTRIBUTION OF MALARIA IN THE UNITED STATES (after Trask).



MAP 2. DISTRIBUTION OF MALARIAL MOSQUITOES IN THE UNITED STATES.

applicable, preferably combined with the second and third. The last has not proved generally suitable even with malaria, where quinine is a specific remedy, or with plague, where immunization is possible.

Malarial Fevers.—At the present time malaria in its several forms is the veritable scourge of the tropics. It also extends generally into the sub-tropics and warmer temperate regions and is prevalent over a considerable part of the southern United States. In these areas, as appears from investigations of the U. S. Public Health Service, its range is roughly coincident with the moist austral zones east of the 100th meridian as defined by Merriam. Aside from this main area, there is a small one in southern New England and another in central California; there are also a few isolated localities scattered through the country where malaria is thought to be endemic (see Map 1). At least three species of *Anopheles* are known to act as carriers of malaria in the United States and, from data given by Howard, Dyar and Knab (see Map 2), the distribution of these taken together corresponds closely with that of malaria, although slightly more extensive, especially along the Atlantic seaboard. As these malarious regions include a population of about 40,000,000 people, it will be seen that the importance of malaria from the standpoint of public health is very great indeed. It must be remembered, however, that the incidence of malaria varies widely, being greatest in the large southeastern area, and very much less in the more densely populated northern district. Thus in Mississippi about 80 cases of malaria per 1,000 of population were reported during the last year, or 158,000 for the entire state. Other southern states do not report the disease so thoroughly and it is difficult to estimate to what extent they are affected. It would seem, however, that one million cases each year would be a conservative estimate, especially as von Ezdorf found in a portion of one mill town in the endemic area that over 13 per cent., or one person in seven, harbored the malarial parasite in the blood, while 233 out of 500, or nearly 50 per cent., reported having had chills and fever during the summer preceding his examination. Although the death rate from malaria outside the tropics is not very great (9 per 1,000 calculated on the data for Mississippi cited above) it is by no means inconsiderable in the mass. On the other hand, the economic loss is enormous, due to inability to work during the acute attack of the fever and due to a loss of efficiency during prolonged periods following. That malaria responds quickly to anti-mosquito work and quininization is shown by the result following an application of these measures to the mill town mentioned. Referring to von Ezdorf's report, Trask says:

> Measures were inaugurated to get rid of mosquito-breeding places and the use of quinine was encouraged. A year later the town was again visited and the blood of 780 person examined. Of these only 35, or 4.5 per cent., showed infection. The health officer reported at this time that his visits among the mill employees for several months had averaged not over one a day, and that many of these were undoubtedly for old infections lasting over from previous years. The malaria rate had continuously decreased during the months when it was usually at its worst. The health officer of the town in his report for 1914 stated that while during the summer of 1913, prior to antimalarial work, the mills were constantly short of help on account of the large numbers of employees sick with malaria, during the summer of 1914 there had not been a day when the mills did not have sufficient help. The manager of one mill stated that the improvement in the regularity and efficiency of the employees had been such that the amount ($1,000) which the mill had contributed to the fund for anti-mosquito work was more than regained in one month's operation.

While these conditions are those of one of the most severely affected districts, they are nevertheless repeated very generally throughout the entire area, more especially in the lowlands, for the hilly or mountainous and better-drained sections suffer less.

As mentioned above, several species of *Anopheles* mosquitoes are concerned in the transmission of malaria in the United States. Till very recently only one species, *Anopheles quadrimaculatus,* has been thought to be of much importance. Recent studies by Mitzmain and others show that this mosquito is the most important, as it may harbor the parasites of all three types of malaria, but *Anopheles punctipennis* (Fig. 1), a common, widespread species and *Anopheles crucians,* a species abundant along the eastern coast of the United States, may serve both as hosts for the tertian and estivo-autumnal or subtertian forms. The ease and frequency with which *A. punctipennis* may become infected seems to vary greatly under different conditions and its importance at least in northern districts is by no means proved.

Fig. 1. *Anopheles punctipennis,* female.

All three species readily enter houses and are persistent biters, although no more so than some other mosquitoes. Both *quadrimaculatus* and *punctipennis* breed in stagnant water, usually that of permanent nature containing algæ or other plant growth. They commonly occur together, with *punctipennis* usually more abundant. Larvæ of the latter species occur also rarely in temporary puddles and both are occasionally to be found in the growth along the sides of slowly flowing streams. The breeding grounds of *A. crucians* are mainly restricted to regions adjoining the salt and brackish marshes along the coast, although the larvæ are most abundant in fresh water. The two *Anopheles* occurring on the Pacific coast region, *A. pseudo-punctipennis* and *A. occidentalis,* have habits similar to those of *quadrimaculatus,* although the second species breeds in brackish waters also. As is the general habit among adults of *Anopheles,* these mosquitoes feed mainly at twilight and malaria is acquired only by persons who expose themselves to their bites after nightfall. Occasionally they bite during the daytime, but as malaria appears never to follow such bites it seems probable that only newly emerged females and consequently non-infected ones bite at this time, as is the case with the yellow-fever mosquito.

Like other insect-borne diseases, malaria shows in its sea-

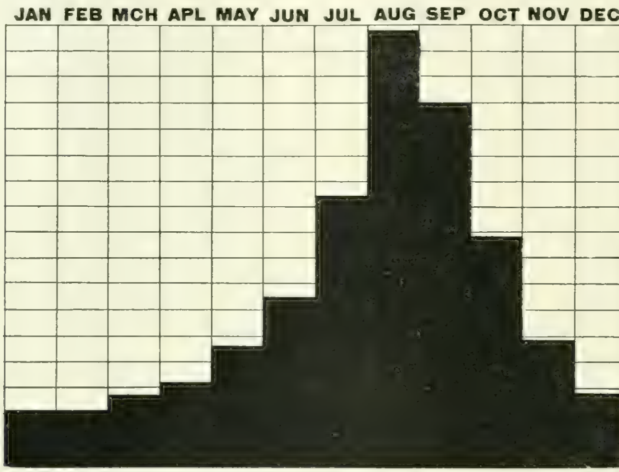
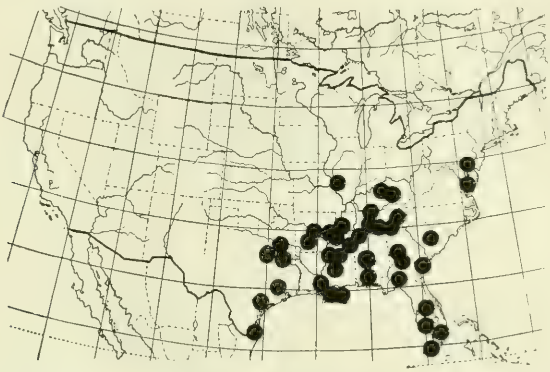


FIG. 2. SEASONAL PREVALENCE OF MALARIA IN THE UNITED STATES.

sonal prevalence a close relation to the seasons (see Fig. 2), undergoing a period of quiescence during the winter and attaining a sudden maximum in late summer, after which it rapidly declines. This is in response to the increasing abundance of *Anopheles* during the summer, coupled with a relatively high temperature, favorable for activity on the part of the mosquito and for the development of the malarial parasites in its body. It has recently been clearly shown by Mitzmain that under the conditions of temperature prevailing in the United States the malarial parasites do not persist through the winter in hibernating mosquitoes, but winter over in the human host from whence the *Anopheles* secure them the following season.

As already pointed out, the reduction of malaria in communities is permanently accomplished most readily by the application of anti-mosquito measures, aimed mainly at the breeding-places of *Anopheles* mosquitoes. Such work is being extensively carried on by the U. S. Public Health Service, by other federal bureaus, by many state boards and commissions, and by certain private or semi-private institutions in widely scattered parts of the country. Through their individual and collective efforts an enormous amount has been accomplished, although painfully little in comparison with what could well be spent upon the problem, which is without question one of the great public-health problems in the United States at the present time.

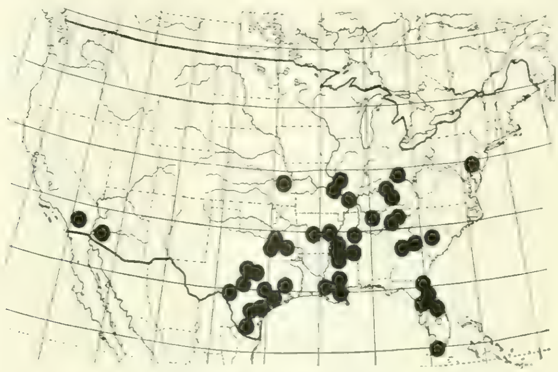
Yellow fever no longer causes serious concern to residents of any part of the United States, or, for that matter, to those of most parts of the American tropics. Most of us can recall very clearly in the not far distant past, however, the terror and demoralization which accompanied its periodical appearance in our southern ports. The yellow-fever mosquito is still abundant and widely distributed throughout the southeastern states (see



Map 3. Distribution of the Yellow-fever Mosquito in the United States.

Map 3) and sometimes becomes temporarily established further north during the summer. There is no yellow fever, except an occasional stray case from the tropics, which does not get beyond the keen eyes of the Public Health Service, and consequently our population of yellow-fever mosquitoes remain free from the dread disease. In this case several factors have combined to make possible the elimination of the disease without more than temporary and local eradication of the mosquito. In our southern states the disease does not easily survive the winter and chronic human carriers do not exist, so that past outbreaks have been due to fresh introductions and have been terminated by cold weather. During the last epidemic that occurred in New Orleans, in 1905, vigorous anti-mosquito measures were necessary, but, due to the greater severity of the disease, the consequently greater ease with which it is recognized, the limited area to be dealt with, and the absence of chronic human carriers, the eradication of yellow fever without permanent mosquito repression has been easy in comparison with the control of malaria. Even in parts of the tropics where it persists throughout the year, it is being rapidly and permanently eliminated. Indeed it bids fair to be the first disease actually to become extinct as a direct result of human discovery and applied science. What a refreshing contrast to the fate of the American pigeon and the forlorn remnants of the American bison!

Another tropicopolitan, semi-domesticated mosquito extends quite widely into the warmer parts of the United States (Map



MAP 4. DISTRIBUTION OF *Culex quinquefasciatus* IN THE UNITED STATES.

4). This is *Culex fatigans,* now known as *Culex quinquefasciatus* (Fig. 3), mainly, if not entirely, responsible for the transmission of a parasite of the blood-stream and lymphatics caus-

FIG. 3. *Culex quinquefasciatus*, female.

ing filariasis or elephantiasis. In this connection it is of small importance to us, as this disease is very uncommon in the United States, but as a carrier of dengue fever or "break-bone fever" it is of considerable importance. Dengue is a mild (*i. e.*, non-fatal) disease which causes great distress and temporary disability. It is therefore a factor contributing to lack of efficiency and goes hand in hand with malaria in this respect. Like malaria, dengue is tropicopolitan in range, and extends only into the warmer parts of the south. Here it sometimes appears in extensive epidemics, but in a much more erratic way than malaria, which has the well-deserved reputation of appearing year in and year out in the same districts. This difference is probably due to the absence of chronic human carriers and the fact that *Culex quinquefasciatus* does not breed in permanent water, but in an almost truly domesticated species which breeds in temporary water near human habitations, and under the climatic and other conditions of our country does not find anything like uniform opportunities for breeding from one season to another. In consequence of their separate breeding-grounds, measures designed to control malarial mosquitoes have no effect or practically none upon the dengue mosquito. It must be dealt with mainly by education leading to individual effort and cooperation in communities. Aside from its pathogenic possibilities, this species is a rather persistent biter, which is another argument for its control.

Less directly detrimental to public health are other mosquitoes not associated with any human disease, but making life miserable at some season of the year for human beings in practically all parts of the world. Although the United States supports an extensive mosquito fauna, a very few species aside from those already mentioned make up the bulk of those annoying man. Two particularly are widespread, abundant and on account of their strikingly different habits, perhaps worthy of mention in this connection. The first of these is the house mosquito, *Culex pipiens*, a palearctic species, now common throughout the eastern states, that breeds in rain-barrels, cesspools, sewer-catch-basins, puddles or practically anywhere, no matter how foul the water. The other, *Aëdes sollicitans*, the salt-marsh or "Jersey" mosquito, breeds only along the coast in salt-marshes. Broods of this mosquito follow the lunar calendar, developing after the high tides flood the meadows and fill the pools in which the larvæ live. The eggs of this form are laid on the mud and hatch quickly when submerged in water. It is generally believed that all the eggs laid by this mosquito must pass the winter before hatching and that the successive broods are only installments of eggs induced suddenly to hatch in turn by successive wettings. This is a true migratory mosquito, which invades the country for many miles adjacent to the salt-marshes. Such incursions follow the appearance of each brood.

Much attention has been given to the control of this mosquito in New Jersey and the territory surrounding Long Island Sound, and its numbers have been marvelously lessened through the drainage of marshes by ditching. In the case of this species reforms have been easier than with the malarial mosquitoes, as an expectation of relief from the great personal discomfort of myriad mosquito-bites exerts a stronger appeal to the average person than the much more important health problem of malaria. In the public mind, the latter is unfortunately not usually regarded as so immediately personal, as the fever and the bite are not coincident.

Black-flies.—At some time during the insect season, usually in the spring, many districts are visited by swarms of small hump-backed flies which viciously bite man and animals alike. On account of their dark color these have been called black-flies. They pass their developmental stages almost entirely in swiftly moving brooks and streams, where the larvæ and pupæ are attached to stones and other objects in the water. Wherever there are suitable streams in which they can breed, these pests appear abundantly, and may be occasionally present far from streams, where they would not be expected. They are not known to be concerned in the transmission of any disease.

Biting-midges, Sand-flies, Etc.—Minute flies, somewhat like mosquitoes, which are vicious blood-suckers, often appear in great abundance, particularly in the cooler parts of the United States. These insects belong to several genera, developing from aquatic larvæ inhabiting fresh water and also brackish water along the sea-coast. They are generally crepuscular, biting most abundantly at dusk, and are very persistent at that time, causing a stinging sensation out of all proportion to their almost microscopic size. None of our species are known to be disease-carriers.

Housefly Diseases.—Of these it may be urged that, strictly speaking, there are none, at least in the sense of mosquito-borne diseases. The housefly is not known to be wholly responsible for the transmission of any disease and its relative importance in disseminating several infections of man is still a moot question. By some it is strongly urged as the main means of transmission for several enteric diseases in certain communities; by others it is cast aside without reasonable consideration as a sort of entomologist's nightmare. I can not believe that either course is justified; each seems to be based on prejudice due to lack of knowledge, either respecting the fly or relating to other channels of infection.

The housefly (Fig. 4) is more truly domesticated than any other insect; it lives and flourishes wherever man establishes himself, but does not thrive elsewhere. It has evidently been

FIG. 4. HOUSE-FLY FEEDING ON A LUMP OF SUGAR.

associated with him from the remotest antiquity, but has by no means failed to adapt itself to changed conditions. It still develops in his feces or those of his domestic animals and still invades his habitations to partake of his food. In short, it is practically ever-present, for its preferred larval food, horse manure, is usually to be found, and, if not, substitutes are available in greater or less abundance.

The chain of events through which the housefly may infect food with bacteria or other organisms derived from excremental materials is obvious and has been so repeatedly described that it is unnecessary to outline it here. The frequency with which this actually happens is of course the vital point, and it is upon this that it is very difficult to obtain concise data.

It has been shown rather conclusively that adult flies do not retain in the alimentary tract bacteria which they may have ingested as larvæ that have developed and fed in material containing, for example, the bacillus of typhoid fever. On the other hand, adult flies readily obtain this bacillus from contaminated substances and may retain and later deposit it in a living condition on food designed for immediate human consumption. There can be no question but that this occurs commonly under many circumstances, particularly in communities where there is no adequate system of sewage disposal. That these bacteria should be more attenuated than those occurring in drinking water does not seem probable. Many facts show that flies are a very important factor in the dissemination of typhoid fever. The greater frequency with which persons on country vacations contract the disease is very striking, although this may, of course, be attributed to bad water supply. Other opportunities for infection, aside from the fly, are, however, no greater there than in the city. In other parts of the world where the water supply is reasonably good, *e. g.*, certain South American cities, typhoid flourishes to an alarming extent, due undoubtedly to excessive soil pollution, where flies can almost instantly transfer material from typhoid carriers to food, while the latter is abundantly exposed on the streets for sale to be eaten on the spot. In our own country the seasonal incidence of typhoid fever corresponds to some extent with fly prevalence, and still more significant is its greater summer prevalence in regions where systems for sewage disposal are not generally installed. This disparity is shown on the accompanying chart (Fig. 5), which gives data for two of our eastern states, New

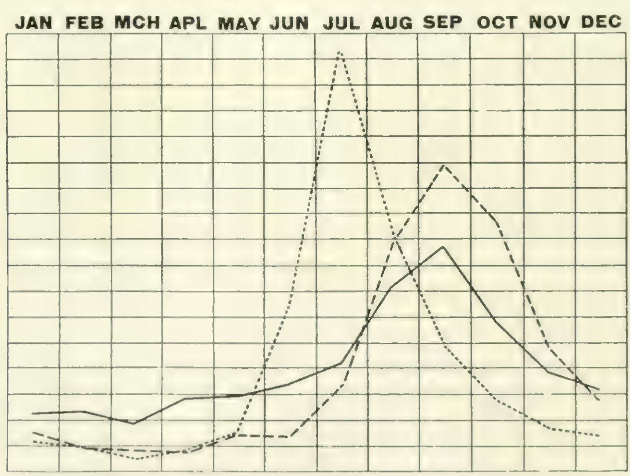


FIG. 5. SEASONAL PREVALENCE OF TYPHOID FEVER IN SEVERAL STATES; solid line, New York; dotted line, Alabama; dashed line, Washington.

York and Alabama, and one western state, Washington. The greater uniformity throughout the year in New York, where the opportunities for fly-borne infection are curtailed, is very marked. Another way in which the housefly can aid in the spread of typhoid is through infecting milk on dairy farms where carriers are present and offer the flies a chance to become infected.

Flies are also responsible, and to a much greater extent, for the prevalence of infantile diarrhea or summer complaint, and here their relation is very easily seen.

Other activities of houseflies detrimental to public health are of far less importance, but by no means negligible. They can carry the eggs of parasitic worms as well as many bacteria and other microorganisms present in the several types of unsavory food upon which they feed indiscriminately.

Recently much progress has been made in methods of abating the housefly nuisance. It has been found by workers in the Federal Department of Agriculture that certain substances, notably borax, hellebore, and a fertilizer consisting of calcium cyanamid, acid phosphate and kainit, are highly destructive to fly-larvæ in horse manure (whence the great majority of our house-flies come) and that these substances do not ruin the manure for agricultural purposes. Practical traps whereby fly-larvæ in stored manure may be caught and destroyed before transformation have also been devised. Richardson has shown that house-fly larvæ can develop only in alkaline material, and some substances may thus be acidified to eliminate them as larval food.

The people of the United States spend great sums of money for fly-screens, fly-paper, fly-swatters and fly-traps and suffer

FIG. 6. STABLE-FLY (*Stomoxys calcitrans*).

much sickness and death as a result of the ubiquitous housefly. As yet no great reduction of houseflies has been accomplished, but the public regards them less and less as harmless creatures, and should soon be in the proper mental state to launch a decisive campaign against them.

The Stable-fly.—Cattle, horses and other domestic animals, and more rarely man himself, are troubled in nearly all parts of the world by a small blood-sucking fly resembling the house-fly in size and general color (Fig. 6). On account of its great abundance about horses and cattle it has been termed the stable-fly, although its larvæ breed mainly in fermenting vegetable material rather than in manure. The adult flies readily bite human beings, particularly in damp weather, and this habit has given rise to the popular idea that house-flies bite before a shower. The stable-fly is most important as a pest of animals, as it has not been definitely proved to be more than an accidental carrier of any disease affecting man. It was at one time thought to be a carrier of poliomyelitis (infantile paralysis), but it now seems probable that such it not the case.

Typhus Fever.—Although this louse-borne disease is of prime military importance in some parts of the world, it is practically non-existent among the civil or army population of the United States. That it should ever be revived seems unbelievable, for it has passed from the proportions of gigantic epidemics in the middle ages to insignificant local outbreaks, corresponding to the continuous improvement of sanitary conditions in our own and other countries. The relaxation of such checks in war-ridden countries has always spelled a temporary increase in typhus. We have every reason to foresee, however, during the present war less typhus than would have been thought possible were the manner of its transmission by lice not known.

Rocky Mountain Spotted Fever.—This is the only definitely characterized tick-borne human disease that occurs within the confines of the United States, although ticks are responsible for the transmission of several other important infections of man in various parts of the world. Rocky Mountain spotted fever is restricted to the far western and northwestern states, whence 290 cases were reported during the year 1916. Over half of these occurred in Idaho, although the disease extends into the neighboring states of Montana, Wyoming, Colorado, Utah, Nevada, California, Oregon and Washington, as well as northward into Canada. As shown by the indicated fatality rate, the disease is most virulent in western Montana and northern Idaho, where the mortality is said to reach 70 or 80 per cent. A single species of tick, *Dermacentor venustus* (Fig. 7), common in these regions is known to act as the vector. The *Dermacentor* ticks occur abundantly on various small wild mammals in the younger stages and as adults on domesticated animals, such as cattle, and from these become transferred to man. It has been experimentally shown that certain rodents are susceptible to the disease, and that a tick thus infected in the nymphal stage can retain the disease organism till it becomes adult. It may then reach its human host through the medium of domesticated animals such as cattle. It appears that this is the ordinary way in which human cases have their origin, *i. e.*, through the bites of adult ticks, although the newly hatched "seed ticks" derived from eggs laid by infected mother ticks are known to contain the organism also.

Although Rocky Mountain fever is of minor importance at present, it is feared that it may increase its range at any time, since other ticks of wider distribution are apparently capable

Fig. 7. Rocky Mountain Spotted-fever Tick, male at left. Unengaged female at right.

of acting as carriers. Whether this may happen is by no means certain, however, and the vigorous measures already undertaken to reduce the abundance of ticks on domesticated animals will undoubtedly bear fruit in the gradual reduction of this locally much-dreaded disease.

Bubonic Plague.—From 300,000 to 400,000 cases of this disease are reported from India every year, over half of which terminate fatally. In past centuries it periodically visited many parts of the world as epidemics of even greater proportions, causing it to rank as one of the worst scourges of mankind. As is now well known, plague is a disease of rats which becomes transferred to man almost exclusively through the agency of fleas. At the present time it is most widespread and abundant in tropical countries, although by no means confined to them, and is excluded from our own country only by dint of repressive measures administered with the greatest thoroughness. Within the past few years it has appeared only sparingly in the United States, but at several times has given rise to a temporary apprehension lest it pass beyond control. That

FIG. 8. TROPICAL RAT-FLEA (*Xeno psyllacheopis*).

it has not done so shows that the probability of future danger is remote.

Nevertheless there are other good reasons why we should spare no efforts in reducing the number of rats. They are said by Nelson to destroy annually $200,000,000 worth of our foodstuffs and other property; they constitute a fire-menace, and, besides, they can hardly be considered as deserving our hospitality from an esthetic standpoint. In short, war against rats is important for many reasons, one of which is the security against plague which it entails, and gradual repression through individual effort is much easier than intensive campaigns necessitated by the advent of plague in a community.

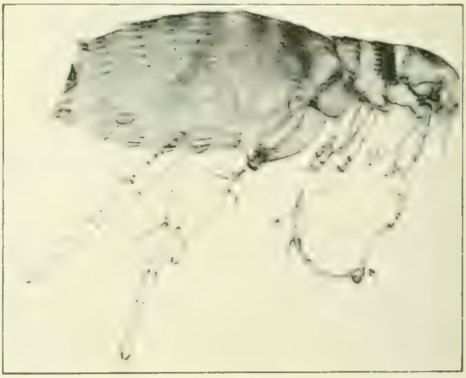


FIG. 9. RAT-FLEA OF TEMPERATE REGIONS (*Ceratophyllae fasciatus*).

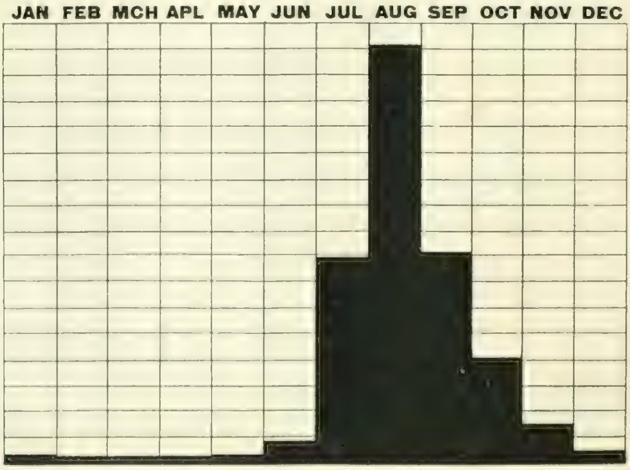


FIG. 10. SEASONAL INCIDENCE OF INFANTILE PARALYSIS IN THE UNITED STATES DURING 1916.

The relation of the flea to the transmission of plague is due to the fact that rats are regularly infested by fleas that may become infected with the bacillus of plague, if it be present in the blood of the host upon which they are feeding. These bacilli remain in a viable condition for some time in the gut of the flea and may be transferred to a human subject bitten by an infected flea. Thus, when a rat dies of plague, its fleas leave it to search for a new host; if they attach themselves to a rat, that animal is liable to infection, or if they feed upon a human being, as they frequently do, the disease may become transferred to man. Two species of fleas are commonly concerned in the transfer, one in tropical and subtropical regions and another in temperate regions. The tropical rat-flea, *Xenopsylla cheopis* (Fig. 8) is thus of greatest importance in the warm countries where it is most abundant, and the other, *Ceratophyllus fasciatus* (Fig. 9), in cooler countries. Both occur in the United States, neither specifically associated with plague except as previously outlined; other fleas may act as carriers equally well, but are not so abundant on rats and do not bite persons so frequently.

Infantile Paralysis.—Perhaps a few words in regard to this baffling disease may not be amiss. There are strong reasons for believing that it is carried by insects. Its summer prevalence (Fig. 10) is well known and its general distribution and occurrence are similar to those of insect-borne diseases. That it may be proved to be spread by the rat-flea is not improbable, and if so, would be another strong argument for the reduction of our rat population.

ZOOLOGY AND THE WAR

By Professor MAYNARD M. METCALF

OBERLIN, OHIO

THE request to write upon zoology and the war suggests two lines of thought—first the contribution zoology is making, and may make, to effective conduct of war activities of various sorts, and second the effects upon zoological science and practise likely to follow from the war. Both are worth considering.

Speaking broadly, no other science is doing more, perhaps none as much as zoology, or rather biology, to promote effective and successful prosecution of the war. This seems a strong statement, as one thinks of our dependence upon chemistry for explosives and a thousand other products, upon mechanics for ordnance and all sorts of war engines and upon engineering for the great activities of military and naval construction. Of course all the sciences are so interdependent that no comparisons can really be drawn. The statement is of value chiefly to challenge attention and persuade the reader to examine the relation of zoology—purely scientific zoology—to the problems of the war.

Man is an animal and all our knowledge of him and his activities is biological and all our methods of dealing with him and his life must be founded upon biological science. A mere roster of the biological sciences is sufficient to show our dependence. Some of these are: Morphology, including anatomy and embryology; physiology, both normal and pathological; ecology, including parasitology with bacteriology as its major subdivision; genetics; psychology; surgery and scientific medicine are but an application of anatomy, physiology and parasitology; and perhaps as vital as any in its effects upon all human life has been the knowledge of the fact of evolution.

It is often said this war is a scientific war and it is true both in its destructive aspects and in its safeguarding and protecting features. It is equally true that when all is said as to guns and explosives and poisonous gases, the last word lies with the man power of the belligerents. And it is here that zoology's great service is rendered. It is purely biological studies that have made possible the assembling of great numbers of men without disease slaying far more than fall before the guns of the enemy. The surgery which restores ninety per cent. of the wounded would be impossible without the knowledge reached by decades of parasitological research. Our knowledge of sanitation and the prevention of infectious disease has doubtless saved many more combatants and non-combatants than have been slain in all the battles. It isn't only Serbia which has been saved from typhus. Without our knowledge of the method of transmission of this disease, and the preventive measures thus made possible, all the belligerent nations would have been worse than decimated by this scourge. Typhoid fever, cholera, bubonic plague, smallpox, would each have taken similar toll. For every dozen lives lost from battle, hundreds would have been destroyed by infectious diseases which we are now able to hold in check.

Of course there are many lesser contributions to war effectiveness through animal husbandry and our knowledge of the sea and its life—all dependent upon zoological research.

But more important than any or all of these specific benefits from biological research has been the introduction of the era of scientific thinking, which since Darwin's time has been replacing superstition and ignorance. Step by step the physical sciences fought their way to recognition, but the dawn of the new age really came only when the phenomena of human life were recognized as biological and the puerile distinction between science and the humanities was destroyed. From this time the approach to human problems could be truly scientific without reservation, and the ideals themselves could be scientific. Tested truth, that is science, became the means and the goal.

It is this change in our whole habit of thought that has brought the advance in all lines of science, giving us our discoveries and inventions, creating whole new departments of science before undreamed. We must not overestimate biology's share in this emancipation of the human mind. Its contribution was later and more conspicuous, but no more real, than those of other sciences. The promulgation of the idea of evolution, coming last, as it did, and attacking superstition in its very citadel in the life of man, was recognized by opponents of the scientific spirit as bringing the last ditch fight. Without this fight and its victory for the forces of progress, the scientific development of the last fifty years could never have occurred. Biology therefore has had its full share in bringing the present day of science. It is this great spiritual contribution to human life that most merits recognition, for from this have flowed all the beneficent activities in every field of science.

Recognizing then the broad service of zoology with the other sciences in helping to the emancipation of man's mind, and remembering as well the special services in medicine, surgery and sanitation and in the production of food and clothing, the zoologist to-day may be somewhat consoled for the fact that in general it is more difficult for him than it is for the chemist or physicist to find ways to use effectively his special training in immediate war service. The transition from pure zoology to special war service is more difficult than that from chemistry or physics.

And it is just here there lies a very real danger to zoological science and to society. The earnest desire to serve in the great emergency, to take an immediately effective share in the strenuous tasks of the war, seems altogether likely to result in overemphasis upon the idea of practical applications in science, to the detriment of the pure science that is the fountainhead. The danger is real.

In some ways zoology is more exposed to injury than some of the other sciences. The pure zoologist must be a good bit of an idealist. Choosing zoology one chooses poverty. In medicine there is fair monetary return. The chemist or physicist knows that in this day of great industrial development and of great construction he can always, if need be, find employment for his trained abilities in ways to bring him money. But in turning to zoology a young man takes Franciscan vows of poverty of purse and enters upon the simple life. This is a sufficient handicap for our science. Add to this the somewhat general impression that in this war the zoologist has often found difficulty in rendering service in the line of his special training and there is real danger of further disadvantage to zoology and of a considerable reduction in the number of college and university students choosing zoological science as their life work. Philistinism, overestimate of the so-called practical, may be as harmful in science as in esthetics.

What is the most helpful attitude in science? What spirit is most productive in research? Is it the desire to make discovery for the sake of financial profit to the student? Is it personal ambition for honorable and dignified position among men of science? Is it the purpose to bend every effort immediately toward direct promotion of human welfare? No, it is something far different from any of these. The man works best who is in the thing for the fun of the game, who follows science because of interest in science itself and not so much in the so-called practical benefits reached through scientific research. There is no field in which singleness of purpose counts for more than it does in science.

There is the greatest danger that ulterior motive will warp the judgment of the student, and if he attempts too much to guide his studies toward practical utility he is less likely to reach major results than if he humbly allows his science to lead him where it will. All science is one great system of truth, interlocked in countless ways, and at almost every step in its pursuit there open to the student great vistas of unexplored territory—heights of vantage from which, when attained, he may view certain areas as a whole and grasp their true relations. The big things in science come through those who are seeking these visions, rather than through those who are searching at each step to gather some nugget of commercial value. In science, as in all life, it is idealism that leads to largest result, and the progress of the world in so-called practical lines is dependent upon the idealist more than upon the student with more immediate purpose. The future of science and of society rests with the seekers for the vision, those who search for understanding of truth for the joy of knowing the truth, rather than the profit such knowledge may bring.

Periods of great emphasis upon the *utilization* of science, such as is this time of war, bring danger of false estimates. There is real risk that the immediate will loom disproportionately large and that the spirit of searching for truth for the very joy of its attainment may in a measure be lost, and it is this spirit that is needed to "guide us into all truth."

One very real service the devotee of pure science can render, therefore, is to keep burning, and burning brightly, the fire upon his altar. Like his brother in other fields, the zoologist should recognize that he worships at no unworthy shrine, and he may well allow others to see something of his loyalty and of his pride in his service. May the light from his altar fire guide many another earnest student to the same shrine, though in coming he passes broader and easier paths.

There is much to-day to discourage. The moving picture, the cheap magazine, the daily newspaper, are real indications of low standards of taste in the drama, in literature and in all life. It seems the day of the low-brow. The man of science who seeks truth in all her beauty can do his full share in resisting this resurgence of philistinism and tawdriness, and he can do it by insistence for himself upon the worthier quest. Can he render in the end any greater national service?

PAPERS PRESENTED BEFORE THE SECTION OF SOCIAL AND ECONOMIC SCIENCE OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A COMPREHENSIVE IMMIGRATION POLICY AND PROGRAM[1]

By SIDNEY L. GULICK, D.D.

SECRETARY OF THE COMMISSION ON RELATIONS WITH THE ORIENT OF THE FEDERAL COUNCIL OF THE CHURCHES OF CHRIST IN AMERICA

THE need of adequate and wise immigration and Americanization legislation is imperative. Now, while war suspends the tide of newcomers to our shores, is the time for enacting the new laws to regulate the coming of fresh aliens.

No one can foretell how large or small will be the immigration from the war-ravaged countries of Europe when the war ceases. Wages in America will be high and the demand for cheap labor will be urgent. Immigration companies and steamship lines will seek for fresh sources of cheap labor to bring to America.

The large influx of foreigners in recent years has produced a serious situation. Our laws have not adequately grappled with the many kinds of problems which have arisen. Present laws afford no method of control either of the numbers or of the race types that may be admitted. We have reason to expect a large immigration of peoples that will prove extremely difficult of Americanization.

Vast masses of aliens in our midst are not Americanized and we have no effective provision for their Americanization. We give them citizenship with very inadequate preparation for it. The procedure in naturalization is needlessly hampered by red tape. We allow serious congestion of race groups. Free immigration from Europe constantly threatens standards of living of American workmen. Differential treatment of, and legislation against, Asiatics produces international irritation. Lack of laws makes it impossible for the United States to keep its treaty obligations for the adequate protection of aliens.

These varied dangers threaten the success of our democracy.

[1] Pittsburgh meeting, December, 1917, arranged by the Secretary of the Section, Seymour C. Loomis.

We now need a comprehensive and constructive policy for the regulation of all immigration, and the Americanization of all whom we admit, a policy that is based on sound economic, eugenic, political and ethical principles, and a program worked out in detail for incorporating that policy into practise.

If we are to attain the best results we should have a series of bills that deal with all phases of the immigrant question, in a systematic, comprehensive and well-coordinated plan in place of the patchwork, incomplete and disconnected legislation that now exists. Our new comprehensive policy, moreover, must take into consideration not merely the relations of America with Europe, Africa and West Asia, but also with China, Japan and India. The world has become so small and travel has become so easy that economic pressure and opportunity are now bringing all the races into inevitable contact and increasing intermixture. To avoid the disastrous consequences of such contacts and intermixtures, and to enable the United States not only to provide for her own prosperity, but also to make to the whole world her best contribution for human betterment, we need policies that are based upon justice and goodwill, no less than upon economic and eugenic considerations.

The following proposals are offered as a contribution to the discussion of these important matters:

Recent immigration has been enormous (10,122,862 for the ten years ending June, 1914) and will in all probability sooner or later become so again. For the poverty of Europe and the frightful taxes that will be inevitable, together with the horror of militarism which has deluged the nations with blood, sown the fields with human bones, and overwhelmed all working classes, will cause millions to flee to a land free from militarism and relatively prosperous.

Although America has vast resources, two thirds of our toilers have been in serious poverty, receiving less than $15 per week when they work. Even at that rate, however, until after the outbreak of the war, they have not been sure of steady employment. The Federal Commission on Industrial Relations has disclosed how serious have been the problems of unemployment and industrial unrest. War prosperity and cessation of immigration have relieved the economic strain for the present. What, however, will be the situation when vast immigration begins again?

America's political institutions and social organization are based on democracy. There is developing among us, however, a large adult male alien population still owing allegiance to other governments. The last census (1910) shows that out of

5,942,000 foreign-born males in America twenty-one years of age and over, 3,221,000 were still aliens. While 770,000 born in Great Britain had become citizens of the United States, 449,000 were still British; in the case of Germany 889,000 had become naturalized, while 389,000 were still Germans. Those, however, who come from South Europe seem less ready to become Americans. Austria, for instance, gave us 149,000 naturalized citizens to 460,000 aliens; Hungary 36,000 citizens to 219,000 aliens, and Russia 192,000 citizens to 545,000 aliens; while Italy gave us only 126,000 citizens to 586,000 aliens.

How many of these aliens had been here less than five years and therefore were still ineligible for citizenship the table did not show. But, however that may be, it seems wholly undesirable that the proportion of aliens to naturalized citizens from any particular land should be so large as these figures show. Should not the rate of permissible immigration be such as to keep the aliens from any land always in a substantial minority of those from that land who have become American citizens?

These facts and considerations suggest the importance, on the one hand, of checking this inflow of vast numbers who maintain allegiance to foreign governments, and also, on the other hand, of promoting such education of aliens permanently residing in America as shall help them rapidly to acquire our ideas and ideals, and transform them speedily into true American citizens.

The need of regulating immigration from Europe and West Asia is so well recognized that nothing further will be said upon it in this brief discussion. It is important, however, that Americans should realize that the present laws dealing with Japanese, Chinese and Hindus are quite obsolete. They are not only obsolete; they are positively dangerous.

New Japan has already acquired the mechanical instruments, the political, economic and industrial methods, and the science, education, ideas and ideals of Occidental civilization. New China is rapidly following in the footsteps of Japan. Both are increasingly self-conscious and insistent on courteous treatment and observance of treaties. They are asking, with growing earnestness, for recognition on a basis of equality with nations of the West.

The great world-problem of the twentieth century is undoubtedly the problem of the contact of the East and the West. Whether it shall bring us weal or woe depends largely on the United States. Shall our Oriental policy be based on race pride, disdain and selfishness? Shall it be entirely devoid of sympathy? And shall we rely on brute force for carrying it through? Or shall we give justice, courtesy and a square deal, refusing to be stampeded by ignorance, ill-founded suspicion and falsehood? Shall we "prepare" to maintain by our military might a policy of arrogant disregard of their needs and feelings, or shall we remove dangers of conflict by a policy of friendly consideration and genuine helpfulness?

The New Orient renders obsolete and dangerous our nineteenth-century Asiatic policy. Let us now promptly adopt a new policy; one that will provide, on the one hand, for the just demands of the Pacific Coast States to be protected from a swamping Asiatic immigration; and yet that also provides on the other hand for full courtesy of treatment and for complete freedom from race discrimination, which is inevitably regarded as humiliating. The new policy should provide for observance of the spirit no less than of the wording of our treaties, and be thus in harmony with the principles of good neighborliness.

All this means that we need comprehensive immigration legislation dealing with the entire question in such a way as to conserve American institutions, protect American labor from dangerous economic competition, and promote intelligent and enduring friendliness between America and all the nations, East and West, because free from differential race treatment.

The legislation needed should deal with:

1. The regulation of immigration.
2. The registration of aliens.
3. The distribution of immigrants.
4. The education of aliens for American life.
5. The protection of aliens by the federal government.
6. The naturalization of aliens.

Legislation dealing with these matters should be controlled by the following principles:

1. The United States should so regulate, and, where necessary, restrict immigration as to provide that only so many immigrants of each race or people may be admitted as can be wholesomely Americanized.

2. The number of those individuals of each race or people already in the United States who have become Americanized affords the best basis of the measure for the further immigration of that people.

3. American standards of living should be protected from the dangerous economic competition of immigrants, whether from Europe or from Asia.

4. Such provisions for the care of aliens residing among us should be made as will promote their rapid and genuine Americanization and thus maintain intact our democratic institutions and national unity.

5. The federal government should be empowered by Congress to protect the lives and property of aliens.

6. All legislation dealing with immigration and with resident aliens should be based on justice and goodwill as well as on economic and political considerations.

IMPORTANT SPECIFICATIONS

1. Regulation of the Rate of Immigration.
   The maximum permissible annual immigration from any people should be a definite per cent. (say five) of those from that people who have already become naturalized citizens, together with all American-born children of immigrants of that people.
2. A Federal Bureau for the Registration of Aliens.
   A Federal Bureau for the Registration of Aliens should be established and all resident aliens should be required to register and to keep registered until they have become American citizens. A registration fee (ten or perhaps five dollars a year) might well be required of all male aliens eighteen years of age or over.
3. The Federal Distribution Bureau.
   The Federal Bureau for the Distribution of Immigrants should be developed and provided with increased funds for larger and more effective methods.
4. A Federal Bureau for the Education of Aliens.
   A Federal Bureau for the Education of Aliens for American Citizenship should be established. While this bureau should not set up its own schools, its duty should be to promote the establishment by local bodies of suitable schools in needful localities and all registered aliens should be given education for citizenship free of cost. The bureau should be provided with funds for subsidies to be granted to schools upon the fulfilment of conditions prescribed by the bureau. The registration fee of aliens might well be reduced by one dollar ($1.00) for every examination passed.
5. Congressional Legislation for the Adequate Protection of Aliens.
   Congress should at once enact a law enabling the federal government to exercise immediate jurisdiction in any case involving the protection of and justice to aliens. The treaties place this responsibility on the federal government, but no laws as yet give it this power. The bill drafted by Hon. Wm. H. Taft and endorsed by the American Bar Association, or some similar bill, should be passed.
6. Amendment of Naturalization Laws.
   The standards of naturalization should be raised. Only those applicants for naturalization should be regarded as qualified who have passed all the examinations of the schools for citizenship and who have maintained their registration without break from the time of their admittance to America. Under the foregoing provisions and rigid limitations as to numbers and qualifications, naturalization should be given to all who qualify regardless of race.

A FEW ADDITIONAL DETAILS

(*a*) No change should be made in the schedule for maximum immigration between the census periods. With each new census a new schedule should be prepared, but it should not go into operation automatically. Congress should reconsider the whole matter once in ten years upon receiving the figures based upon the new census, and decide either to adopt the new schedule or some new percentage rate, or possibly to continue the

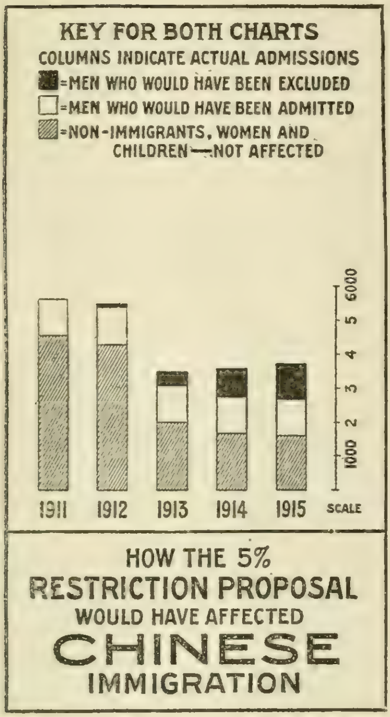


Fig. 1.

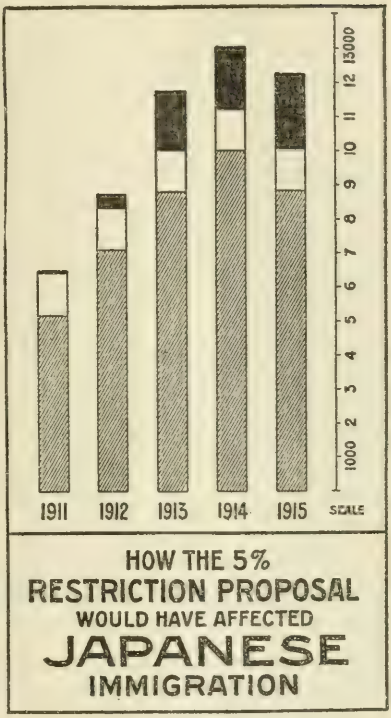


Fig. 2.

same schedule for another decade. This plan does not contemplate automatic geometric increase of immigration, either annual or decennial.

(*b*) Provision should be made for certain excepted classes. Government officials, travelers and students would, of course, be admitted outside of the fixed schedule figures. Aliens who have already resided in America and taken out their first papers, or who have passed all the required examinations, should also doubtless be admitted freely, regardless of the schedule. Women, and children under fourteen years of age, should also be included among the excepted classes. If thought important, unmarried women twenty-one years of age and over might be subject to the percentage rate. By providing for such exceptions the drastic features of the proposed plan would be largely, perhaps wholly relieved.

(*c*) Should the restriction required by the five per cent. plan be regarded as excessively severe, the per cent. rate could be advanced. In any case it seems desirable that the five per cent. restriction should be applied only to males fourteen years of age and over, and to unmarried women twenty-one years of age and over.

(*d*) In order to provide for those coming from countries from which few have become American citizens, a minimum permissible annual immigration of, say, 500 or possibly 1,000 might be allowed, regardless of the percentage rate.

(*e*) Registration, with payment of the fee, might well be required only of male aliens eighteen years of age and over. Since, however, it is highly desirable that immigrant women also should learn the English language, provision might be made that all alien women should register without payment of the fee and be given the privileges of education and of taking the examinations free of cost. This privilege might extend over a period of five years. After passing the examinations there should be no further requirement for registration. If, however, after five years the examinations have not been passed, then they should be required to pay a registration tax (of say five or six dollars annually), a reduction of one dollar being allowed for every examination passed.

(*f*) In order to meet special cases and exigencies, such as religious or political persecutions, war, famine or flood, provision might well be made to give special power to the Commissioner of Immigration in consultation with the Commissioner of Labor and one or two other specified high officials to order exceptional treatment.

(*g*) The proposed policy, if enacted into law, would put into the hands of Congress a flexible instrument for the continuous and exact regulation of immigration, adapting it from time to time to the economic conditions of the country. Is it not important for Congress to take complete and exact control of the situation while the present lull is on and be able to determine what the maximum immigration shall be before we find ourselves overwhelmed with its magnitude? If the post-bellum immigration should prove to be small, a law limiting it to figures proposed by this plan would not restrict it.

(*h*) An objection to the proposed plan is raised by some. It is urged that tens of thousands would suffer the hardship of deportation because of arrival after the maximum limit has been reached. Such a situation, however, could easily be avoided by a little care in the matter of administration. Provision could be made, for instance, that each of the transportation lines bringing immigrants from any particular land should agree with the immigration office upon the maximum number of immigrants that it may bring to America during the year, the sum total of these agreements being equal to maximum permissible immigration from that particular land. There would then be no danger of deportation because of excessive immigration. The steamship lines, moreover, would see to it that their immigration accommodation would be continuously occupied throughout the year, avoiding thus a rush during the first two or three months of the year.

(*i*) A second objection is raised by some, namely, the difficulty of selecting the favored ones in those countries where the restriction would be severe. This difficulty, however, would be completely obviated by the steamship companies themselves. Immigrants would secure passage in the order of their purchase of tickets; first come, first served.

(*j*) In order to alleviate hardship as far as possible, might not immigration inspection offices be established in the principal ports of departure, and provision be made that all immigration from specified regions should receive inspection at those offices alone, such inspection to be final?

(*k*) The most searching criticism of the policy and program here proposed deals with the percentage principle itself. It is said by critics to be mechanical and therefore artificial. Moreover, while it professes to be free from race discrimination, it nevertheless is in fact strongly discriminating, for it seizes upon the accident of a small Japanese and Chinese American-born citizenship to enforce an exceedingly rigid restriction of immigrants from those lands while it permits tens and even hundreds of thousands to come from European lands, merely because their large immigration took place decades ago. The plan, therefore, they urge, cannot be satisfactory to Japan.

These criticisms overlook certain facts. The plan takes Americanization as its foundation principle of restriction. Let the critic face this question. Is it, or is it not true, that Americanization of newcomers from any particular land depends in some close way upon the degree of Americanization of those from that land who are already here? Does a new Italian or Japanese immigrant become an American in spirit and in language equally easily and wholesomely whether the Italian or Japanese group with which he is in daily contact is well Americanized, or hardly Americanized at all? Whether they speak and read English easily and are voting citizens, or whether they speak English only smatteringly, read only their own foreign-language papers and have no voting power or political interests? If the newcomers become Americanized equally easily and rapidly under either set of conditions, then the percentage principle of limitation is artificial and mechanical; otherwise it is sociological and psychological. The writer holds that the keeping of newcomers from any people to some small percentage of those of that people who have already become American citizens is a fundamental psychological and sociological principle, and that the proposal therefore is not mechanical nor artificial.

The admission of larger numbers than can be easily Americanized creates and maintains difficulties of many kinds—economic, political and racial. The welfare of the immigrants themselves and of the American people, and the abiding success of our democratic institutions depends upon the proper and rapid Americanization of all who settle permanently in our land.

Another fact to be kept in mind is that we must start with the present actual situation. We can not ignore or go back on history. We can no more rectify the inequalities of past immigration—Japanese or Italian as compared with English, German and Scandinavian—than we can rectify the accident of an unfortunate grandfather. We must start our new policy and program with the situation as it is to-day. We must insist that immigration from no land shall be larger than we can Americanize. This requires the admission of immigrants from different lands in different numbers, but upon the same principle. This is not "race discrimination" in the usual sense, and in the sense to which Japan raises objection.

The assertion that Japanese will resent this proposal is an assumption based on ignorance. The critic fails to understand the essence of Japan's criticism of our present policies. Japan is not demanding opportunity for free immigration. But she does earnestly ask for removal of the humiliation of differential treatment on the mere ground of race.

As a matter of fact Japanese who understand the foregoing proposals do not resent them. If all immigration to America is restricted on the same principle, that which they resent is removed, and they are satisfied. Baron Kato, then Minister of Foreign Affairs, at a dinner of welcome (February 10, 1915) to Professor Shailer Mathews and the writer, who went to Japan as the Christian Embassy of the Federal Council of the Churches of Christ in America to the churches of Japan, said: "We would not mind disabilities if they were equally applicable to all nations. . . . Questions like this require time to settle. . . . At the same time we can not rest satisfied until this question is finally and properly settled."

It may not be amiss to note that as the decades pass, if those admitted and their children chose to become American citizens, the permissible immigration from any particular land will naturally increase decade by decade. The newcomers, however, being always kept at a small percentage of those already Americanized, the objections to and dangers from increasing immigration from those lands will be held at a minimum.

Conclusion

Would not the above proposals for a Comprehensive and Constructive Immigration Policy coordinate, systematize and rationalize our entire procedure in dealing with immigration, and solve in a fundamental way its most perplexing difficulties? Such a policy would protect American labor from danger of sudden and excessive immigration from any land. It would promote the wholesome and rapid assimilation of all newcomers. It would regulate the rate of the coming of immigrants from any land by the proven capacity for Americanization of those from that land already here. It would keep the newcomers of each people always a minority of its Americanized citizens. It would be free from every trace of differential race treatment. Our relations with Japan and China would thus be right.

Such a policy, therefore, giving to every people the "most favored nation treatment," would maintain and deepen our international friendship on every side.

Criticism of this plan is invited. If the reader finds himself in harmony with this proposal a letter of endorsement would be appreciated.

THE PRESENT ECONOMIC AND SOCIAL CONDITIONS AS RESULTS OF APPLIED SCIENCE AND INVENTION

By GEORGE W. PERKINS

AS recently as when our fathers were boys, Samuel W. Morse, from a room at 100 Washington Square East, New York City, flashed to the world the first message ever carried by electricity. That message was the query "What hath God wrought?" How prophetic was that query, in view of the stupendous revolution in social and industrial relations brought about since then by the use of electricity.

When miracles are mentioned our minds instinctively revert to the miracles chronicled in the Bible, and yet, with the possible exception of the raising of the dead, is there a miracle recorded in the Scriptures that is more wonderful than the miracle of the telephone? It is a miracle of a very real, practical nature; a miracle that has revolutionized every detail of our present-day life, social, financial and industrial; a miracle that has annihilated space and brought the world so close together in its everyday relationships that we have become one small group of people, regardless of the hemisphere on which we live or the race to which we belong.

The revolution in business methods caused by the use of electricity has been so rapid and so complete as to cause bewilderment and consternation in the minds of a multitude of our people. They are fairly staggered by the mighty changes that have taken place, and I sincerely question whether they comprehend the fundamental cause of these mighty changes; and this lack of comprehension, in my judgment, is responsible for much of the unrest that permeates the world to-day. Multitudes of people engaged in their everyday affairs are seeing the results, feeling the results, without understanding the causes, for they have not been furnished by the men who have produced the causes with sufficient information as to the causes and the results which these causes are bound to produce.

The business men of the United States have been very properly charged with having been so engrossed in money-making during the last quarter of a century that they have given very little, if any, attention to public affairs; have given very little, if any, of their superb ability to public service, and have given nearly all of their ability to pursuing selfish ends, largely of a money-making nature. Much can be said to substantiate this charge, but, in my judgment, a similar charge can be made against the men of science. They have been so engrossed in the fascinating problems on which they have been working that they have taken little or no time to inform the public as to the practical effect that modern scientific inventions were bound to have on the everyday lives of our people. These inventions have been placed in the hands of the people of the world within the last third of a century, and their application to business and social affairs has overthrown and carried away a countless number of old practises and precedents. The result has been a mighty conflict between the old laws of man and the new laws of science. One or the other had to give way. As the man-made laws were the outgrowth of centuries of effort and cumulative human knowledge, it did not seem possible that anything could come into the world that would set all this cumulative knowledge and experience to naught, and do it overnight, as it were. Such, however, is the actual situation, but a vast majority of the people of the world do not realize this, do not at all understand it. It is also true that even a large number of our more intelligent men have refused to accept the new conditions in which we live and have insisted on continuing under the old system, following old precedents and practises. As a result, a mighty conflict has engaged us and will continue to engage us until our people and the other peoples of the world realize that a mighty upheaval has taken place; that we have entered a new world of thought and action, dominated almost wholly by the discoveries of science within the last half century; that new codes of business morals, of finance, of industry are being set up, and that it behooves us all to give the best thought, the broadest vision, the most unselfish devotion to the erection of a new structure that will be in harmony with the modern economic needs of our people.

Who can be of more help in this great reconstruction period than the scientist? Should he not, in the present troubled and confused thought of the world, give of his thought and his time to the work of informing the people in simple, easily understood language as to what he has done to upset our old practises and customs? Should he not tell them wherein his work and accomplishments will be of benefit to the people and why? Should he not show them how impossible it is to follow old precedents and practises when he, the scientist, has by his discovcoveries and inventions completely wiped out old methods; when he, the scientist, has, through the miracles he has wrought, destroyed old tools and substituted new ones? Until the people as a whole fully realize this it is going to be most difficult to readjust our minds sufficiently to make us capable of rearranging our social and industrial practises.

The bitter conflict that has been waged in our country during the last twenty-five years between the old laws of man and the new laws of science has been caused by a lack of understanding on the part of our people as to what has been going on. I believe that a half century from now—yes, much sooner—our people will look back at the struggle in which we are engaged and marvel at our shortsightedness. They will look upon it then much as we nowadays look upon the witchcraft of early New England days.

For the last twenty-five years the scientist and the inventor have almost daily placed in the hands of the merchant and the manufacturer some new instrument or device that has made it possible for him to speed up his business and reach out and do business at far distant points; some device that has made it possible for a single human mind to do infinitely more business than any human mind ever did before. As soon as the business men began to employ these devices, our old man-written laws of a quarter or half century ago were invoked to prosecute these men who as a matter of fact were simply using, in their practical everyday work, the discoveries of science and the instruments of the inventor.

How perfectly absurd it is to allow a man to invent a machine, to applaud and honor him for such invention, and the very next instant attempt to place behind the bars the business man who uses that invention. This is precisely what our country has been doing for a quarter of a century. The telegraph that Mr. Morse invented and the telephone that Mr. Bell invented have been acclaimed as the great discoveries of the age, and these men have been hailed everywhere as great benefactors of the human race; yet had it not been for these two inventions, how utterly impossible it would have been ever to have had an interstate corporation or a so-called trust. Our politicians have told us that the tariff made the trusts. They seem to have forgotten that while we have had a tariff in this country for more than a hundred years, we have only had large interstate corporations for a matter of thirty or forty years. Intercommunication, improved and developed through the use of electricity, has been the underlying cause of the great industrial interstate and international enterprises. Raise or lower the tariff as much as you please and leave modern intercommunication undisturbed, and your great interstate and international industrial unit of to-day would continue; but take away that strange force which we call electricity and your interstate and international business concern would fall to pieces in short order. The telephone, not the tariff, made the trusts.

Intercommunication is the first requisite for doing business. In our grandfathers' day there was no concern larger than that of the store owned and operated by one individual, for the simple reason that an ox or horse team could not go very far and they were the only methods of intercommunication. Intercommunication has rapidly improved, thanks to the marvelous work of the scientist and inventor, and as it has improved and extended business has grown from the individual to the firm, from the firm to the company, from the company to the great international corporation. The only way to stop this development, to set it back where it was in our grandfathers' day, is to eradicate the causes that have produced the results.

My plea is that our people be told all this in plain everyday language; that they be told it by you, the men who are so largely responsible for creating the cause that has produced the result. Until our people understand the fundamental cause, we are going to have a conflict of titanic proportions. A campaign of education is therefore imperative, for much that we learned in our youth must be consigned to the scrap heap, discarded altogether. We must learn new methods of thought and of action. In order to do this our people must have the facts. We can not expect them to readjust their thought and their action to such a great extent as they must without facts that are indisputable. Who can give them these facts better than the men who have created them—the scientist and the inventor?

Steam and electricity have been the great unifying forces in business. With their advent it became perfectly natural for men to reach out and command larger areas of trade, to have great practical visions of interstate and international conquest in trade. The people as a mass do not understand this. They almost feel that supermen have come into the world in the last quarter of a century, men of far greater mental ability than ever existed before. This of course is not true. The men of the last quarter of a century have accomplished what they have not because they were endowed by the Almighty with vastly better mental machines than their fathers possessed, but because they have been endowed by the scientist and the inventor with vastly better material machines than their forefathers possessed. If our grandfathers wished to talk to a man in the next block they had to put on their hats and go and hunt the man up. If a man living in Boston wished to talk to a man living in San Francisco he had to transport his body across the continent before he could do it. To-day all that is necessary is for you to turn in your chair, pick up a tiny instrument and command the voice of your friend whose body is on the other side of the continent, and his voice immediately sounds in your ear.

The Germans were the first people who had sufficient vision and courage to comprehend what mighty and practical changes the scientist and the inventor had wrought in business methods. They lost no time twenty-five years ago in shaping their future to be in keeping with the great new electrical age upon which the world was entering. They formed large trading companies and with great rapidity abandoned the old axiom "competition is the life of trade" and substituted the new slogan "cooperation is the life of trade." With this slogan they went out for the trade of the world. At the same moment our country took exactly the opposite course and, through the passage of the Sherman Law, declared that competition was and must continue to be the life of trade.

Japan is another country that has lost no time in throwing off the customs and precedents of the past and entering the great new electrical world with broad vision and splendid courage. Witness what Japan has accomplished in less than half a century. She has cast off the customs and precedents of centuries and reached out with great eagerness for the newer and more advanced thought of the world. She has sent her best young manhood to the universities of all the civilized countries. She has sent commissions of her most able men to all points of the globe, that they might bring back the best thought and most advanced practises in social and business relations. For the last quarter of a century precedent has meant nothing to Japan. She has thought only of the matchless opportunities that are opening to the world because of universal education and vastly improved methods of intercommunication.

In both Germany and Japan the government has worked hand in glove with its merchants and manufacturers, leaving no stone unturned to make it clear to their people that the customs of their fathers and forefathers were things of the past and that new beliefs, methods and practises must take the place of old ones.

We pride ourselves on being a new country, a progressive country, free from the shackling influences of precedent. As compared with Germany and Japan and their accomplishments of the last quarter of a century we are an old benighted country. While both Germany and Japan have been reaching out into the future with new methods and practises our so-called statesmen and laws have tried to bind us hand and foot to an archaic past.

Fifteen years ago some of our business leaders with vision and courage attempted to organize the railroads of our great Northwest into one company, and planned to connect that railroad system on the Pacific coast with a line of steamships to Japan and China. Under an archaic law our government attacked the enterprise, declared it illegal and prevented its being carried out. The project was abandoned and the ships for the Pacific were never built. Later on the La Follette Law was passed, which effectualy disposed of the few ships we had remaining on the Pacific Ocean, and to-day in place of our being a potential factor in the carrying trade of the Pacific we are a negligible quantity, while Japan, whom many of our people still regard as an ancient nation, has forged ahead and practically taken possession of the carrying trade of the Pacific. All this is largely due to an utter lack of understanding on the part of our so-called statesmen and our people as a whole as to the great economic changes that have been brought into the world, not so much through the selfish desires of business men as through the potential achievements of science.

The modern commercial accomplishments of Germany are too numerous to mention, but the latest one of which I know is the creation in Berlin of what is known as a Federal Purchasing Bureau. I understand that hereafter when a merchant in Germany wishes to purchase some commodity that is to be procured outside of Germany he will be required to go to this purchasing bureau of the government and lodge his order. Take copper for instance: If the Germany copper merchants wish to buy copper they will each go to the government purchasing bureau and lodge their respective orders for, say, May copper. When the orders are all in this purchasing bureau will go out into the world to buy, say, fifty million pounds of copper. It will naturally come here, for we produce such large amounts of that metal. When it comes here it will find that our laws require that our copper merchants compete with one another in the sale of copper, while the German law requires that their merchants cooperate with one another in the purchase of copper. The method of Germany is, therefore, exactly the opposite of our method. Which is right? If Germany is right, then she is acquiring from us one of our most precious metals on terms very advantageous to her and very disadvantageous to us.

Twenty-five or thirty-five years ago, before science and invention had perfected electrical intercommunication, such arrangements as these did not and could not exist. But to-day they can and do. Not only this, but in the judgment of all thoughtful men they are but in their infancy, for science and invention are making stupendous strides in perfecting instantaneous intercommunication of thought and the more rapid transportation of our bodies and commodities from point to point. When this war shall have finished the conquest of the air will have been accomplished. The wireless will be a practical everyday instrument. The submarine telephone will doubtless be in operation, and international lines will then mean about as little as state lines mean now, all because of what science has accomplished.

Surely you men of science have vast accomplishments to your credit. You have reason to be exceedingly proud of a great record of achievement; but is it not high time that you did your bit by making it plainer to the people as a whole what your accomplishments mean to them in their work-day lives, making them understand that while you have destroyed an old order of things you have created a new and better order of things. Would it not be highly beneficial to our country if some of your meetings and discussions were given over almost wholly to the task of enlightening the people as to why it is that old methods must be discarded for new methods? Will you not give your splendid talents to plain talks with the multitude, for a great crisis confronts the world. It is the crisis of changing in a night, as it were, from the age of the ox team to the age of the flying machine. Certainly no such stupendous revolution has confronted the world in all its history, and unless our people can comprehend it all, can understand it all, they will not be qualified to deal with it in their homes, in their business and, above all, at the polls where representatives are selected by them to make new laws and discard old ones.

THE FINANCING OF PUBLIC UTILITIES

By NATHANIEL T. GUERNSEY

GENERAL COUNSEL, AMERICAN TELEPHONE AND TELEGRAPH CO., NEW YORK CITY

A FUNDAMENTAL factor on the economic side of the management of every public utility is that provision must be made for a constant supply of new capital.

When a new plant of a public utility has been completed, it has not been completed; in fact, its construction has just commenced. It would be a most exceptional situation if such a plant were finished before it had become necessary to consider and provide for additions to it. The communities which these utilities are serving, whether the utilities are local or more than local in their character, are constantly growing. This constant growth necessitates constant additions to the plant. The utilities can not stand still. Unless they go forward, they will go backward. It is absolutely essential not only to the public welfare and convenience, but also to the success of the utility itself that it meet these constant demands promptly. A failure to do this means inadequate and insufficient service which usually causes and, unless it be due to extraordinary and abnormal conditions, justifies public dissatisfaction, criticism and controversy, with all of the losses and embarrassments to the utility and the public which they directly and indirectly involve.

Every well-managed public utility recognizes its obligation to meet these demands as they arise and to anticipate and provide for them in advance, so far as this may reasonably be done. The definite determination of what these future demands will be in any concrete case, in the nature of things is involved in more or less uncertainty; and where this uncertainty is such as to render the investment unjustifiable it imposes a necessary limitation upon construction in advance of known requirements. As to every utility, the correct engineering point of view, because it is the correct financial and economic point of view, is always with reference to the future. If the property is a well-managed property, speaking broadly, the work that is being engineered and financed to-day is normally with reference to future requirements; the plant that is in use to-day, meeting present requirements, was engineered, financed and constructed in the past.

The magnitude of the investment in these utilities and of this persistent demand for new money is seldom appreciated. The statisticians inform us, using the figures for 1916, that the investment in the principal utilities of the United States, including steam railroads, telephones, telegraphs, street and electric railways, electric light and power plants, water transportation, express companies, the Pullman Company, manufactured and natural gas plants, water plants and pipe lines, aggregated more than thirty-two billion dollars. It is said that during the last five years, the additions to this investment have, upon the average, amounted to more than one billion dollars in each year. This figure is too low to be taken as the basis for determining the amount of money required for these purposes. It is well known that during this period, the additions to railroad plant and equipment have not been sufficient to meet the public requirements.

It is scarcely necessary to refer to the fact that these additions can not be provided out of surplus earnings. Such earnings can and should provide a part of them, but they can not be relied upon as the sole or as the principal source from which the new money is to come. It must be attracted to these investments from the body of surplus capital which is at the time seeking investment.

Another fundamental fact, so obvious that there would be no excuse for alluding to it if it were not very frequently overlooked, is that basic economic laws require that there shall be paid for this new money what it is worth in the money market.

This general market to which the public utilities and all other enterprises desiring to obtain money must go, is in the very nature of things a highly competitive market. Those who have money to invest will invest it where, all things being considered, it will bring to them the highest return. It will go to the highest bidder. Investments in public utilities, just exactly like investments in real estate, manufacturing, banking and everything else, must be attracted by a prospective profit, and this profit, taking into account hazards and other conditions, must be equal to that offered by other available investments. Otherwise, the investors, who are seeking a profit, will place their funds in the more profitable enterprises and the money will be diverted from public utilities. To secure normal, natural business conditions, the profits to be derived by the investor from the various channels of investment must be equal when the variations in hazards and other material conditions are taken into account. When this equality exists, each class of investments will normally secure its proper proportion of the general supply of money. If one class of investments is temporarily more profitable than another, money will flow into that class until, through the operation of the laws of demand and supply, it is brought into its proper relation with the others. The late Professor William G. Sumner once said that in the final analysis returns from government bonds and gold mining must be equal.

The contention that because capital invested in public utilities is devoted to a public use, it is therefore not entitled to relatively the same return as capital in private investments, the conditions, hazards and other factors affecting the investment being considered, will never be sound as long as the laws of demand and supply remain effective. The man with a thousand dollars, or five thousand or ten thousand dollars to invest will not put it into securities of public utilities, no matter what he may reasonably believe they will earn in the way of a return, if at the same time there is offered to him an opportunity to invest this money in other securities equally sound which will bring to him a greater return. This attitude on the part of the investor is not only a cold, hard fact, but it is right. There is no legitimate reason why the business of furnishing the public the service which it requires should not be upon a sound, economic basis. The same reasons which compel public utilities to pay the market prices for what they require of labor and machinery and iron and copper and other materials, and coal and oil and other supplies, require them to pay the market prices for money. It would be as legitimate—and no more futile—to argue that the labor used by utilities should be furnished at less than the market rate because in a public service, as it is to apply this argument to capital.

Because the fundamental economic laws of supply and demand apply to money just as broadly and effectively as they do to everything else, there has not been and there never will be devised any plan or any scheme under which, speaking broadly, public utilities can be enabled to obtain the money which they require for less than it is worth. To assert that this should be done, either in the case of capital or in the case of labor, is to assert that these services, which are of such value that they have become absolutely essential factors in our social and business life, should be furnished to the public for less than cost. This would amount to a denial of their economic right to exist. From the economic point of view nothing has a right to be unless it can pay its own way.

Because this money must be obtained in a competitive market, where the investor is not limited to these investments but may do with his money what he pleases, and will and should make the disposition of it which in his judgment promises the greatest profit, in the final analysis it is the investor who determines what return will induce him to part with his money, and therefore what return the public utility must pay in order to obtain this money. It is the investor who has the money to sell. It is he who actually fixes the price which will induce him to part with it. The investor is the public, or a very considerable and influential part of it. The opinion of every investor, from the savings-bank depositor to the holder of millions, is an element in this determination; so that it is the public itself which fixes the return which will attract money to its service.

It is clear from what has been said that in considering what is a fair return upon money invested in public utilities, or in any public utility, the question must be approached from the standpoint of the requirements of new capital to provide the necessary additions to plant. Much of the discussion of this question has been predicated upon the assumption, sometimes unconscious, frequently not stated, but very frequently present and underlying the whole argument, that the investment in a public utility, once made, is fixed, and that the question presented is what should this utility fairly and equitably earn upon this fixed investment. This is inherently wrong, because it is directly opposed to the fact that the investment in a utility is not fixed and is not completed. It is inherently wrong, because the concrete fact with which these utilities must constantly deal is the rate that must be paid for new money.

The return which will attract to these investments their proper proportion of the available money seeking investment is that return which will place them upon a parity with other enterprises, and which is therefore a fair return.

The public utilities of the United States are much regulated. Within the last few years, commission laws have been enacted until now in every state except Delaware there exists a state commission, exercising more or less jurisdiction over the utilities within its territory. The Interstate Commerce Commission has jurisdiction over interstate carriers, including the telegraph, telephone and express companies. The jurisdiction of these commissions varies, but in general it embraces the matters of rates, service, accounting and capitalization. In addition to these larger regulatory bodies, it is probably true that there is no state which has not delegated to its municipalities greater or less power to regulate public utilities.

For the purposes that I have in mind to-day, it is not necessary to hold a brief either for or against regulation. Personally, I favor it because I believe that regulation, notwithstanding the fact that it is still in the development stage and has as yet by no means worked out to perfection, will in the long run be better for the public and better for the utilities than no regulation. But regulation costs money. It involves direct expenses to the public and expenses that may be called indirect; because in the final analysis the expenses of the utilities on account of regulation must be repaid by the public as a part of the expenses of their operation. To justify itself, regulation must be worth more than it costs. It can not be a benefit to the public unless it is also a benefit to the utilities. They are so closely interdependent that what helps or hurts one similarly affects the other.

The recognition of the two fundamental propositions which have been under discussion will go far toward realizing sound regulation of financing by public utilities. That the public requirements must be met and that the public must pay for what it receives are inevitable. It is indisputable that the requirements which the public imposes upon every kind of service afforded by public utilities are constantly growing and that this growth must continue. Sound regulation must recognize this fact and must recognize the necessity for providing the additions to plant required to adequately take care of this continuous growth. These are facts which can not be affected or controlled by laws, or by decrees of courts, or by the enactment of orders by regulatory bodies, whether they be state commissions or municipalities. Any attempt at regulation which does not recognize this limitation upon the power to regulate is in this respect unsound.

I am not familiar with local conditions in Pittsburgh. I am confident, however, that out of the growth of its population, out of the enormous increase of its business due to the war, there has arisen an increased demand upon every utility serving this community, upon the telephone service, the telegraph service, the railroad service, the water service, the gas service, the electric-light service, the street railway service, the express service, and others. What I have attempted to emphasize is that this demand is due to conditions over which no commission or regulatory body can possibly exercise any control. It is something that can not be affected by any action or by any order of any constituted authority. If it has not been anticipated, if the investment necessary to take care of it has not been made—and it is not believed that it was humanly possible to foresee and to adequately provide for existing conditions—then there has resulted some impairment of the service, with some inconvenience and loss, which must continue until the abnormal conditions incident to the war will permit the necessary readjustments. What is true of Pittsburgh is true of every other community and of the country as a whole.

It is just as true that it is beyond the power of regulation to say what shall be paid for money. There is some loose talk on the part of commissions, and more on the part of those who appear before them, about what the commissions or the laws under which they are created will permit the utilities to earn. This is all based upon misapprehension. What rate of return will attract new capital to these utilities is a question of fact to be determined by the application of sound judgment to all of the material evidence, just as much as the value of a piece of real estate, or the value of the property of a telephone company, or a water company, or a gas company, is a question of fact. What the legislature, or commission, or municipality can do, and all that it can do, is to determine this question of fact. Their authority goes no further than to authorize them to ascertain as accurately as they can what return will appeal to the public as sufficient to induce the investment of money in these enterprises. If this question of fact is determined correctly, new money will be forthcoming; if the conclusion is too low, it will not be forthcoming: and since the regulatory body has no power to compel the public to change its opinion, it will be necessary for the regulatory body to revise its own conclusion.

With the recognition of these two fundamental propositions by the public and by the regulatory bodies, the foundation is laid for sound regulation of public utilities from the financial standpoint. It is fortunate that they are neither difficult to understand nor inequitable in their results. Every one, no matter how limited his attainments, can readily appreciate and easily comprehend that increases in population, increases in business, and developments in the services of the utilities which broaden their usefulness, all tend to create a necessity for more plant and for more money to create this plant. Again, to reverse a homely phrase, they all understand that in this situation foresight is better than hindsight; it is obvious that foresight in the provision for these growing demands means the greatest efficiency and least interruption in the service.

To demonstrate that to induce money to flow into these enterprises they must appeal to the investor as offering him as much in the way of profit or return as is offered to him by other investments taking into account hazards and other conditions, is just as easy. All that is required is to put yourself in the place of the investor and to ask yourself which investment you would choose for your own money.

The equity in what these propositions involve is plain. They contemplate that the public shall have the service that it wants when it wants it. They contemplate that the public shall pay for this service what it is reasonably worth. The service is indispensable and is worth much more than the public can ever be required to pay for it.

Because these propositions are simple and are equitable, I believe that the public generally will accept them, just as soon as they are brought to its attention so that it understands them. Speaking broadly, I do not believe that the public generally either wishes to or believes that it could obtain these necessities for less than a fair remuneration. It knows that it can not obtain something for nothing. It is willing to pay a fair price. The essential thing is that it understand what is a fair price.

SCIENTIFIC CRITERIA FOR EFFICIENT DEMOCRATIC INSTITUTIONS

By Professor ALBERT H. WRIGHT

UNIVERSITY OF PITTSBURGH

IN recent years the American public has been treated to much heralding of the advent of efficient government. Ballot changes, civil service reform, investigations of research and efficiency bureaus, proposals for more businesslike administration of public office and devices for giving freer expression to the popular will have been offered at various times. Severally they represent faith in the punishment of wrongdoers, confidence in the methods of private business, or trust in the wisdom of a powerful electorate, for the development of sound and satisfactory government. Excellent as some of these proposals are, they furnish no answer to grave questions which have been forced on democracies in recent months. What is the aim or goal of democratic government? Can democratic government survive the rude shock of a great public trial? How may it escape the dangers due to conditions bred of its chiefest virtues? How may it, in a social order as yet imperfectly understood, find the knowledge and the method requisite for the formulation and prosecution of social policies vital to its continued existence?

For our American democracy we have at the least the first of these questions answered. Whether by reference to the operation of government, the pronouncements of party leaders, or public opinion we shall find that the maximum possible of personal liberty and individual opportunity constitutes the aim and justification of our political life. It needs no demonstration that to secure and maintain this condition for all citizens our governmental institutions are put under the duty of developing the material and social resources of the land to the full. It is fairly evident that our present political institutions as they function do not satisfy this ideal requirement. It may be feared that they are ill prepared to face confidently any of the issues in which the continued existence of democratic government is at stake. If the politician and the statesman have failed us, what resources of leadership have we remaining? What more natural than that the social scientist should feel that he should be the guide?

Subject to the sometimes narrow limits of political expediency our governments, local, state, and national, have accepted the standards of the physical scientist. But the social scientist finds discouragement everywhere. His technique is new, his knowledge is tentative, his method is untried. He may not aspire to the precision of older sciences. His statements are liable to gross misinterpretation as they encounter ingrained beliefs, prejudices, wilful ignorance and resentful selfishness. As if to minimize his efforts the inadequacy of his information forces him to extreme modesty in his claims. Who, for example, would dare set up a standard for population increase? What view on the immigration problem shall prevail? What shall be our decision as to the distribution of social income? There is hardly a matter of major interest to our democracy for which social scientists may claim even tentative standards.

Insufficient knowledge is, of course, no rightful objection to the leadership of social science, if even that knowledge surpasses any other and gives promise for the future. A serious obstacle will be encountered when that leadership is asserted. Those in charge of our governments do not frequently seek the advice of the social scientist. A widely disseminated suffrage furnished a fertile field for the development of the professional politician. The politician responds to the interests, influences or groups which maintain him. The disintegration of government makes the politician necessary to harmonize outdated political institutions with modern social and economic creations. The politician champions fervently the further extension of the electorate that his own position be made more secure. Scientific leadership in politics must await the reconstruction of our political mechanism.

As an accompaniment to the remarkable material progress of the past fifty years we must note the unfortunate, steady deterioration of government, not alone in quality, but in power as well. It is a commonplace of recent American history that from the close of the Civil War to the end of the nineteenth century Americans were so intent upon the conquest of the resources of the country that they neglected public affairs. It was this period which gave over the governments of the country to the professional politician. Other contributing influences may be traced. Certainly a share of the responsibility goes to the inventions which facilitated transportation and communication, thus causing those in charge of these expanding media of commerce to regard state boundaries as artificial obstructions to be surmounted in the interest of developing industry. Likewise, the influences which caused the gradual concentration of the production of certain articles of manufacture within the limits of a small section, sometimes a single state, helped reduce the power of government. The development of large-scale production, the integration of industrial processes, the concentration of credit control in a few centers, and the growing use of the corporate form of organization all assisted to weaken local governments, obliterate state lines, and render the federal government, to a degree, helpless. The weakening of government was inevitable. Industry grows, rewards, interests, directs. It mingles intimately with the citizen's life. Its returns are tangible and immediate. Business organization responds quickly to demands for change. Our governments are still permeated with eighteenth-century concepts, their organization in part is of the same derivation. Governments move slowly, change seldom, reward poorly. On demand for change they await the slow coalescence of public opinion. It could not have been otherwise than that industry should have loomed large in the popular imagination, that it should have enlisted popular interest and that government the while should have suffered increasing obscuration. Consequently when industry used the politician to turn the creaking wheels of government in its interest, every social or economic group with a vestige of power turned to the same practice, thus making the politician fairly secure.

Rightly or wrongly, political stocktaking will show us a national government restricted in power as is no other great national government because based on a constitutional system constructed in apprehension of rather than in confidence in democratic institutions. We shall find our state governments monotonously alike in their main outlines, and largely based on obsolete constitutional principles. Some local governments we shall find responsive to democratic impulses, but many more restricted in power and at the mercy of the state legislature. The entire system is managed by party leaders who must placate supporting interests and who rarely dare disinterested public service. Before executive officers and legislators, who hold office by the caprice of popular election, press various groups seeking protection for their class interests. Legislation and administration reflect class demands. Governments thus become mere prizes of power and their results, spoils, concessions, or compromises.

Hardly an encouraging outlook for the efforts of social science! Seemingly a double duty is enjoined. The student of social science must continue his study of social phenomena for the evolution of definite standards for social action. At the same time he must strive for the creation of conditions which will afford opportunity for the development of his leadership. Such action is, clearly, not the sole prerogative of the social scientist, but he must assume a leading part in the forward movement.

What can be done? How can a democracy be persuaded to change its habits? What changes will bring the promise of scientific leadership? Leaving aside the familiar contention that popular education through the shaping of public opinion will achieve the desired end—an optimistic outlook of doubtful value—we may suggest some few changes which will make less difficult the reshaping of democratic government. Undoubtedly one favoring condition for the professional politician lies in the ease with which the privilege of the suffrage may be secured and used. When the indifferent, the uninformed and the incapable voters determine election results for the benefit of the political worker patriotic intelligence is placed under a heavy handicap. This evil might be minimized by (1) requiring of both naturalized and native citizen preliminary training for the initial use of the suffrage, (2) by the elimination of mentally subnormal voters by appropriate psychological tests—if competent for school children and soldiers why not for voters—and (3) by basing registration for elections on the voter's knowledge of the issues or candidacies involved in the forthcoming contest. Perhaps we may take a lesson from ancient Athens, whose youths began civic responsibilities at eighteen but gained political privileges only gradually thereafter, reaching full privileges at thirty. The vote will be prized only when it is worth prizing. From an intelligent electorate may we not expect conscientious service and a chance for educated leadership?

To-day the fitness of an elected official for the duties of his office is a matter of pure chance. Indeed, candidates have been rejected at the polls for apparently no other reason than that they were competent. This seemingly hopeless condition may possibly be remedied in some degree in the future if universities undertake the training of young men of executive promise who desire to enter public service for the definite purpose of seeking public executive positions which offer the chance of determining political policies. It should be possible thus to train local leaders to compete with local politicians on more than equal terms.

For our present legislative lottery must be substited something better. At present any member of a legislature can introduce measures at will. No important bill can be considered until several rival measures have been pigeonholed. Even then the bill is subject to the tender mercies of committee action, proposed and actual amendment when before the whole body, change in the other house of the legislature, the compromises of a conference committee and possible executive veto. The executive's program of legislation should be given the right of way. The bills should be drafted by an expert draftsman working under the direction of a committee of competent authorities on the subject-matter of the measure. Amendments should be permitted only with the consent of the drafting committee. When it is recognized that legislation is a science we shall be well toward an efficient democracy.

Finally, constitutional changes should be constructed in quite different fashion from present methods. Reverence for custom and imitation may have their uses, but they are hardly reliable guides for the reconstruction of government. Piecemeal change has slight justification, if a single gain is used as an excuse to preserve several outworn practises. Periodically the whole social and economic structure of the governmental area should be examined, the standards and desires of all groups ascertained and then a governmental organization be framed in the light of this information for the realization of democratic aims without regard to the fate of the old framework. We should cease trying to make society conform to what a few consider correct government, and instead mold our government to conform to the facts of society.

If, throughout our operation of political institutions we advance patiently to the acceptance of the experimental attitude and the method of social diagnosis as our basis of action, democracy may presently be safe for scientific standards.

RAILROAD FINANCE FROM THE STANDPOINT OF EFFICIENCY

By Professor HOWARD C. KIDD

UNIVERSITY OF PITTSBURGH

IN studying the problems of railroad finance and credit, there are two angles of approach: rates and costs. The first is in the hands of the Interstate Commerce Commission; the second is in the hands of the railroads.

The solution of the financial problem through increased rates seems hopeless, because there is little probability that the Interstate Commerce Commission will grant a substantial rate increase. Even if the roads were granted all they ask, it would not be long before they felt the effect of the "vicious circle" of costs rising at a faster rate. Their relative position would register no improvement. It is a case of lifting yourself by your bootstraps.

The solution of the problem by cutting down costs is the only course open to the roads. It is a question of efficiency and scientific management of present railroad equipment. Economy of operation is forced on the railroads because of abnormal traffic volume at a time when they are short of labor and equipment. In the first six months of 1917, American railroads handled 14 per cent. more freight than during a corresponding period of 1916, and 50 per cent. more freight than for the same months of 1915. In the same period the railroads added to their equipment 1 per cent. new mileage; 2 per cent. new locomotives; 3 per cent. new freight cars. This disparity between traffic demands and new equipment has compelled the railroad managers to study intensively the best improved methods of operation.

To meet the new traffic conditions, railroad policy has been directed in order to secure two general results: first, unified and central executive control; second, maximum efficiency in the use of labor and equipment.

The desire for a policy of centralized control is not new as far as the railroads are concerned. The approval of the government, however, is a decidedly new attitude. The railroads have been attempting a scheme of pooling or consolidation since the period of cut-throat competition and insolvency in the '70s. First the pooling of earnings was tried, but declared illegal by the Interstate Commerce Law of 1887. Then the roads resorted to the pooling of traffic. This practise was outlawed by the application of the Sherman Anti-trust law of 1890, applied to the railroads in the Trans-Missouri decision in 1897. The railroads then tried the pooling of securities, but here again they were checkmated by the ruling of the United States Supreme Court in the Northern Securities case. The last attempt at consolidation has been the recent attempt to pool equipment in Trunk Line territory. If it had succeeded, government operation of the roads during the period of the war would not have been necessary. The failure of this pooling arrangement seems to have been due to confusion arising from the conflict of orders given both by the government priority committee and the committee representing the railroads. The policy adopted by Mr. Wilson of operating the railroads of the country as a unit should produce maximum efficiency of operation, and also safeguard the financial interests of the investors.

The solution of the present railroad problems, however, can not be reached by merely centralized control, much as such a scheme may help. Greater efficiency in the use of present railroad equipment must be quickly developed.

A few years ago, Mr. Louis Brandeis made the statement that by the use of up-to-date methods of handling labor, and the application of practical science in working their plant, the railroads of the United States could save $1,000,000 a day. Whether the remark was true or not, the railroads within the last few months have learned the value of scientific management in such matters as packing, handling freight at terminals, loading cars, and especially in generating locomotive power.

With regard to packing, the railroads, in cooperation with the shippers of the country, can effect great saving of space, which will, of course, reduce unit costs of operation. As an example of the need of improvements in packing, the cotton situation might be cited. A recent article which appeared in the *Textile Recorder* of Manchester, England, points out that the present density of the United States bale is 22 pounds; the Egyptian 37; the Indian and Chinese from 45 to 60. The article concludes that, were the American compress methods more improved, a saving of vessel cargo space would total 9,305,000 tons dead weight. The argument which applies to vessel space could be drawn with equal force to freight-car space which could be utilized to relieve the present traffic congestion.

In the matter of loading cars, the roads have effected substantial economies. Comparing the first six months of 1916 and 1917 the railroads of the country increased the average carload from 24.4 tons to 27 tons. This savings is equivalent to adding to the rolling-stock equipment 200,000 freight cars.

The improvements in handling "less than carload" shipments have been especially noticeable. Fairfax Harrison, chairman of the Railroads War Board, recently issued the following significant statement:

> On 77 of the principal railroads of the United States, a saving of 114,109 cars was effected in one month this year solely by increasing the "less than carload" freight. The reports show that the average loading for that class of freight during July this year was 13,927 pounds, as compared with an average of 11,619 pounds during the same month last year.

At seaboard terminals, where congestion is greatest, efficiency in freight handling is being developed. At the Pennsylvania R. R. piers, New York, located on the North River, mechanical improvements in recent years have reduced the cost of handling bulk freight, such as coke, coal and limestone, from $.56 to $.04 per ton. A 12,000-ton steamer can be loaded in twenty-three minutes. However, in the handling of mixed cargoes, methods had improved very little within the last fifty years. Recently the use of the electric tractor, to which is attached a train of four or five trailers, has produced results very satisfactory in comparison with the use of hand trucks. The speed of the hand truck is approximately one mile per hour; that of the tractor-train is about 4 miles per hour. The following comparison indicates the relative saving of work:

Packages	Weight	Trailers	Equivalent in Hand Trucks
40 boxes, oranges	31,200	3	10
102 half chests of tea	7,650	5	25
12 cases, tobacco	2,520	3	12
146 packages, groceries	3,400	4	29

Possibly the place where railroad efficiency can be promoted to the greatest extent is in their locomotives. It is estimated that of the 63,500 locomotives in use on American railroads, only one third are mechanically modern. To make the two thirds modern would require an average expenditure of $3,000 per locomotive, involving a total expense of $120,000,000. The result would be an increase in general equipment capacity of about 33 per cent. To increase capacity to this extent in any other way would probably cost about thirty times this amount, or $3,600,000,000. Even if the steel and labor, necessary for such enlargement, were available, the present condition of the money market would make such financing impossible. President Markham, of the Illinois Central R. R., has pointed out that as a result of mechanically improving the locomotives on his line, an average freight mileage of 40 miles per day has been reached. Just what this achievement means will be appreciated when it is remembered that the average freight mileage for the United States is 29 miles per day.

The possibilities of the electric locomotive are being seriously investigated by railroad men. Mr. F. H. Shepard, of the Westinghouse Electric and Manufacturing Company, says that the "electric locomotive of to-day, in its ability to handle the heaviest trains in congested service, to make long sustained runs and to remain continuously in service, has demonstrated its unquestionable superiority over any method of steam operation."

The electric locomotive has probably had its best test on the Chicago, Milwaukee and St. Paul, where it has been tried out on 226 miles of difficult grade on the Rocky Mountain Division. Vice-President Goodnow sums up the following advantages of electric compared to steam locomotives:

1. Higher efficiency in cold weather.
2. Has made double tracking unnecessary.
3. 11.3 per cent. of the power consumed has been generated by trains on down grade.
4. Greater ease and safety in handling trains on grades, involving less wear and tear on equipment.
5. "Dynamic breaking," or the holding of trains at uniform speed on down grades without the use of air brakes.
6. Longer and heavier trains.
7. Greater speed.
8. Possible elimination of round-houses.
9. More work from one half the number of locomotives.

The possibilities of generating electric energy by the use of water power is another item in favor of the use of the electric locomotive. One fourth of our coal supply is consumed by the railroads. The substitution of any other source of power would not only solve a vital problem for American railroads, but also have far-reaching industrial effects in the period of reconstruction which must follow this war.

In conclusion, the following interesting statement regarding the problem of railroad efficiency was made a short time ago by Mr. Henry Ford:

> The freight car weighs as much as the load it carries. Heavy cars require heavy engines, heavier rails, greater strains in starting and stopping, more coal, heavier bridges, and the result is increased waste and depreciation. Four fifths of a railroad's work to-day is hauling the deadweight of its own wastefully heavy engines and cars.
>
> Nature has distributed alloy materials which, with heat treatment, make steel of 150,000 or 200,000 pounds tensile strength, instead of 50,000, and then the weight can be cut down proportionately. Alloy steel of high tensile strength cuts down the weight.

Whether the railroads remain in the hands of the government, or are returned to their present owners, the problem of efficiency along the general lines suggested above, must be studied by operation and traffic managers. An unprecedented traffic crisis, which will continue indefinitely after the conclusion of peace, calls for rigid economy and intelligent cooperation.

LABOR CONDITIONS WITH REFERENCE TO THE WAR

By Professor FRANCIS TYSON

UNIVERSITY OF PITTSBURGH

WHAT of the labor shortage? The question is on the lips of many war leaders and most business men. The American labor supply seems less adequate to meet the demands than ever before in our development.

From the West come dire predictions of failure of our aims of feeding our Allies if we do not effectively increase the agricultural labor force. Greater acreage or more intensive cultivation will require more labor. The fuel administrators and mine operators face a real labor shortage as well. Western Pennsylvania is asking now for miners. Continued and increased production is needed to keep our furnaces and factories supplied with fuel. The exhaustion of the railroad labor reserve has helped to bring the transportation crisis.

The building of houses to care for growth of population and emergency construction around new munitions works are halted by lack of hands. Even the shipbuilding program upon which our success in the war so largely depends is endangered by want of an adequate and appropriate supply of workers.

And the situation will no doubt go from bad to worse. The war is sure now to last at least another year, and the taking of another half million or more men from industry for military service will further deplete our labor force. The labor of supplying an increased army with munitions, clothes and food will still further tax our productive powers. As the war goes on and the brunt of the struggle passes to the United States, the demand for materials will increase disproportionately, and our industrial efforts must be inordinately increased to supply our own shortage—not to emphasize the need of our Allies,—likely to be increasingly bitter.

No wonder that panic-stricken editors have been seeking the breakdown of standards of hours of work, asking for the widespread employment of women and for industrial conscription. The production required to support our armies and navies and win the war is being deterred by the chaotic condition of the labor market, the dearth of effective man power. This is the first time of industrial expansion in which definite and universal attention has been called to the anarchic individualism of our employment system. Hitherto we have been content merely to discuss and worry with the problems of employment in times of distress and depression. The futility of past attempts is seen in the panic of 1914, when immediate relief and not constructive change still characterized our policy. In peace times we have failed to solve our labor problem, the great task of providing comprehensive machinery for the securing and maintaining of an adequate labor supply. Now as an inevitable measure of war efficiency we face the need of grappling successfully with the problem.

This trying and complex situation will not be met by sweeping generalizations, by hurling denunciation, or calling for panaceas. It can be met alone by authentic information, temperate analysis and slow constructive effort. Where are we to get the labor to serve our industrial effort?

The problem of labor shortage admits of many solutions. For the time being, at any rate, two solutions must be ruled out. The supply can not be increased by immigration, and English experience proves that extension of hours of work does not increase, but actually decreases, production. There is another theoretical solution which may be of scant immediate practical significance—the reduction of labor need by technical improvement and introduction of automatic machinery to replace labor power appreciably. The main practical expedients at hand, then, are obviously the increased employment of women; the diversion of workers from the production of luxuries that the nation must forego in the rigors of war, and finally the adequate and complete organization of the labor market to eliminate or reduce turnover and time loss between jobs, and lessen unemployment. We must utilize the existing labor supply to the fullest possible extent in the present crisis, if we are to attain the great aims we have set for our nation.

Valuable distinctions which must be borne in mind in getting at our difficult problem, are between shortage in skilled and unskilled labor, and net shortage as contrasted with local, temporary shortage.

There was undoubtedly with the falling off of immigration in a period of industrial boom following the war an unprecedented dearth of unskilled labor in the North in steel and railroad industry and in construction work. This shortage was met by bringing or inducing to come North more than half a million negro workers from the low-priced labor market of the South. But less than five per cent. of these workers are being introduced into skilled services. Again, women have been and are now being drawn into rough, unskilled work in increasing numbers and they are being slowly trained and directed into skilled activities. In Europe the use of women in industry has been remarkable.

A year ago, over a million new women had entered industry since the start of the war—about 985,000 replacing men. Employment of women saved England. Munition work is largely done by them. According to a recent editorial in The New Republic at Woolwich Arsenal, for instance, in August, 1914, only 125 of 10,866 workers were women. Now over a third of the 75,000 workers employed are women. In the United States there is as yet no definite information, but unofficial reports show rapid recruiting of women into industry, in munition works, railroading and other occupations formerly engaged in by men alone.

Conscription of Labor

In the unskilled groups particularly, the inability to secure an adequate labor supply is now marked, because of the casual character of the labor force of single men available. The turnover figures run above a thousand per cent. and are almost incredible. It is no wonder that the call comes for "conscription of the labor force." Yet on second thought this is but a short-cut remedy of coercion. If we understood the implications of the term we would not use it so glibly. Forced labor has never been efficient. Even organized Germany with her great war need has not proven that military control and punishment secure results from unwilling workers except in the crudest tasks and its supervision is too costly save by an army in the field; and conscription would be unfair and inexpedient except in a completely socialized nation. A return to compulsory labor even in war time might be a return to "slacking" and "sabotage" losses which have always gone along with such work. The present labor force is, in a measure, working gladly and energetically; add to its numbers by conscription and force them to work by law or threat of army service and the mutiny that agitators teach will seem to have a cause in fact. The seeds of organized revolt may soon be sowed in our midst. In any case, the young, unskilled casuals will be taken in the draft and that new experiment is difficult enough.

Rather must this unskilled labor force outside the draft age be attracted and held than coerced. It can be held, we were convinced, by a study of the negro migration this summer, only by selection of family men and provisions of living conditions on a family basis. In this regard the problem is exactly that of the skilled worker; the reduction of turnover and securing of a stable labor force in any plant must wait upon adequate provision of decent housing facilities. But the subject of industrial or governmental housing is another story and would require separate treatment.

Skilled Labor Shortage

Is there a net shortage of skilled workers? When we hear of the labor force that the Emergency Fleet Corporation will need to create its 6,000,000 tons; now announced as 300,000 men, and the increasing shortage of the munitions plants, there seems to be a great lack. But no one knows if these men do not exist, or are merely out of touch with the new jobs. We know, indeed, that men are being now laid off in numbers by industries suffering from the war, because of lack of fuel and materials, or decreased demand for products. For instance, in Pittsburgh with a marked shortage of unskilled men, an actual surplus of mechanics and carpenters, who have drifted in perhaps from the cantonments and who need to be placed elsewhere, now exists. The war work of the nation has been curtailed because no comprehensive system of labor management has been developed.

Organization of the Labor Market

Our greatest problem, particularly in meeting the skilled labor need, is still the distribution of our labor force to the necessary industrial work, reducing part-time work, elimination waiting between jobs and the tremendous turnover of labor. This is now estimated by employment managers to average over 100 per cent. a year, through this country, and in the shipbuilding force and the unskilled negro labor group it runs over 1,000 per cent. Our present labor force because it is inefficiently handled is not rendering one half of its possible service, is not fifty per cent. efficient.

Competition has in the past been unregulated by considerations of national welfare. Industry has habitually depended upon a surplus labor force, and hiring and firing with free contract, to obtain workers. We disregarded the pathetic need of the surplus laborer; now the dire need is that of the nation and we must meet it. It is lack of mechanism for distribution of labor rather than a dearth of labor that brings the present crisis.

Labor Exchanges

We have not yet created national agencies to connect the jobless man and the manless job. The 23 state public employment bureaus have been sadly handicapped by insufficient funds and untrained personnel and have worked mostly with placing the unskilled laborer. Now the states are seeing the situation more clearly in Committees of Public Safety. Pennsylvania has set aside $25,000 of the Defense Fund for the labor-placement work of the Civilan Service and Labor Committee, and the number of offices has been increased from five to thirteen. The United States Employment Service which grew out of the work of Immigration Bureau of the Department of Labor has some 94 offices at present. The last session of Congress appropriated only $250,000, a mere fraction of the cost of an adequate system. It placed about 41,000 in August, a small per cent. of the need. For five weeks, ending July 13, the British Exchanges, 400 in number, placed 175,000. The members of the British Munitions Board on their recent visit announced the English plans to increase the number to 2,000; over ten times as many as the United States with a population twice as large.

A Federal Employment Service and the Robinson-Keating Bill

A new Employment Service has been given independent organization in the Department of Labor, in charge of a director appointed by the President. As a special emergency measure and upon official request a bill has just been introduced into Congress for federal coordination of Public Employment service throughout the country to secure maximum production in essential war industries. Congress is asked to grant the federal service a considerable appropriation. The bill extends and unifies all labor-exchange functions of the government. Centralized control and unified policy would assure efficiency; close cooperation of state bureaus in touch with demand and supply of labor is secured by national aid, "dollar for dollar" to such state and city bureaus.

Gains from National Organization

If the bill is passed, it will not only help to mobilize our labor to war strength, but will provide for the period of reconstruction and demobilization after peace, an effective method of absorbing soldiers back into industry; such regularization of industry will meet the increasing industrial needs of the future.

It may also provide the means for systematic inquiry, bringing real knowledge of the possibility of the substitution of the labor reserve of women for that of men; the men displaced could be directed to the industries needing their service most; and the need for training the new industrial army of women would be made clear.

Analysis of the Labor Force

An efficient policy of labor distribution must be based on knowledge of the number of men engaged in trades, where they are, and the nature of their work and experience. The Bureau of Labor Statistics does not have and is not equipped to secure this information. Congress has given the Bureau but meager funds. Yet no intelligent policy of labor priority can be developed for the government by the War Industries Board Priority Committee, for instance, and followed by labor exchanges, until we have this full and detailed information about the labor supply, in the form of an index capable of practical use in finding individual workers.

The draft supplies such an index for the male labor force between twenty-one and thirty-one. But we need now a national registration of men and women between sixteen and sixty well planned and executed. This would be accomplished by a similar system, standardized for the nation; it would be simpler than the draft, as the irksome questions of dependents and liability to service would be eliminated. Such registrations, inadequately done, have already been tried by five states and, despite the crudity of the method, have proved of value. A modern filing system would convert a standardized national registration into an index of man power, to be used by exchanges, and of immeasurable value for subsidiary registrations to meet specific war and peace needs.

Employment Management in Plants

In addition to an efficient system of labor exchanges and an index of labor to utilize our labor supply to the full by distribution, there must be real employment management inside the plant. Without waiting for securing a labor index, much can be done to meet the pressing needs of distribution of labor. The Emergency Fleet Corporation has introduced modern employment methods in the shipyards. In each yard, hiring is now done by this employment manager, who has analyzed his job. Applicants are put at work for which they are best fitted. If capable of taking training they may be sent to special schools. Teachers for this standardized instruction are already being trained at Newport News. If foremen fire men the latter report to the manager before leaving, so that if possible they may be sent to other work in the plant, or be referred to the Federal Exchange for labor service in other shipyards. The local manager is the clearing house for labor and turnover will be much reduced, as it has in the last year by the introduction of similar methods of the New York Shipbuilding, Newport News and Fore River plants. This work will be materially aided by effective government aid to housing; the need here now constitutes the largest single factor in the disorganization of the labor situation. These methods must now be extended to all essential industries, steel and munition plants and railroads, especially. It represents the framework of the new machinery for labor distribution—local managers who work through the Public Employment Service, using scientific information publicly compiled.

WHAT ARE ENZYMES?

By Dr. BENJAMIN HOROWITZ

COLUMBIA UNIVERSITY

THE word enzyme comes from a Greek word meaning "in yeast" (*en*, in; *zyme*, leaven). Perhaps the most acceptable definition in the light of recent scientific research is to say that it is a substance showing the properties of a catalyst and produced as a result of cellular activity.

But what is a catalyst? The reader will recall his first very simple experiment in the preparation of oxygen. Here the learned instructor tells the bewildered youth that if you put a little potassium chlorate in a test tube and heat this very strongly, a gas is evolved which is later identified as oxygen. Now by merely adding a small quantity of a dirty black-looking powder, called manganese dioxide, to the potassium chlorate, the oxygen is evolved much more rapidly and at a much lower temperature. But this is not all. A careful examination at the end of the reaction shows that the manganese dioxide has not changed in any way: we have the same substance, and the same amount, at the end of the reaction as at the beginning. Many such substances are known to chemists. They all have this peculiarity: that they *accelerate* chemical reactions, and that a relatively small—at times insignificant—quantity of the catalyst suffices to bring about the chemical change.

In cells we find substances of this type, but thus far these cellular catalysts, unlike the manganese dioxide, and like proteins, have never been produced outside of the cell.

When we consider that life is possible only because of continued cellular activity, and when we bear in mind that this activity is largely the result of chemical changes brought about by these enzymes, the paramount importance of these substances becomes manifest.

Alcoholic fermentation in yeast, the souring of milk, processes of putrefaction, and various other examples of changes in organic materials with, often enough, the accompanying liberation of bubbles of gas, had long been known. The epoch-making researches of Pasteur had shown that fermentations and putrefactions were inaugurated by the presence of living organisms. Then later extracts from the saliva and the gastric mucosa of the stomach were obtained which also had the power of bringing about chemical changes in carbohydrates and proteins. This led to the classification of ferments into those which, like yeast and certain bacteria, acted because of certain vital processes (organized ferments), and those which, like the extracts from the saliva and stomach, were presumably "non-living unorganized substances of a chemical nature" (unorganized ferments). Kühne designated the latter "enzymes." This classification was generally accepted, and the "vitalists" held absolute sway until Emil Buchner, in 1897, overthrew the whole theory by a series of researches which, in their influence, were only second in importance to those of Pasteur in an earlier generation. One of Buchner's classical experiments consisted in grinding yeast cells with sand and infusorial earth, and then subjecting the finely pulverized material to a pressure of 300 atmospheres—a pressure far more than enough to destroy yeast, or any other cells. The liquid so obtained had all the fermentative properties of the living yeast cell. Obviously, then, the living cell could not be responsible for the fermentation. On the other hand, this experiment did suggest that cellular activity gives rise to some substance which, once produced, exerts its influence whether the cell is alive or dead. All subsequent experiments have but strengthened the conviction that cells do produce these substances, and that the chemical changes are due *not* to the living organisms, but to the *lifeless* substances (enzymes) to which these organisms give rise.

Minute in quantity, and tenaciously adhering to substances present, particularly protein, the isolation of an enzyme in the pure state has become one of the most difficult problems in physiological chemistry. Yet any elementary student in the subject finds little difficulty in performing simple experiments which convince him either of its presence or of its absence. How are they done?

The method consists essentially in making use of the so-called "specificity" of enzymes. To use Fischer's simile, just as one key fits one lock, so any one enzyme will act on only a certain type of substance. Take, for example, the enzyme found in saliva, ptyalin: it readily acts on the carbohydrate, starch, but has absolutely no action on protein. Again, take the pepsin of the stomach: this enzyme breaks down proteins, but is without result on carbohydrates. These instances may be multiplied indefinitely.

Some enzymes show their specificity to an even more marked degree. In the yeast cell, for example, we find one, sucrase,[1] which acts only on cane sugar (sucrose); but on no other sugar or carbohydrate. A simple little experiment demonstrates this beyond question. A yeast cake is ground up very intimately with a little sand and water, and the mass filtered. A small portion of the filtrate is added to a solution of cane sugar, the mixture placed in an incubator kept at 38° C., and allowed to remain there for about 30 minutes or so. At the end of that time the mixture, if heated with Fehling's solution,[2] will yield a red-brick precipitate—a result which could not be obtained either with the cane sugar, or with the enzyme solution alone. No other carbohydrate solution—or protein, or fat solution, for that matter—can take the place of the cane sugar; our enzyme will be without effect. If we take our original yeast extract, and first heat it to, say, the boling point of water, then cool it, and from here on repeat the experiment as before, no grape sugar is obtained. If instead of heating the enzyme solution, we cool it, the action is considerably delayed.

Some of the yeast extract may be poured into an excess of alcohol, the precipitate separated by filtration, and redissolved in water. This solution will show all the properties of the yeast extract.

Evidently, then, the watery extract of yeast contains something which has the power of breaking down cane sugar. This something is exceedingly sensitive to heat, rather less so to cold, and is precipitated—together with other substances (as could be shown)—by alcohol. The last three properties are characteristic not only of sucrase, but of all enzymes to a greater or less degree. That a minute quantity of enzyme can act upon an exceedingly large quantity of substrate is also readily demonstrable. The laws of catalysis hold firm.

One other fact about enzymes is most important. Graham, as far back as 1861, found that certain substances (cane sugar, salt, etc.) in solution, when placed in a dialyzer consisting of a parchment bag, which in its turn was surrounded by water, would diffuse through the bag, whereas others (proteins, gum, starch, etc.) would not. The diffusible ones he named crystalloids, those non-diffusible, colloids. If some of our original

[1] The ending "ase" denotes enzyme.

[2] This is the well-known alkaline copper solution used by all medical men to test for sugar in the urine. The sugar in the urine is not, as might be supposed, ordinary cane sugar, but grape sugar. Fehling's solution reacts with the latter, but not with the former.

The cane sugar is split or "hydrolyzed," by the sucrase, one of the products being grape sugar.

yeast extract were placed in such a parchment bag, none of the enzyme would find its way into the surrounding layer of water. Enzymes, like the proteins, are *colloids*.

The fact that enzymes show colloidal properties, and the fact that they are invariably associated with proteins, made it seem probable that when ultimately isolated in the pure condition, they would be found to be proteins. Attempts to obtain pure enzymes have been many. The general method of procedure in almost all cases consists in first extracting with water[3] —as already explained—or submitting the mass to much pressure (Buchner), if the enzymes are "intracellular."

Having obtained a solution, the next step is often that of dialysis (Graham). Diffusible bodies, particularly inorganic substances, are thereby separated. Three of the classical investigators in this branch, Osborne, Peckelharing, and Fraenkel, have all employed this method.

Now usually comes precipitation. Some substance—alcohol, acetone, or ammonium sulphate—is added in which the enzyme is insoluble. The precipitate so obtained contains many impurities (proteins, certain carbohydrates, etc.). To purify it, it is redissolved, re-dialyzed, and reprecipitated many times. On occasion, a biological procedure, first suggested by Effront, and put into practise by Fraenkel, may be used. This consists in fermenting the impure precipitate with yeast. The carbohydrate and protein are thereby used up, but according to Fraenkel, the enzyme is not touched.

The laboriousness of such an operation may best be gathered from a specific example. Let us take an experiment from the work of Professor Sherman, of Columbia, an active investigator. Here is his method for preparing a starch-splitting enzyme from the pancreas: Mix thoroughly 20 grammes of pancreative powder—a commercial preparation—with 200 cubic centimeters of 50 per cent. alcohol at 15–20° C. [S. finds that much of the contained protein is left behind by the use of this 50 per cent. alcohol.] Allow this preparation to stand 5–10 minutes, then filter, keeping the temperature below 20° C. (This takes from 1 to 2 hours.) Pour the filtrate into 7 times its volume of a mixture of 1 part of alcohol to 4 parts ether (more protein and other impurities are here separated). Within 10–15 minutes the enzyme (including certain impurities) separates as an oily solution. Decant the supernatant liquid. Dissolve the precipitate in the smallest amount of pure water at a temperature of 10–15 degrees Centigrade and

[3] Often containing alcohol, toluene, or chloroform (as preservatives).

reprecipitate at once by pouring into 5 volumes of absolute alcohol. Allow it to settle, keeping temperature low; filter, dissolve in 200–250 cubic centimeters of 50 per cent. alcohol containing 5 grammes of maltose. Pour the solution into a collodion sack of 500 cubic centimeters capacity, and dialyze against 2,000 cubic centimeters of 50 per cent. alcohol at not above 20° C. and preferably not below 15° C. Replace dialyzate twice: after 15 hours and a second period of 8–9 hours with fresh 50 per cent. alcohol. Continue dialysis 40–42 hours. Filter. Pour clear filtrate into an equal volume of a mixture of alcohol and ether (equal parts). Filter in the cold, and place the precipitate in a vacuum desiccator.[4] The powder obtained is so active that it can digest 20,000 times its own weight of starch. And still we are not at all certain that this is an enzyme uncontaminated with foreign bodies!

Of the three or four representative workers in attempts to isolate a pure enzyme, the substances obtained by Professor Sherman and Dr. Osborne (of the Connecticut experiment station) showed decided protein characteristics; whereas the two German investigators, Lentner and Fraenkel, both agree in proclaiming their products as carbohydrate in nature. How near or how far from the truth is either group? To begin with, no proof that any of these products is 100 per cent. pure has been advanced, and the chemist through bitter experience knows the danger in discussing the composition of impure substances. Another fact to be kept in mind is that, often enough, the purer the enzyme, the less active does it become. In several of these cases it has been shown that a loss in activity goes hand in hand with a proportional loss in the phosphoric acid content of the substance. This gives rise to the possibility—expounded further on—that the enzyme is not a chemical individual, but consists of at least two substances: (*a*) a something which has the power of acting only when activated—in this instance—by (*b*) phosphoric acid. And yet, if arguing by analogy is at all permissible, it may be maintained that since all the inorganic catalysts are distinct chemical individuals, why not enzymes?

Of course, all this does not at all exclude the possibility that different enzymes may have different structures and the conflicting results of investigators may be due to this fact. Some of the men worked on amylases (starch-splitting enzymes), others on lipases (fat-splitting), others still on proteases (protein-splitting). Why assume that such diverse substances

[4] A vessel (containing a hygroscopic substance to take up moisture) from which the air has been exhausted.

should all have the identical composition? It may be, as Professor Armstrong has suggested, that the enzyme in constitution is similar to the substance on which it acts.

Extremely suggestive as the basis for much present-day activity has been the work of Professor Gabriel Bertrand, of the Sorbonne, Paris. Most of this has been on laccase, an oxidizing enzyme first found in the milky latex of the tree *Rhus vernicifera,* and since then in many plants. The production of the beautiful Japanese lacquer from the latex of *Rhus vernicifera* was shown to be due to the activation of the atmospheric oxygen by the laccase (hence its name). Bertrand was able to prove that the activity of the laccase was connected with the manganese present, for by repeated precipitation with alcohol, he divided his laccase preparations into three fractions of different manganese content, each with an activity distinctly proportional to the amount of manganese present. As further proof of the importance of this manganese, he was able to show that a minute addition of a salt of manganese (manganese sulphate) increased the activity of the laccase, whereas other metals had no such effect. This led him to the dual conception of an enzyme, also advocated by Armstrong: one of the constituents is capable of producing, to a slight degree, on its own account, the chemical reaction associated with the particular enzyme in question, but requires its activity to be augmented by the presence of another substance—inactive in itself—before its action becomes appreciable. The former may consist of acid, alkali, calcium or magnesium salt, etc. The latter component is more complex, usually protein-like (egg-white, for example), and colloidal.

Bertrand's views—perhaps, also, Fischer's colossal work on the synthesis of proteins from amino acids—has led the school of enzyme chemistry to shift its ground considerably. Why these laborious, and always futile attempts to isolate a pure enzyme from the cell? Why not attempt to synthesize one from simple inorganic and organic materials? Trillat, in 1904, prepared a mixture of traces of manganese chloride and egg albumen which showed the reaction of laccase and other oxidases (oxidizing enzymes): it blued guaiacum, its action was prevented by heat and acid, and it could be precipitated by alcohol, and redissolved in water without losing its oxidizing powers—characteristic properties of *all* enzymes. Wolf with his colloidal iron compounds, and Euler and Bolin with their calcium salts of organic acids (citric, malic, etc.), and many others, have produced strong evidence in favor of the view that many of the enzymes, at least many of the so-called oxidases, are relatively simple substances.

Along somewhat modified lines is the work of Panzer, who claims that various carbohydrates show distinct diastatic (carbohydrate-splitting) activity when heated with hydrochloric acid gas, and then ammonia; and that of Woker, whose findings, at present rather disputed, would tend to the belief that formaldehyde (the "formalin" of commerce) may, under certain conditions, act in place of diastase in hydrolyzing starch.

Some very far-reaching possibilities are suggested by the studies on the lipases (fat-splitting enzymes) of castor and soya beans by Dr. Falk, of the Harriman Research Laboratory. Every worker in the field is aware how very easily enzymes are inactivated or destroyed by heat or the presence of relatively small quantities of certain foreign bodies, such as acids and bases. The inactivation of the lipases of the beans could be brought about not only by these means, but also by neutral salts, alcohols, acetone, etc. Dr. Falk conceived the idea that this inactivation was due to an internal rearrangement of certain of the atoms in the molecule of the enzyme. Many cases of such tautomeric changes—of rearrangement within the molecule—are known to organic chemists, and are often stimulated by the action of mild chemical agents. Dr. Falk's hypothesis is to the effect that the grouping involved is to be found in all proteins, and hence, probably, in enzymes. If inactivation means the rearrangement of a group from configuration 1 to that of 2, activation, or change from 2 back to 1, may be brought about by the action of dilute alkali—often used to bring about these changes in configuration. Actual experiments on the action of alkali on proteins (themselves quite inactive) have endowed these substances with fat-splitting power.

Whilst, therefore, we are far from a comprehensive knowledge of the chemical configuration of an enzyme, studies on the production of artificial enzymes, and on the possible rearrangements of certain groups within the molecule, may throw much light on a very perplexing problem.

THE GIRASOLE OR JERUSALEM ARTICHOKE, A NEGLECTED SOURCE OF FOOD

By Professor T. D. A. COCKERELL

UNIVERSITY OF COLORADO

THE sunflowers, genus *Helianthus*, are native only in the Western Hemisphere. Botanists recognize about 70 valid species in America north of Mexico; but Mr. S. Alexander, who minutely studied the sunflowers of Michigan, recognized some hundreds of forms, which he regarded as species. These have not yet been described. About a dozen species are known from Mexico, one is recorded from Guatemala, and about 25 come from South America, nearly all from the mountains of Chile and Peru. The South American sunflowers need investigation, but the materials for a revision do not exist in American herbaria. Only two or three of those represented in the herbarium of the New York Botanical Garden appear to be genuine *Helianthus*, but one collected by R. Pearce at an altitude of 8,000 feet in Bolivia, and also collected in Bolivia by Rusby, is quite of the type of the North American perennial species.

It is in the northeastern United States and adjacent Canada that species of *Helianthus* develop edible tubers. Mr. S. Alexander, who paid particular attention to the root-system, distinguished a great group of sunflowers which possess no permanent crown, but reproduce annually by seeds and earth-branches. These he called "binatal annuals," although they are ordinarily classed as perennials. They are of course perennial in the same sense as the potato. A key based on Mr. Alexander's manuscript subdivides this group as follows:

Leaves petioled.
  Petioles winged.
    Species with cord-like migrators................*Helianthus* sp.
    Division *Tuberosæ* (Alexander), with distal ends of migrators bearing tubers......................*H. tuberosus* and allies.
  Petioles not winged..................................*Helianthus* sp.
Leaves not petioled.
    H. doronicoides, H. mollis, H. ciliaris, H. radula, H. cinereus.

The last is a very miscellaneous lot, the species not closely related. *Helianthus tuberosus* is the Jerusalem artichoke. The Tuberosæ, according to Mr. Alexander, include *H. tuberosus* and its variety *subcanescens* of Gray, and "at least 100 or more well-marked species," all of which are undescribed. These latter would probably not be considered species by most botanists, but their comparatively slight differences may prove very important in the development of horticultural types.

In both the potato and the Jerusalem artichoke the tubers arise from underground stems, the earth-branches of Alexander. As has been pointed out by Reed (1910), the tubers of the potato are terminal, whereas those of the *Helianthus* are formed laterally as well, or the earth-branch itself may swell up and become a tuber. Consequently the *Helianthus* bears a mass of tubers close to the crown, though others may be more widely separated in the soil. It results from this arrangement that the tubers are very easy to harvest, and the tuber-bearing region occupies a surprisingly small space, considering the quantity of the tubers.

Helianthus tuberosus is not the only member of the genus which has been used as a source of edible tubers. *H. subtuberosus,* the so-called Indian potato of Michigan and Minnesota to Saskatchewan and Montana, has thick fleshy edible tubers. It was used by the Assiniboines. *H. doronicoides,* native from Ohio to Missouri and Arkansas, is used as food in Europe. Vilmorin of Paris offers it for sale, remarking that "les rhizomes de cette plante, produits en abondance, peuvent être consommeés à la facon de salsifs." It has been found by von Héries-Tóth and von Osztrovsky (1911) that the tubers of *H. doronicoides* are good raw material for the production of alcohol, while the refuse contains considerable amounts of fat and protein, and can be fed to stock.

Helianthus tuberosus, as a source of food, was well known to the natives of America long before the advent of the white man. Dr. V. Havard (1895), in an account of the food-plants of the North American Indians, says:

> The first place belongs to the Jerusalem artichoke (*Helianthus tuberosus* L.). It produces many edible tubers, sometimes two inches in diameter, in our day mostly used for the feeding of cattle, horses and pigs, but which were precious to the Indians on account of their hardiness and prolificacy, retaining possession of the soil for many years. These tubers were mentioned by Champlain in 1603, and brought to France by Lescarbot, who, in 1612, describes them as being "as big as small turnips, excellent to eat, with the taste of artichoke but more agreeable, and multiplying in a wonderful way." As the plant is native of the valleys of the Ohio and Mississippi, and does not reach any part of Canada, it is evident that the Canadian and New England Indians who planted it must have obtained it from the tribes further south and west, so that we may infer a rather large area of cultivation. The Jerusalem artichoke is, so far, the only contribution of North America, exclusive of Mexico, to the vege-

table garden of the world, and it can be said to be an aboriginal contribution. Strange to note, it is now much more cultivated in the Old World than on this continent.[1]

The tubers appear to have been highly appreciated in Europe from the first. The plant was grown in the Farnese Garden at Rome, and was distributed thence under the name Girasóle Articiocco, or sunflower artichoke. It was early reputed, by some mistake, to be a native of Brazil, and this error crops up in various compilations, down to recent times. Venner (1620) stated that the tubers were usually eaten with butter, vinegar and pepper. Parkinson (1629) noted that they were very commonly offered for sale in London.

The name artichoke is supposed to be derived from the Spanish-Arabic alkharshof, applied to the thistle-like plant *Cynara scolymus*, a native of the Old World. This is the true artichoke, and the edible part is the flower-head, particularly the thickened involucral bracts. Thus the true artichoke and the Jerusalem artichoke have little in common, the plants being entirely different in appearance, and furnishing quite different parts as food. The name artichoke appears to have been given to the *Helianthus* solely on account of the more or less similar flavor, while "Jerusalem" is an English corruption of the Italian "Girasole," or sunflower. Thus the designation "Jerusalem artichoke" is as misleading as "guinea pig," or "Christian Science."

The confusion resulting from the name necessitates considerable caution in using published records. Thus in Edw. Smith's well-known book on foods (Internat. Science Series), which has gone through ten editions, the two plants are discussed as if they were varieties of one thing, and most of the statements are made as if equally applicable to both. C. E. Quinn (1908), in a Farmers' Bulletin on forage crops for hogs, discusses the *Helianthus* under the name artichoke, with no indication of the fact that it is not the true plant of that name. It is quite common to find the name artichoke thus applied indiscriminately, and unless one knows the difference between the plants, and can find the characteristics mentioned in the text, it is difficult to understand what is intended. The French have a distinctive name, *Topinambour*. This is rather long and difficult to pronounce, but the Italian *Girasole* is short and simple, and is the proper form of the absurd "Jerusalem." We may therefore perhaps use it for our *Helianthus*, though it is open to the objection that to an Italian it means a sunflower, and probably suggests the annual species of gardens rather

[1] *Bull. Torrey Bot. Club*, March, 1895.

than any other. Britton and Brown give two English designations, earth apple and Canada potato. The first is objectionable, since pomme-de-terre is French for a potato; while the second is doubly misleading, the plant being neither a potato nor originally specially characteristic of Canada; though to-day it is said to occur from Nova Scotia and Ontario to Manitoba. On the whole, then, Girasole seems the least objectionable term. It is a singular fact, as Havard remarked, that a plant so highly esteemed by the American aborigines, and for three hundred years used in Europe, should find so little favor to-day in the land of its origin. The literature indicates that it is probably even less used now than when Havard wrote, some twenty years ago. Our experience at Boulder having indicated the astonishing size of the crop, and the value of the tubers as human food, we could not understand the apparent neglect. Wishing to ascertain the exact facts, I wrote to a number of experiment stations and to Washington, and am exceedingly indebted to those addressed for their prompt and courteous replies. The following will suffice to show the prevalent opinion:

U. S. Department of Agriculture. As to the possible usefulness of Jerusalem artichoke as an emergency food, all that you say in regard to its productiveness is thoroughly justified. . . . A new vegetable at best is adopted very slowly . . . it seems to me rather an impressive fact that the plant has not made its way in the United States, although it is undoubtedly a native of this country and has been with us during our whole vegetable gardening history. Apparently there must be some lack of appreciation of its flavor or some difficulty in its production, storing or cooking which has served finally to discourage every enthusiastic advocate who has started to preach its values in the past. I know there must have been many such advocates, and the fact that their labors so far have apparently accomplished so little is to me rather discouraging for a new attempt. (D. N. Shoemaker.) Reference is also made to the difficulty of preparing the irregular tubers for the table. Dr. L. C. Corbett, writing to the U. S. Food Administration (the letter kindly transmitted by Professor V. L. Kellogg), adds another objection—that it would be difficult at present to secure enough seed (*i. e.*, tubers) to plant any considerable acreage. (It would of course be easy by planting this year, to secure plenty for the year following.)

Arizona. We have tried artichokes down at the Yuma Garden; finding, I believe, that they were very badly infested by a lace wing bug of some sort, which spread from them to other plants, including sweet potatoes. We regarded them, therefore, undesirable as a crop. (R. H. Forbes.)

Arkansas. Bulletin 31, a number of years ago, gave details of experiments and analyses. At Newport the yield was 453.75 bushels to the acre; at Fayetteville 612 bushels. The tubers were fed to hogs. There are no recent developments.

Colorado. I do not think that any of our station men are really doing any experimental work with the Jerusalem artichoke. On last Sunday I was in Dean Johnson's garden, where he had planted a few artichokes, and was astonished at the very large yield. One plant had fully a peck of tubers. Artichokes are quite often planted as food for hogs, which do their own harvesting. (C. P. Gillette.) Colorado Exper. Station Bull. 146, on raising hogs in Colorado, and Bull. 199, on Vegetable Growing in Colorado, make no mention of the Jerusalem artichoke.

Connecticut. It is grown occasionally in gardens in Connecticut, but to my knowledge no one has grown it as a crop. (E. H. Jenkins.)

Illinois. This institution has done no work on the raising of Jerusalem artichokes as a crop. (E. Davenport.) We have so many things which seem to be much more important, that we will have to confine our attention to such crops. (W. L. Burlison.)

Massachusetts. Bulletin 47 contains analyses. They were never raised to any extent.

Michigan. This old, well-known plant has been grown very little to my knowledge in this state. We have not tried out any variety of it. . . . Where I have seen it grow, it did not yield sufficiently heavy to give a very large return per acre. (C. W. Waid.)

Missouri. No information available.

Nebraska. We have had no experience with artichokes of any kind or variety. A few have been grown in some sections of the state, but they are grown entirely as hog feed, the hogs being allowed to root them out. (W. W. Burr.)

South Dakota. Jerusalem artichoke was cultivated to some extent years ago for hogs, but I do not know why the matter was not carried on further. I believe the plant could be greatly improved as a crop for feeding to swine. It certainly can be raised cheaply, and the swine can do their own harvesting. (N. E. Hansen.)

Washington State. Our Western Washington Experiment Station has done some work with the artichoke, but we have never considered it a plant of great merit, and have therefore done very little to encourage its production. (Geo. Severance.) Bull. 7, however, gives some remarkable results, cited below.

Wisconsin. We have done nothing with its culture here. It is grown to some extent as a plant upon which to pasture hogs, but I know of no particular work which has been done with it. (J. G. Moore.)

The above statements might be sufficient to discourage any one, but there is another side to the question, and it is worth while to review the principal facts about the plant as a crop, and as a source of food for man and beast.

At Boulder, Colorado, in 1917, we planted the white variety in a field which had been for two years in *Helianthus annuus*. No fertilizer was used, but the soil was exceptionally good for the locality. The tubers were planted three feet apart in the rows, and the rows were two feet apart, each plant thus occupying six square feet. The yield was found to be at the rate of 9.66 tons to the acre. This greatly exceeds the average yield of potatoes. The most astonishing yield is reported from Western Washington by W. H. Lawrence (Bull. 7, Wash. Exper. Sta., 1912). Of the red variety, "335 lbs. of tubers were dug from an area of 360 square feet—at the rate of 20.26 tons per acre." The white variety was even more prolific; "on upland clay near Alequa 2,015 square feet produced an estimated yield of 38.9 tons per acre." (In the Experiment Station Record, XXVIII., p. 531, it is erroneously stated that this yield was in sandy soil.) No wonder the author added:

> Jerusalem artichokes have not been given the attention they should receive. From the experiments it is evident that a large tonnage per acre can be grown of either the white or red variety, and that large yields may be obtained at a low cost.

Yet to-day, in Washington State, the experiment station authorities have lost interest, following the general trend throughout the country. M. Rau (1914) compared the Jerusalem artichoke with the potato on the basis of German experience, and decided that the former was superior as a forage crop, "as it requires less labor to plant and cultivate, yields more heavily in tubers and straw, is of higher food-value, and the tubers have a greater frost resistance" (*Exp. Sta. Record,* XXXI., p. 433). Analyses are given, showing the difference in favor of the girasole.[1] Sutton and Sons of England report that a gardener (J. Barker) planted six pounds of tubers and got 18 stone of "splendid tubers, pure white, with excellent flavor." The Massachusetts Station Annual Report for 1892 records a yield of 8.5 tons to the acre. The Encyclopedia Americana states that the usual yield is 200 to 500 bushels to the acre, but 1,000 bushels are sometimes obtained. The average yield of potatoes per acre in the United States is said to be 84.5 bushels, but Maine, Montana and Nevada average 150–163 bushels.

The girasole can not become a competitor of the potato in such regions as the mountains of Colorado, but it thrives along the foothills and on the plains. S. M. Tracy, in Farmers' Bull. 509 (1912), dealing with forage crops for the cotton region, describes it as a valuable grazing crop for hogs in the northern and central parts of the cotton region, but states that it yields less heavily and is less desirable farther south. He adds that it yields much more heavily than Irish potatoes, and is worth fully as much for feed.

> They are strictly a winter feed, not being well matured until December. From that time on until March they furnish perhaps the least expensive roots grown for hog feed.

Thus, taking the country over, the potato is best adapted to the northern and upland regions, the sweet potato to the south, and the girasole occupies more especially the great intermediate region, as a promising source of tubers. Although the girasole

[1] In Experiment Station Record, XXXI, these figures are accidentally reversed, as I learn from Dr. E. W. Allen.

is apparently at a disadvantage southward, it can be grown under an astonishing variety of conditions, considering its rather restricted original habitat. Piper (1911) lists it among the crops grown in the Philippine Islands, and it is grown in South Africa. A special variety is said to be grown in China and Japan. Dr. L. H. Bailey writes me that he saw it freely displayed for sale in China during the past year. C. H. Shinn reported that in California it grew well on alkali soils, where legumes were not successful.

Under cultivation in Europe, the plant has produced several varieties. Vilmorin (1913) lists the following: (1) *Ordinaire.* (2) *Patate,* with yellow tubers. (3) *Blanc amélioré,* with round white tubers. (4) *Piriforme,* with red tubers, flesh sugary. (5) *Rose,* with oblong tubers, rich in sugar. The last three were introduced by Vilmorin. Sutton, of England (1917), lists *White, Rose* and *Purple,* the last being described as "the old variety," presumably Vilmorin's "ordinaire." The white and rose are described as improved forms introduced by the Sutton firm. Much work in the development of varieties is undoubtedly ahead of us; it may be safely assumed that modern methods of breeding, with more attention to the particular characters desired, will in time greatly improve the plant and give us sorts adapted to special purposes, as in the case of the sugar beet.

Analyses suggest that the food-value is about the same as that of the potato, but, as the carbohydrates are different, further investigation is desirable.[2] Mr. Russell N. Loomis, of the University of Colorado, has kindly analyzed the white variety grown in Boulder, with the following results from two samples, the figures representing percentages:

	Sample 1	Sample 2
Moisture	83.09	83.89
Ash	0.77	0.77
Protein	1.41	1.50
Ether Extract	0.35	0.55
Carbohydrates (direct method)	11.60	10.44
	97.22	96.45
Crude fiber (included in carbohydrates)	0.76	0.69
Carbohydrates (by difference)	14.38	13.29
Calculated on Water-Free Basis		
Ash	4.55	4.57
Proteins	8.31	9.68
Ether Extract	2.06	3.14
Carbohydrates (direct method)	68.53	64.80
Crude fiber	4.48	4.22
Carbohydrates (by difference)	85.03	82.49

[2] I am greatly indebted to my colleague, Dr. J. B. Ekeley, for advice concerning the chemistry of the plant.

Comparing three German analyses and one in Mass. Bull. 47, we find general agreement. Our water-content is highest, the other records showing about 71.5 to 81 per cent. This may be due, at least in part, to our sample being analyzed soon after digging. There is a marked discrepancy in the ether extract, other analyses giving (as fat) .70 to 1.30 per cent. of dry weight only. My colleague, Dr. Ramaley, remarks that our ether extract doubtless includes the resin, of which there is probably a considerable amount. It is not quite clear, however, that this is excluded from the other analyses, which seem to have been made in the same manner. The protein content is evidently variable, different records showing a range of from 6.20 to 12.82 per cent. of dry weight. The same variability is found in the potato, which showed a range from 6.52 to 17.56 in samples from eight different stations in Germany. The usual analyses give the carbohydrates as "nitrogen-free extract," obtained by deducting the water, ash, protein and ether extract from 100. This is evidently very inexact, as direct analysis gives a much lower figure, as will be seen above. Our figures agree with other analyses, whether made by the one method (Behrend) or the other (Strohmer and Stift, Rau, Mass. Bull. 47).

The whole subject is complicated by the peculiar nature of the carbohydrates in the girasole. The taste is sweet, and there is evidently free sugar. The tubers of Compositæ, as a result of photosynthesis, store up inulin, in place of starch. Inulin has the composition $(C_6H_{10}O_5)_n + H_2O$, and occurs, not in granules, but in solution in the sap. It may be separated out as a white powder, and is slightly soluble in cold and readily soluble in hot water. The saliva does not convert it into sugar, but it is presumably made digestible by being changed into levulose in the stomach by the acid gastric juice. Experiments reported by Sandmeyer (1895), Mendel and Nakaseko and Mendel and Mitchell indicate that inulin may have only moderate value as food; though "inulin" bread and biscuit have been put upon the market, and are supposed to be good for invalids. E. H. S. Bailey[3] states that the girasole tubers "contain 14.7 per cent. of sugar and no starch, but they contain considerable inulin, a substance isomeric with starch." Tanret,[4] who appears to have made the most exact analysis, found two other carbohydrates in the tubers, *helianthenin*, $12C_6H_{10}O_5 + 3H_2O$, and *synanthrin*, $8C_6H_{10}O_5 + H_2O$. He also stated that the levulin or synanthrose reported by previous authors is a mixture of saccharose (cane sugar) and synanthrin.

[3] "The Source, Chemistry and Use of Food Products," 1916.

[4] *Compt. rend.*, 1893.

Further investigations may show that the tubers can be used in the manufacture of special products. In Europe they are utilized in the manufacture of alcohol. Edw. Smith notes that 55.9 per cent. of the salts in the tubers is potash, and cultural experiments agree in indicating the value of potash salts as a fertilizer for the crop. Behrend indicates the presence of 3.88 to 6.47 per cent. of dry weight of pentosans, a class of insoluble carbohydrates.

The use of the tubers in feeding stock, particularly hogs, has been referred to above. C. E. Quinn, Farmers' Bulletin 331, states that the girasole "is superior to the common beets and turnips for hogs, and about equal to potatoes, and richer in protein than sweet potatoes." It should not be fed pure, but as part of a mixed ration. S. M. Tracy states that three bushels of tubers fed with one bushel of corn to hogs in the winter are fully equivalent to two bushels of corn, and the fresh feed which the tubers give keeps the animals in much better health than when fed on corn alone. At the Agricultural High School in Berlin the dried leaves and stalks of the girasole were fed to sheep and cows, and found about equal in nutritive value to good meadow hay. It was found advisable to use it as part of a mixed diet. Since the green parts of the plant are very large, there is here another important source of profit. The young plants are sometimes used as food for cattle. Magen reports that peasants in the south of France are in the habit of feeding the tubers to work horses, and get good results. In an experiment they were fed with crushed grain and chopped hay, and no unfavorable results were noted. The ration was found to be very economical, "both on account of the small value of the land on which the artichokes are grown and the ease with which the plant may be cultivated." Various other experiments give essentially similar results, and need not be described.[5]

Girasole tubers can be used as a boiled vegetable, as salad, or in soup. We have found them excellent food, and while the taste often strikes people as peculiar at first, it is easy to acquire a liking for them. Some prefer them to other vegetables. The tubers may be left in the ground during the winter, and dug as required. They are not injured, when thus left out, by the frost. If they are stored, they should be put in pits, with a covering of straw and earth. In preparing them for the table, the irregularity of the tubers is a disadvantage, making them hard to peel. It may be said, however, that the thin skins may

[5] In looking up references the volumes of the Experiment Station Record (U. S. Dept. Agriculture) are invaluable.

be eaten with the rest, and are not objectionable except from the standpoint of appearances. The cook-books consulted give very little information, but Mrs. Cockerell supplies me with the following notes, based on her experience. The tubers have a delicious aroma (due to essential oil) when cooking, and this should be preserved as far as possible by keeping them covered. They should be *put in boiling water*, a few tubers at a time, so as not to lower the temperature; steaming would probably be still better, reducing the loss of soluble contents. The boiling should continue 15–20 minutes (possibly less at sea-level), when the skin is easily removed. At this stage the following recipes may be employed, but in the case of the salad (No. 2) the cooking should last a little longer.

1. Soup may be made with the addition of celery tops rubbed through a colander, with milk or stock or cream added.
2. The cooked tubers sliced with egg or celery or endive, served with French dressing or mayonnaise, make a delicious salad.
3. Slice the boiled or steamed tubers, cover with milk, use salt and pepper to taste, cover with bread crumbs, and then bake for an hour. Grated cheese may be added to this dish.
4. Slice boiled tubers and fry with steak or chops.
5. Slice boiled tubers, mash, add cream, salt and pepper; or cream by adding sliced tubers to rich white sauce, and serve with toast.

It appears that we have in the girasole a plant which produces enormously, and is equally valuable as food for man and beast. In addition to its other merits, we have found it remarkably free from pests; though in Europe there is quite a long list of insects attacking it, many of them primarily infesting the burdock (*Arctium*). It seems impossible to avoid the conclusion that the cultivation of this plant, especially perhaps in small gardens, may add very considerably to the food-resources of the country, at a time when such increase is more than desirable. The greatest obstacles seem to be prejudice and lack of knowledge. In this, perhaps, as in so many other matters connected with the war, our success must depend very largely on our ability to respond to needs and rapidly adjust ourselves to circumstances.

THE MATHEMATICAL PRINCIPLES OF PICTORIAL REPRESENTATION

By Professor ARNOLD EMCH

UNIVERSITY OF ILLINOIS

THE object of artists in painting pictures, in making drawings and designs, in creating works of plastic art and sculpture, is to represent a landscape with the moods of nature, human and other living beings in their association with historic and social events, to portray and sculpture single figures and groups of figures of importance in the cultural development of a people; or merely to depict incidents of human interest in everyday life. The purpose of decorative art is embellishment and the breaking of the monotony of blank surfaces where purely utilitarian considerations do not interfere or make decoration desirable. Contrary to popular opinion that fine arts are or should be concerned with the representation of the beautiful only, they sometimes intend to create a certain impression, or to influence public opinion for a certain purpose which is moral rather than specifically beautiful. By his incomparable battle-scenes the great Russian painter Wereschtschagin, who went down with the *Petropawlowsk* near Port Arthur during the Russian-Japanese war, for example, wanted to impress the people with the horrors of war.

The methods and styles by which artists accomplish their purpose are of such a great variety that only a complete history of fine arts could convey an idea of what has been accomplished in this ideal endeavor of the human mind.

In sculpture the form of the represented model is mostly similar, if not identical, with that of the true object, while in painting a plane surface must serve as a base of representation, so that, in general, there is no geometrical similitude between the external forms and their plane pictures. The same is true of relief-modelling in which the relation between the plastic and the original figure in space is that of a certain variable scale. The laws which govern these changes in the correspondence of forms are expressed by the technical term collineation, or rather by a particular kind of collineation, called perspective. We shall be concerned with this alone, *i. e.*, with the geometrical laws which connect the original form with its pictorial representation. Other elements of depiction, like color, shades and shadows, aerial perspective, and other effectives, lie beyond the scope of this essay. I shall first explain the principles upon which artistic perspective is based. These are so simple that any person with elementary geometrical knowledge is able to understand them. A certain minimum of theoretical considerations of this kind is necessary for the comprehension of the critical and historical remarks on the application of perspective in painting during various historic periods.

The fundamental idea of representation, or depiction, is contained in the principle of correspondence between the elements of space, *i. e.*, points, lines, and planes of the object and the elements of the figure which is supposed to represent the same. This figure we shall simply call the perspective (relief) of the object. This is merely a special concrete case of the theory of correspondences, a theory which is of the greatest importance in many lines of modern mathematical research.

In Fig. 1, let p' be a fixed plane, usually in a vertical position, and C a fixed point in space, not located in p', called picture-plane. The point C is called center of perspective and takes the place of the eye of the observer. We may think of p' as the film of a camera, or as the plane of the canvas upon which the picture is to be painted. To obtain the perspective of any point A in space, join A to C. The intersection A' of AC with p' is then the perspective of A. Thus, to every point in space corresponds a point in p'. To a point P which lies in

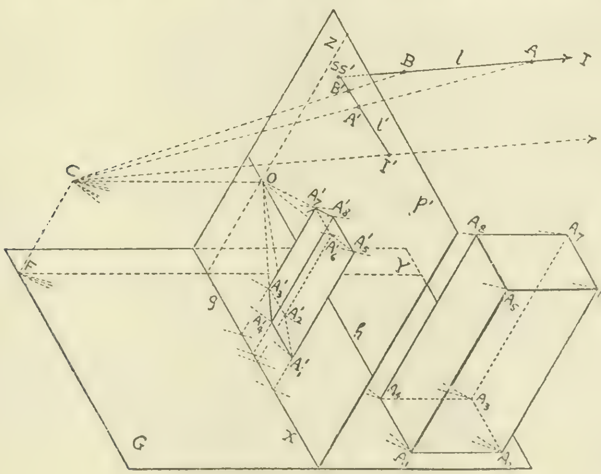


Fig. 1.

p' itself corresponds the point itself, *i. e.*, P' coincides with P. A straight line, or simply a line l is determined by two points, say A and B, so that its perspective is obtained as the line l' joining the perspectives A' and B' of A and B. The perspective l' of l is also obtained as the intersection of the plane passing through C and l with p'. A line, like CA, is called the projecting ray of A. When a point I moves on a line l beyond any finite region, then the projecting ray CI becomes parallel to l, and the perspective of I, *i. e.*, the intersection I' of CI with p', is called vanishing point of the line l. If S is the point where l pierces the plane p', then S' coincides with S, so that l' may also be obtained as the line which joins S' and I'. From the definition of the vanishing point of a line it follows that parallel lines in space have the same vanishing point, so that the perspectives of parallel lines all converge towards the same point, as is well known. The improper position of the point I on l beyond any finite point of l is in projective geometry defined as the infinite point of l. It is likewise possible to assume without meeting contradictions that the non-finite region of a plane is a straight line, that of ordinary space a plane. In this manner all statements in the foregoing correspondence become perfectly general. Parallel lines are now lines through an infinite point, to which corresponds the vanishing point of those lines. Lines parallel to a given plane pass through the infinite line of this plane, so that their vanishing points lie on a line in p', which corresponds to the infinite line of the given plane, and which is obtained as the line of intersection of the plane through C, parallel to the given plane, with the picture-plane p'. The only parallel lines which are projected into parallel lines are parallel lines which themselves are parallel to p'. If the picture-plane stands vertically upon a horizontal ground-plane G which intersects the picture-plane in the ground line g, then the vanishing points of all horizontal lines lie on a vanishing line h called "horizon."

In the terminology of artistic perspective these results may be stated as follows:

1. Corresponding points of the object and of its perspective lie on rays through the center.

2. Corresponding lines meet in points of the picture-plane. The perspective of a line through the center is the point of intersection of the line with the picture-plane.

3. Parallel lines have the same vanishing point through which their perspectives pass.

4. The vanishing points of lines parallel to the same plane lie on the same line.

5. The vanishing points of horizontal lines lie on the horizon.

6. Parallel lines parallel to the picture-plane are projected into parallel lines.

7. Vertical lines are projected into vertical lines.

8. The point of intersection of two lines is projected into the point of intersection of the perspectives of those lines.

9. Plane figures parallel to the picture-plane are projected into similar figures.

10. The diagonals of an ordinary quadrangle, which is the perspective of a rectangle (square), intersect in a point which is the perspective of the center of the rectangle (square).

11. The vanishing point of lines perpendicular to the picture-plane is called the eye-point of the perspective. It is also the foot-point of the perpendicular from the center to the picture-plane.

12. The vanishing points of two perpendicular lines lie on a semicircle through C over the segment between the vanishing points as a diameter.[1]

These rules, which might be increased, are sufficient to test the correctness of the perspective of a painting.

In Fig. 1, the eye-point is denoted by O. The rectangular prism $A_1A_2A_3A_4A_5A_6A_7A_8$ is placed upon the ground-plane G and with two faces $A_1A_5A_8A_4$ and $A_2A_6A_7A_3$ parallel to the picture-plane p'. Accordingly, $A_1'A_4'$, $A_5'A_8'$, $A_2'A_3'$, $A_6'A_7$, are parallel to g; $A_1'A_5'$, $A_2'A_6'$, $A_3'A_7'$, $A_4'A_8'$ are vertical and the rest of the edges in the perspective, $A_1'A_2'$, $A_4'A_3'$, $A_5'A_6'$, $A_8'A_7'$, prolonged, pass through O on the horizon h.

Fig. 2 shows the application of the principles of perspective to landscape drawing. The perspectives of parallel horizontal lines, when produced, meet in some point of the horizon h, while vertical lines appear as vertical lines. In the landscape the background is formed by gently rolling hills. The horizon will therefore be slightly below the crest of the hills. Also the ruts

[1] For those readers who are familiar with the elements of analytic geometry, the analytic form of the perspective may be established as follows: Let G be the xy-plane, p' the xz-plane, and the plane through C perpendicular to p' and G the yz-plane, and the space in which the prism stands, the octant in which all coordinates are positive. Then when $FC = c$, $CO = b$, the coordinates x, y, z of a point A and the coordinates x', z' of the corresponding point A' are related by the formulas

$$x' = \frac{bx}{y + b}, \qquad z' = \frac{cy + bz}{y + b}.$$

of the level wagon road, which run along more or less parallel lines, when extended will meet in a point in or near the horizon. Notice also the proper perspective reduction of the scale of distant buildings and trees.

In a similar manner we may establish the geometrical principles of theatrical and relief perspective. Such a correspondence between the elements of the object and those of the

Fig. 2.

relief is technically known as a perspective collineation of space; and is determined when the center C, the plane of perspective (axial plane) s, and two corresponding points A and A' on a ray through C are given. If any other point B is given, the corresponding point B' is found by prolonging the line joining A and B to the intersection S with the axial plane s, Fig. 3. Then, join S to A', and find the intersection B' of SA' with CB prolonged, if necessary. B' is the required point. Consider next the indefinitely extended lines l through A and B, and l' through A' and B'. The infinite point I of l' is projected into a point I' of l'. Conversely, there is a point J on l whose perspective J' is the infinite point of l'. In order to shorten the theoretical discussion it is sufficient for our purpose to state that if the points I' and J are constructed for every pair of corresponding lines l and l', it is found that all points I' lie in a plane q', all points J in a plane r, both of which are parallel to the axial plane s. Again we may set up a number of rules:

1. Corresponding points lie on rays through the center C.
2. Corresponding lines meet in points of the axial plane s.

3. The perspectives (reliefs) of parallel lines meet in a point, those of parallel planes in a line of the vanishing plane q'.

4. The vanishing points of horizontal lines lie on the horizon h, which is in q'.

5. When the axial plane s (hence also q' and r) stands vertically on a ground-plane G, cutting the latter in the ground-line g, the horizon is parallel to g, and to vertical lines correspond vertical lines.

6. Corresponding planes meet in a line of s.

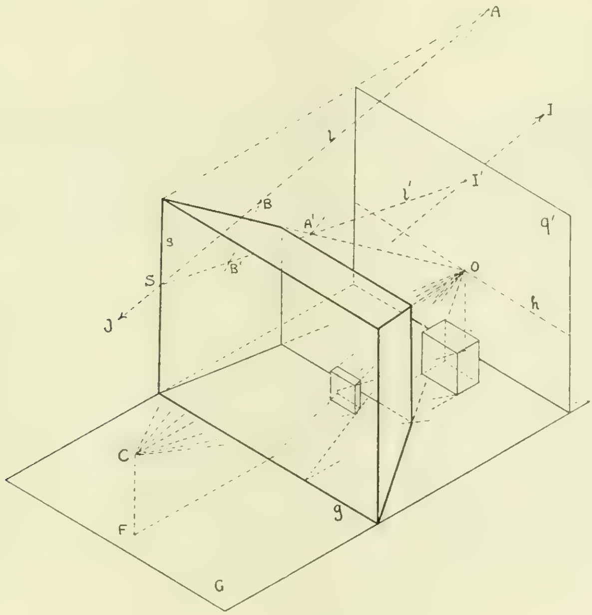


FIG. 3.

7. To planes parallel to s correspond planes parallel to s.

8. To lines perpendicular to s correspond lines passing through the so-called eye-point O of q'.

This list is, of course, by no means complete, and might be indefinitely extended.[2]

[2] To obtain the analytical form of theatrical perspective choose again G as the xy-plane, s as the xz-plane, and the plane through C perpendicular to s as the yz-plane. Let b be the distance of C from s, the space in which the object is located as the octant in which all coordinates are positive, e the distance of r from C, e also the distance from s to q', x, y, z the coordinates of a point A, x', y', z' the coordinates of the corresponding point A', then the coordinates are related by

$$x' = \frac{(b+e)x}{y+b+e}, \qquad y' = \frac{ey}{y+b+e}, \qquad z' = \frac{cy+(b+e)z}{y+b+e}.$$

On the stage of a theater the axial plane s may be taken as the plane of the front-curtain, the plane q' as the rear wall of the stage. The observer is supposed to take the place of C. Naturally this theoretically ideal condition cannot be realized practically. There are many observing centers, so that considerable latitude and deviation from the mathematical theory is admissible. Although the mathematician speaks of the plane of the curtain as the invariant plane of the collineation, it is of course not his intention to impose his theory upon the theater-goer.

Fig. 4 represents a typical example of theatrical perspective.

FIG. 4. STAGE-SETTING FOR ACT I. OF PUCCINI'S MANON LESCAUT AT THE METROPOLITAN IN NEW YORK.

It shows the setting of Act I. of the opera "Manon Lescaut" by Puccini at the Metropolitan in New York.

Fig. 5, likewise, may give an idea of the wonderful perspective effect of the stage-setting of the ballroom in the Duke's Palace at a performance of Verdi's Rigoletto, also at the Metropolitan.

The development of the principles of perspective in their practical applications to painting has a long history. It evolved from the primitive, purely intuitional efforts of ancient artists, and reached the present state of a perfect system only after many centuries of improvements and rational scientific coordination with geometry. As a matter of fact, synthetic, or projective geometry grew out of geometrical discoveries revealed by the study of artistic perspective. Desargues's (1593–1662) brilliant accomplishments in this field make him one of the foremost pioneers of modern geometry. On the other hand, projective geometry had a great influence upon artistic perspective and the comprehension of its essential simplicity. We have here again a characteristic example for the interesting fact that a branch of mathematical science grew out of a field of practical, more or less intuitional rules, which in its turn was used to clarify the original primitive notions, to simplify and systematize the collection of practical rules and to make their application easier.

Traces of pictorial representation may be found almost as far back as we have knowledge of the prehistoric human race.

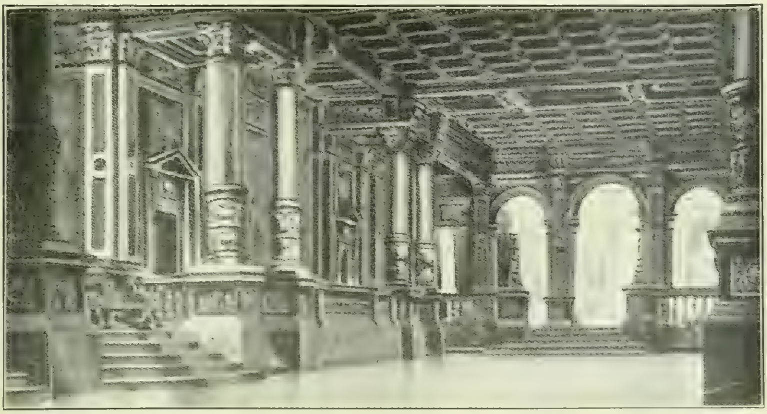


FIG. 5. SETTING OF ACT I. IN VERDI'S RIGOLETTO AT THE METROPOLITAN.

It is, however, not until possibly thousands of centuries later that we see Babylonians, Egyptians, Assyrians and other races make extensive use of graphic representations in their cultural development. But they do not have any knowledge of how to make more than two dimensions appear on a picture. All objects are shown in elevation, or in a front view. When a plan, or top view, is drawn, vertical objects are depicted on the plan as they would appear in elevation.

The ancient Greeks, although even now unsurpassed in sculpture and in the true conception of architectural laws, were not much better when it came to drawing and painting. Front-views were the customary methods of decoration and drawing. As there seem to be no paintings of Greek antiquity in existence, it is impossible to arrive at a correct evaluation of their treatment of form. From writings on objects of art it would appear that the Greeks were not in possession of a deductive system, and that they relied entirely upon empiric, *i. e.*, in this case, visual impressions. On the other hand it is surprising what anecdotes tell us of some marvelous illusions which Greek paintings seem to have produced. Thus the "grapes of Zeuxis" were painted in such true imitation of nature that the birds tried to pick them. Parrhasius painted an open door with curtain drapery on a wall, through which people, who did not know of the illusion, tried to pass.

As appears from mural decorations of Pompey, Roman artists had some crude knowledge of empirical perspective. But it was without control by correctly deduced geometrical laws, and therefore faulty.

The same may be said of the early Italian painters, like Giotto (1266–1337) and his pupils, whose frescoes in the chapels of St. Croce in Florence, of Madonna dell' Arena in Padua, and others, exhibit very little knowledge of perspective. It was not until the early Renaissance, the Quartocento, that perspective was established as a science. During this period we find writings on the principles of perspective by the architect Brunellesco (1377–1466), by the sculptor Donatello (1386–1468), and by the architect Alberti (1404–1472). The full development and mastery of perspective for artistic purposes was accomplished by the great masters of the Renaissance at the end of the fifteenth and in the sixteenth century: Leonardo da Vinci (1452–1519), Raffael Santi (1483–1520), and Michel Angelo Buonarotti (1475–1564). Leonardo da Vinci, a universal genius, who attained fame not only as a painter, but also in engineering, in physics, in anatomy, and in music, wrote a Trattato della pittura, which contained also a monograph on perspective. Unfortunately this important work has been lost.

As an example of the complete mastery of the laws of perspective I refer to Raffael's "The Wedding of Maria" in the Milan gallery, of which Fig. 6 is a half-tone reproduction. In the whole representation of the architectural features the perspective correspondence between the external world and the canvas is correctly and minutely established. Also the human figures are portrayed with equal carefulness and proper reductions of the scale. In spite of the geometrical correctness of the construction no unpleasing distortions of form appear in the picture. This is the more remarkable as at that time no control by photographic processes was known.

Many other paintings of equal renown by Raffael and other painters of this period might be analyzed, which would merely corroborate the statement concerning the highly and rationally developed sense of form perception of these masters.

Fig. 6. Raffael, The Wedding of Maria.

It is strange that during the following period some artists became careless in regard to the coordination of their painting with consistent perspective forms. Paolo Veronese's (1528–1588) "The Wedding of Cana," which is in the Louvre (Paris) gallery, for example, contains seven eye-points and five horizons. This is unfortunate, as the painting is otherwise of great artistic value. Fr. Bossuet showed in his "Traité de perspective" (Brussels, 1871), by a reconstruction of the architectural features of Veronese's painting with one eye-point, that the

FIG. 7. ALBRECHT DÜRER, BIRTH OF CHRIST.

intended impression and effect of the painting do not suffer in the least from a correct construction.

Of other than Italian painters of the Renaissance I shall simply mention Albrecht Dürer (1471–1528), who, like Raffael and his compatriots, had a perfect knowledge of the principles of perspective, as revealed by all his paintings. He wrote the first German work on perspective, called "Unterweysung der

Messung mit Zirkel und Richtscheyt," in which a number of devices (glass plate) are explained how to make true perspective constructions. The "Birth of Christ," reproduced in Fig. 7, is an example of Dürer's art with its careful attention to perspective details.

Most of the great painters of modern times show a profound knowledge of perspective, where proper delineation and reduction of scales are imperative. This, of course, is always the case when architectural features form a part of the setting. See, for example, some of Boecklin's famous paintings, or Rochegrosse's "The Flagellants," in collections of reproductions of modern paintings. Certain styles and varieties of painting require less or no geometrical preliminary work. It must be said, however, that in certain cases deviations from the geometrical laws are permissible. But great painters are conscious of such deviations and do not introduce them deliberately, when not needed. The mistakes of some mediocre painters and their flagrant neglect of correct forms are due not so much to conscious modifications as to their ignorance of the laws of perspective. The mastery of these laws requires some serious thinking and study, which is too arduous a task for so many "heroes of the brush." In so many cases of modernism and impressionism the claim of originality and progressiveness is merely a flimsy cover or excuse for the painter's inability and his ignorance or misunderstanding of some of the most fundamental principles of fine arts.

A thorough mastery of these requires years of intensive study and practise. The lack of these is responsible for much of the mediocrity of the present day.

Franklin Paine Mall

THE PROGRESS OF SCIENCE

FRANKLIN PAINE MALL

FRANKLIN PAINE MALL, professor of anatomy in the Johns Hopkins Medical School and director of the Department of Embryology of the Carnegie Institution of Washington, was born in Belle Plaine, Iowa, September 28, 1862, and died in Baltimore, November 17, 1917, from complications following an operation for gall stones. He was the son of Francis and Louise (Miller) Mall, both of German descent. In 1895 he married Mabel Stanley Glover, of Washington, D. C. He is survived by his widow and two daughters, Margaret and Mary Louise Mall.

In 1883, he was graduated in medicine from the University of Michigan, and then went to Germany, where he studied first in Heidelberg and later under His and Ludwig in Leipsig. On his return to America he was first fellow in pathology in the Johns Hopkins University, then adjunct professor of anatomy at Clark University, professor of anatomy at the University of Chicago, and finally when the Johns Hopkins Medical School opened he undertook the direction of the new department of anatomy. When he started work, medical education in this country was at a very low ebb. He reorganized the teaching of anatomy by developing a laboratory in which his subject was taught by professional anatomists, devoted to scientific research, and his influence can be seen from the fact that twenty-five of the chairs in anatomy in different medical schools in this country have been filled from his department.

In science he ranks with the great leaders of his generation, and his work, embodied in one hundred and four publications, leads up to certain scientific generalizations. In anatomy he broke away from the study of pure morphology and studied structure from the standpoint of how all of the tissues of an organ are adapted to their function. This work led to the conception that most organs are made up of structural units which are equal in size and in function. The size of these ultimate histological units is determined by the length of the capillary. These ultimate histological units are grouped together into lobules in various ways in the different organs. These conceptions of structure find their best expression in Dr. Mall's studies of the intestine, the stomach, the liver and the spleen.

In the science of embryology Dr. Mall was the first to trace the development of an individual organ from its early embryonic form to its condition in the adult. For example, he followed the development of the loops of the intestine from their beginning, tracing through successive stages their displacement out into the cord, their return to the cœlom, and finally the establishment of their adult position. He determined the normal position of these loops in the adult, and then by experiments on animals showed that when they are displaced they tend to return to this normal position. This type of work may be summed up in the term "organogenesis." Through the complete development of organogenesis the study of anatomy may be rationalized, for thereby normal structure and the limits of variation may be understood.

The later years of his life were devoted to the organization of the Department of Embryology of the Carnegie Institution of Washington.

One of the most striking points in his career is that in these years, devoted to the organization of a new institute, he accomplished some of his best scientific work. He made an exhaustive study of the causes of monsters. To this study he brought a mastery of all the older literature on the subject, a critical judgment in analyzing the results of experimental embryology, and an extensive first-hand knowledge of abnormal embryos. He concluded "that monsters are not due to germinal and hereditary causes, but are produced from normal embryos by influences which are to be sought in their environment." They are due to causes bound up in their faulty implantation whereby alterations in the nutrition of the embryo at an early critical stage produce changes which range all the way from complete degeneration of the embryo up to a monster which survives to term.

In the new institute of embryology Dr. Mall proposed to complete the study of organogenesis and to analyze problems associated with growth which need for their solution large amounts of material and expert technical assistance.

In addition to his great contribution to the development of his science, Dr. Mall was a great teacher. He will be remembered as having trained a large group of the men who are now prominent in scientific medicine. He was one of the foremost men in the reorganization of the American Association of Anatomists, making it one of the distinguished scientific bodies in this country. He played a prominent part in the development of scientific publications in this country, being largely responsible for the establishment of the *American Journal of Anatomy*, the *Anatomical Record*, and finally the *Contributions to Embryology* published by the Carnegie Institution of Washington. He was a man of rare personality; modest, generous, original, unswervingly devoted to ideals and possessed of a genius for stimulating thought.

FLORENCE R. SABIN

A CRYSTAL MIRROR FOR FOCUSING X-RAYS

LIGHT rays may be focused either by passing them through a lens (Fig. 1) or by reflection from a concave mirror (Fig. 2). Although X-rays are known to be of the same nature as light, workers engaged in scientific research have found it impossible to focus them by the first method on account of their stubbornness in resisting refraction, or bending, in passing through ordinary matter, as light rays are bent and focused in passing through a lens. Moreover, difficulty presents itself in attempting to focus them by reflection, for the smoothest mirror that can be manufactured presents a "rough" surface to X-rays, causing them to be reflected diffusely rather than "regularly" (angle of incidence equal to angle of reflection), although presenting a "smooth" surface to light rays, and for the reason that the wave-lengths of X-rays are so very short compared with those of light.

X-rays have nevertheless been recently focused by reflection from a crystal mirror in the new Dershem X-ray concentrator.

It was found only four or five years ago that natural crystal surfaces are "smooth" enough to reflect X-rays regularly rather than diffusely. The idea occurred to Dr. Elmer Dershem, working in the physics laboratory of the University of Iowa, of making a concave mirror of crystal surfaces. Mica is the crystal that comes naturally to mind for such a purpose, as it can be readily split up into thin flexible sheets capable of bending to shape.

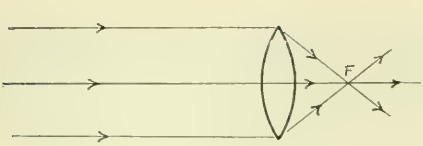


FIG. 1.

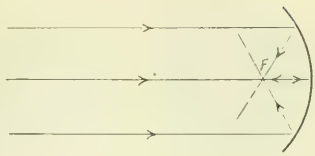


FIG. 2.

Fortunately, also, it reflects X-rays exceptionally well.

Dr. Dershem's crystal mirror, while concave, is not made in the usual form of concave mirror, but rather in the shape of an open-ended barrel, such that the source of the X-rays, which is a small spot on the surface of the target in the X-ray tube, is near one end of the "barrel" form were laid the sheets of mica, that were fastened in position by gluing strips of paper over them. The whole was then immersed in melted paraffin, which, on solidifying, gave a cast. The form was then removed, leaving the hollow paraffin cast with the mica held firmly in place against its walls. A horizontal tube lying along the con-

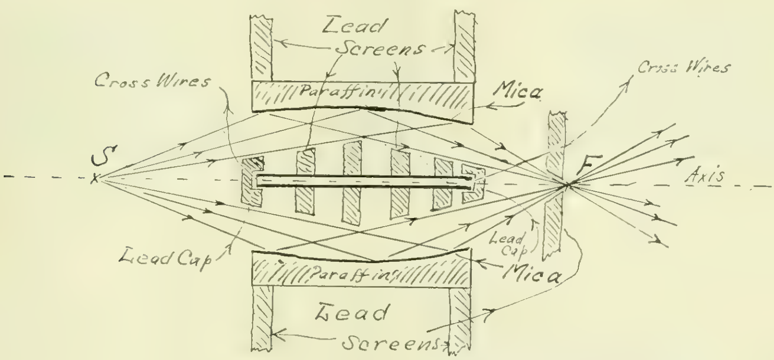


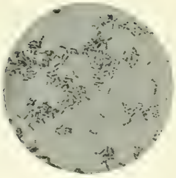
FIG. 3. CROSS-SECTION (SCHEMATIC) OF DERSHEM CONCENTRATOR.

(Fig. 3). The X-rays that would otherwise pass directly through the barrel without reflection from the inside walls are screened off by sheets of lead inserted as shown. The mica barrel is so shaped that an X-ray striking on the inside walls, no matter where, is regularly reflected so that all the reflected rays pass approximately through a point, *F*, the focus.

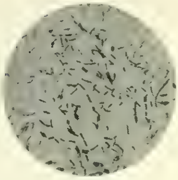
The first X-ray concentrator was made by turning out on a lathe a wooden form of the desired barrel shape. The diameter of the form was a little over 2 inches, and the length about 4 inches. Over this centrator axis carries a pair of cross wires at either end so that the instrument can be "sighted" on the target of the X-ray tube.

The particular concave shape required for an X-ray focusing mirror was found by mathematical analysis. It is obtained by revolving a segment of logarithmic spiral about an axis formed of the straight line passing through the two points that are to be source and focus, respectively.

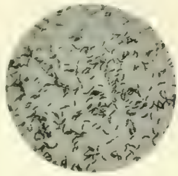
The effectiveness of this X-ray focusing mirror, or concentrator, has been demonstrated by photography of the spot focus, with the tungsten target of a Coolidge X-ray tube fur-



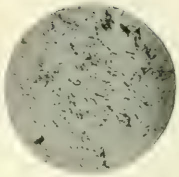
DIPHTHERIA.



TYPHOID FEVER.



ASIATIC CHOLERA.



TUBERCULOSIS.

MANY diseases are known to be caused by living germs which grow in the body as mold grows in jelly. These harmless-looking germs are so small that millions might lodge on the point of a pin, and yet they cause such diseases as tuberculosis, diphtheria and typhoid fever.

LARVAE AND PUPAE OF THE FILTH FLY IN OLD PAPERS

THE HOUSE FLY OR FILTH FLY.

MAGGOTS (LARVAE) OF THE FILTH FLY, IN STABLE MANURE.

THE House Fly breeds in stables and garbage dumps and might better be called the Filth Fly. From these dirty places it often carries germs on its feet to food that we eat, and thus spreads disease.

A DIRTY COW BARN

MILK from dirty cow barns may carry disease germs. When kept two or three days and handled by several people before reaching the household, it may become so changed as to be poisonous, particularly to babies. Every summer, in New York City, thousands of children die from infected or decayed milk.

THE best way to keep well and to resist disease is to stay out-of-doors during the day in the fresh air and sunshine and to take part in wholesome games. Not only are these conditions conducive to good health, but also they aid the growth and development of the body and keep it strong.

nishing the source. It can also be demonstrated in a qualitative manner with light rays, as was done by Dr. Dershem some months ago at the University of Iowa.

The X-ray concentrator is of particular interest in science because it separates out a single wave-length from a beam containing many wave-lengths, and at the same time focuses it, thus giving a single wave-length with an intensity at least a thousand times greater than can be obtained by the usual reflection from plane crystal surfaces.

There are at least two possible applications that may be made with the X-ray concentrator. One is to study the effect of single wave-lengths of X-rays on the electrical resistance of selenium, since it has been shown that X-rays affect this element in the same way as light waves. The other is to test X-rays of different wave-lengths for their physiological effects, such as X-ray "burns," and the effects of "treatments" by the rays on the human body.

PUBLIC HEALTH CHARTS OF THE AMERICAN MUSEUM OF NATURAL HISTORY

THE Departments of Public Health and Public Education of the American Museum of Natural History five years ago prepared under the direction of Dr. C.-E. A. Winslow, curator of its Department of Public Health, three series of public health charts for the use of schools of New York City. Each consisted of a folio of wall charts illustrated from original photographs and devoted to the following subjects: "The Spread and Prevention of Communicable Disease," "Insects as Carriers of Disease," and "Bacteria and their Work in the World."

The demand for these charts in the schools was many times greater than the supply, and the Museum has now issued a new edition of the set, entitled "The Spread and Prevention of Communicable Disease" in sufficient number to supply all the schools of the city.

There are here reproduced, on a scale comparatively very small, four of the charts. The original charts are 22 x 28 inches each. Each set consists of 15 charts on heavy paper, bound at top and bottom with tin, and suited in every way for hanging on the wall. Although each chart is clearly labeled the sets are accompanied by a booklet containing information which may be of service to teachers in talks on the subject of physical well-being.

The delivery and collection of the charts is being attended to by the museum. As with the circulating collection of natural history specimens, the loan period is three weeks.

The charts may be purchased by educational institutions outside of the city.

MEDICAL RESEARCH IN FRANCE AND THE RED CROSS

THE War Council of the American Red Cross has appropriated $100,000 for general military medical research work in France, including special methods of recognition and study of diseases among soldiers. This action followed a report from the Red Cross Commission in France to national headquarters in which they said:

"An extraordinary opportunity presents itself here for medical research work. We have serving with various American units some of the ablest doctors and surgeons in the United States. Many of these men are already conducting courses of investigation which, if carried to successful conclusions, will result in the discovery of treatments and methods of operation which will be of great use not only in this war, but possibly for years afterwards. To carry on their work they need certain special laboratory equipment, suitable buildings and animals for experimental purposes. At present equipment and personnel can not be obtained through ordinary government sources without delay, which makes this source of supply quite impracticable."

This recommendation, like others of a medical nature from the commission, was submitted to an advisory medical board in France composed of leading American physicians and surgeons working with our forces in that country, and was approved by them.

This advisory board is headed by Dr. Joseph A. Blake, with whom are associated Colonel Ireland, of General Pershing's staff; Dr. Livingston Farrand, president of the University of Colorado; Dr. Alexander Lambert, professor of clinical medicine, Cornell Medical School; Dr. John M. Finney, professor of clinical surgery at the Johns Hopkins University; Drs. Richard P. Strong and W. B. Cannon, professors at Harvard University; Major George W. Crile, head of the Cleveland Base Hospital Unit; and Dr. Hugh H. Young, professor at the Johns Hopkins University.

The committee in charge of this research work in France, headed by Dr. Cannon, includes Dr. Blake, Dr. Crile, Colonel Ireland, Dr. Lambert, Dr. Strong, Dr. Kenneth Taylor, Dr. Harvey Cushing, professor of surgery at Harvard; Dr. James A. Miller, professor of clinical medicine at Columbia; Dr. William Charles White, associate professor of medicine at Pittsburgh; and Dr. Homer F. Swift, professor of medicine at Cornell.

SCIENTIFIC ITEMS

WE record with regret the death of Ellery Williams Davis, dean of the college of arts and sciences and head of the department of mathematics of the University of Nebraska; of Rollin Arthur Harris, mathematician to the U. S. Coast and Geodetic Survey; of Charlotte Fitch Roberts, head of the department of chemistry at Wellesley College; of G. P. Girdwood, professor of chemistry in McGill University, and of C. Christiansen, professor of physics in the University of Copenhagen.

M. PAINLEVÉ, professor of mathematics in the University of Paris and recently premier of France, has been elected president of the Paris Academy of Sciences, succeeding M. d'Arsonval. M. Léon Guignard, professor of botany at the School of Pharmacy of Paris, has been elected vice-president.

THE SCIENTIFIC MONTHLY

APRIL, 1918

WEATHER CONTROLS OVER THE FIGHTING IN MESOPOTAMIA, IN PALESTINE, AND NEAR THE SUEZ CANAL[1]

By Professor ROBERT DE C. WARD

HARVARD UNIVERSITY

WHEN the British Expedition invaded Mesopotamia from the Persian Gulf in 1915, the fighting was carried into a region whose climate and weather differ markedly from those which characterize any other portion of the war area, although they resemble, in some respects, the conditions in Gallipoli and in the region about the Suez Canal. Mesopotamia is a country of aridity; of intense summer heat; of deserts and steppes; of relatively mild winters; of cold-season rains. It has a good deal in common with the Mediterranean countries, but its rainfall is less, and its summer heat greater. It is a country where campaigning is best in winter. There is then a better water supply, and the temperatures are on the whole favorable for the movement and the comfort of the troops.[2] Occasional

Temperatures at Bagdad (Lat. 33° 21′ N.; Long. 44° 26′ E., Alt. 60 Meters)

January	48.7° F.
August	92.5°
Mean annual	71.2°
Mean minimum	21.9°
Mean maximum	119.5°

colder spells, with northwest winds, lower the thermometer several degrees below freezing; frosts occur, and snow falls locally. In the region of the lower Euphrates and Tigris snow is rare, but it is common in upper Mesopotamia, and on

[1] This account is brought down to February 10, 1918.

[2] The essential temperature data for Bagdad may be taken as fairly representative of the region in which most of the fighting has taken place.

the mountains. Hail falls infrequently, but occasionally occurs over considerable areas. The winter months bring the "rainy season." The designation is misleading unless it is clear that a *relatively* wet season is meant. The total mean annual rainfall is only about 8 or 9 inches, and some years but half as much. Precipitation, as usual, is heavier on the mountains than on the arid lowlands. The rains fall between October and May. This is also the cloudiest season. The remaining months are practically rainless. Showers are very rare in summer. At Bagdad, February or March is the rainiest month (1 inch to 1.5 inches). Of great importance in the life and development of Mesopotamia are the annual floods, which, being dependent on the rains, come in late winter and spring, and are generally at a maximum in March and April. The lowest water is in late summer and early autumn.

The summers are excessively hot. The highest temperatures average between 115° and 122° F., and in individual cases they may even run a few degrees higher. The sun blazes in a cloudless sky of wonderful blue. The air is clean and clear, except when filled with dust. The every-day routine of life is regulated by the temperature. During the hottest hours of the day, the natives take refuge in underground rooms in which the temperatures may be 10°–25° lower than outdoors. The air is, however, "dead" and close. In the houses of the well-to-do various cooling devices are resorted to. Water is sprinkled abundantly in the courtyards. The cooler, fresher air of early morning and evening brings the people out on to the flat roofs of their houses, where meals are eaten and the most comfortable conditions for sleeping may be found. Still worse than the relatively dry heat of central Mesopotamia is the "hothouse" air of the region at the head of the Persian Gulf, where damp southerly and southeasterly winds bring almost unbearable conditions of stifling muggy air.

Mesopotamia has not always been the desert which it is to-day. In the old days it was the home of powerful peoples; the center of ancient civilization. The Garden of Eden is generally supposed to have been here. If properly conserved and wisely distributed, there is water enough in Mesopotamia to turn immense areas of desert into green fields of cereals and of cotton, and into blossoming orchards. There is no reason, so far as water supply is concerned, why Mesopotamia should be a "brown wilderness, vast and uninhabited; the abiding place of wind, and dust and silence," as a recent writer has described it.[3] No "change" of climate is responsible for the present condition. The incapacity of the Turkish government is the sole source of the trouble. Plans for the reclamation of Mesopotamia had been drawn, before the war, by Sir William Willcocks, already famous for his irrigation work in Egypt.[4] It appears that the ancient irrigation canals were well placed and can be repaired and again utilized, while new canals and ditches can be constructed without very great cost. It is reported that English engineers have recently built a barrage on the lower Tigris which has made possible the irrigation of a piece of land where enough cereals, dairy products and poultry are being supplied to feed the British Expeditionary Force. The general situation as to the present neglect of the available water supply of Mesopotamia is strikingly emphasized by Sir William Willcocks when he speaks of "the exhibition of two mighty rivers flowing between deserts to waste themselves in the sea for nine months of the year, and desolating everything in their way during the remaining three."

The foregoing facts regarding the climate of Mesopotamia make it clear that meteorological handicaps a military expedition into that country must inevitably meet. The reports, both official and non-official, regarding the military operations during the Mesopotamian campaign have given abundant illustration of the importance of the weather factor in warfare in that historic region, once so prosperous, now so decayed and backward. The intense heat of summer; the lack of water; the cold-season rains and storms; the floods; the cold spells of winter—all, as was to be expected, played their part. It was obvious from the first that great difficulty would result from the aridity of Mesopotamia. The former canal system long ago fell into disuse, and water can only be obtained from the rivers, many of which dry up completely in the hot summers.

Very little news came through regarding the early stages of the British invasion. It will be remembered that General Townshend's column, proceeding up the Tigris, captured the historic city of Ctesiphon, but partly because of lack of water was obliged to retire when within a short distance (about twenty miles) of Bagdad. There were marches "over burning sands." There was intense suffering from thirst. The army had to be kept near the river, where there was a plentiful supply of water; but, as one of the medical officers wrote, "neat

[3] El Hamran, "The End of the Year: Mesopotamia, 1915." *Blackwood's Mag.*, Vol. 201, May, 1917.

[4] "The Irrigation of Mesopotamia," London, 1911.

Tigris is not a very healthy drink at the best of times." Temperatures of 128° to 130° F. were reported, but these are doubtless a few degrees too high, owing to poor exposure of the thermometers. An officer in the Royal Field Artillery wrote of temperatures of 110°, and of the exhaustion of the infantry in the hot sun. "We can not carry nearly enough water," he notes, "and one's tongue swells when the sun is up." The heat was "about the limit of human endurance." In the hospital tents temperatures of 130° were reported, and this may easily have been the case. Under such conditions "the suffering of the sick and wounded was distressing to contemplate." On an afternoon march one officer reported that his goggles became so hot that they blistered his face, even under the shade of his helmet. The men fell ill as a result of the excessive heat, and of the bad water.

The expedition under General Aylmer, going to the relief of the beleagured troops in Kut-el-Amara, met with serious difficulties on account of the rains.[5] A London despatch (January 22, 1916) mentions a "hurricane" (really only a winter storm), which had made navigation and other operations most difficult. The Tigris rose rapidly. On January 24, 1916, it was reported that the river had risen seven feet in forty-eight hours at Kut, "preventing all troop movements by land." "At this season," one despatch noted, "the Tigris is very full, with a strong current," the reference being to the winter high-water stage, resulting from the rains at that season. With northwesterly winds it was reported as "bitterly cold." It is reasonably certain that the temperatures were not many degrees (perhaps 10°–15° F.) below freezing, but with a strong wind, after the excessive heat of the summer, the words "bitterly cold" doubtless express what the men really felt.

The British surrender at Kut-el-Amara came as a distinct and most depressing shock. Lord Kitchener, who was then War Minister, emphatically stated that adverse elements alone were responsible for the lack of success. Constant rains and the resulting floods had not only impeded the advance of the Relief Expedition, but had compelled, in place of a turning movement, a direct attack upon an impossibly narrow front. The House of Lords, the War Minister said in his speech before that body, 'would not fail to realize how tense was the strain upon the troops. For more than twenty weeks they had held

[5] The "first rains of the year" were reported November 25, 1915. Mention was made of a succession of heavy storms.

their positions under conditions of abnormal climatic difficulty and on rations calculated for protraction to the furthest period until imminent starvation compelled capitulation.' Several interesting meteorological conditions attracted the attention of the besieged troops in Kut-el-Amara.[6]

The winter rains, described in such terms as "several days of steady rain"—it "poured"—"two days rain"—"more rain"; the mud; the cold, with 8° or more "of frost"—"hoar frost in the morning"—"bitter cold"—"very cold"—"clear bracing air"; the late winter and spring floods, in one instance driving the men from the trenches; the snow-clad hills: all these receive mention. At the end of March, according to the Kut observers, a violent thunderstorm, with heavy rain, occurred, and a Berlin despatch reports that during a thunderstorm in March the principal British camp was struck by lightning and "extensive damage was done." An especially interesting occurrence was a "deluge of hail" (April 3), with stones one half an inch in diameter, the record stating that "it was well to get under shelter, for they hurt." On April 12, 1916, General Lake reported that water was driven by a northwest gale into some of the enemy's trenches, forcing the Turks out to a new position. Many engagements were fought with the men up to their hips in water. Of the sufferings of the British during the Kut-el-Amara campaign an English officer writes as follows:

> Nothing that has been printed about the hardships of that ill-fated expedition came up to the conditions the men had to contend with. . . . The water was thick with mud and unfit to drink, but it was impossible to keep some of the men from slaking their thirst, which resulted in their death by cholera. When I was down with fever the heat in my tent was 117°, and there was nothing to eat but stodgy porridge; no medicines or medical comforts of any kind. . . . For hundreds of miles there was not a blade of grass, and no chance to get cover from the scorching sun or the enemy's guns. . . . Flies gave us the most trouble in Mesopotamia, where they are worse than in any part of the eastern countries. They settled so thickly on the faces and arms of the men that it looked as if they were wearing armor. One fly out of every twenty appeared to be able to bite and inflict a severe sting.

With the advance of spring (1916) the heat became greater. On May 20 General Lake reported: "The weather is intensely hot and trying," with temperatures over 100° in the shade. It was so hot (over 120°) in July that both British and Russian troops had to remain inactive for many days. The Russians retreated almost 80 miles in the Bagdad region. The principal

[6] C. B., "Besieged in Kut and After," *Blackwood's Mag.*, Vol. 201, May, 1917.

reason assigned for this retreat was the heat, which made campaigning very difficult. It was reported that the Russians planned to remain in the cooler hill country until the temperature conditions made the resumption of the advance expedient. On July 16, 1916, Sir Victor Horseley, the eminent surgeon, died of heat stroke.

Mesopotamia is obviously a region where campaigning is easier in winter than in summer. After several months of inactivity on account of the intense heat, the British Army resumed operations about the middle of September (1917). It appears that supplies of munitions and food were sent forward by the Germans along the Badgad Railway during the dry summer months, before the wet season might make transportation difficult. Rains, coming as was to be expected, hampered the movements of the British troops (late December, 1916). Late in February (1917), heavy rains brought the Tigris to flood level, and made it difficult to move troops, this being the normal time of year for high water. It was clear that the British ought to advance to Bagdad and seize the railway before the hot weather came on. In the House of Commons on March 12, 1917, Mr. Bonar Law, in announcing the fall of Bagdad, said:

> Notwithstanding heat and dust the British made a brilliant march toward Bagdad.

The pursuit of the Turks "was conducted in a country destitute of supplies, despite the commencement of summer heat." General Maude reported that "during the recent fighting, fierce gales and blinding dust storms, the lack of water away from the river, and the vigorous pursuit, made the operations arduous."[7]

Late in March (31st) the British and Russian troops, in their converging march toward Khanikin, had difficulty because of wet snow. An unusual occurrence was reported on April 10, when British fighting in Mesopotamia "had to be temporarily suspended owing to a mirage, but upon this lifting, our offense continued." The intense heat constantly interfered with the activity of the troops. On April 13 the heat "rendered the task of keeping in touch with the reteating enemy difficult."

As a whole it is evident that both British and Russians did their best (until the Revolution demoralized the Russian

[7] A despatch dated March 17 notes the withdrawal of the Russian troops to a town on the Persian border north of Bagdad on account of the heat, which made a retreat to the mountains advisable.

troops) to bring the campaign in Mesopotamia to a successful conclusion before the intense summer heat and lack of water made operations more difficult, if not impossible.[8] The preparations for the 1917 campaign were far ahead of those of 1916. Ice plants; refrigerating barges for meat; hospital ships with complete electrical equipment for lighting, cooling and ventilation; transportation, etc., were all carefully planned for.

> The soil, the rain, the climate, the floods, the flies and the heat combine to make the conduct of a campaign in the Tigris valley during the summer months a task of stupendous difficulty. These difficulties are being tackled and overcome with success.

There could be only very slight activity during the hot season. One of the few reports (July 11, 1917) mentions a British advance which was broken off owing to the extreme heat. A despatch from Washington, July 12, noted Turkish preparations for a campaign for the recovery of Bagdad when cooler weather set in in the fall (1917), adding, "the heat in Mesopotamia at present makes a campaign on a grand scale almost impossible."

Bagdad was taken in March, 1917. After the end of April there has apparently been comparatively little fighting of importance. The heat of the summer, the withdrawal of the Russians, and the British campaign in Palestine doubtless, in part at least, help to explain this relative lull. One despatch mentioned the deaths of many of the British officers and men who, having surrendered to the Turks at Kut-el-Amara (April, 1916), were marched hundreds of miles into the interior. The change from the heat of the Mesopotamian lowlands to the cold of a higher altitude and of a more northern latitude must surely have caused great suffering among these men.

In the spring of 1917, the British extended their campaign into Palestine, a region very rich in historical interest, whose possession is of the greatest military importance to England. The climate of Palestine merits special attention at the present time, not only because of the immediate interest of the cam-

[8] What has become of the Russian Army in Mesopotamia is still more or less of a mystery. The cooperation of Russian and British troops before the fall of Bagdad promised great things for the future. The complete and speedy subjugation of Mesopotamia, a victorious march on Constantinople, and the fall of the Turkish capital, seemed quite on the cards. But the Russian Army has vanished. As lately as last April (1917), after the Revolution, the Russian soldiers were actively fighting the Turks in Mesopotamia. Early in April they captured Khanikin. Since then there is no definite news of the Army of which so much was expected.

paign there, but also in view of the discussion as to the future of the region as a home for the Jewish people.[9]

The country lies roughly between Lats. 31° and 33° N. It is long and rather narrow. The Mediterranean lies on the west, the Syrian Desert on the east. The Jordan-Dead Sea depression cuts through it from north to south. Rough hilly tablelands lie to the east and west of this valley. On the east, these slope to the desert. On the west, to the Mediterranean. Palestine has what is known among climatologists as a "Mediterranean climate," and has much in common with the whole extended region bordering upon the Mediterranean Sea. It lies in the so-called "Subtropical Belt," at the equatorward margin of the "Temperate" Zone. The countries lying within these belts are far enough from the equator to escape continued high temperatures throughout the year, yet near enough to it to be spared the extreme cold of the higher latitudes. Their rainfall régime is alternately that of the prevailing westerly winds, which prevail on their poleward side, and of the trades, which blow on their equatorward margin. They are thus associated, now with the "Temperate" and now with the Tropical Zones. In winter, following the sun, the equatorward migration of the great pressure and wind systems brings these latitudes under the control of the "prevailing westerlies," whose irregular storms, most frequent during the colder months, give a generally moderate winter precipitation. These rains are not steady and continuous, but are separated by spells of fine, sunny weather. In summer, when, following the sun, the trade winds are extended polewards, dry and nearly continuous fair weather prevails, with general northerly winds.

It is essential, in dealing with the climate of Palestine, to bear in mind the three general topographic subdivisions of the country, the seacoast, the "hill country" of the interior, and the depression of the Jordan and of the Dead Sea. In the north, the central tableland reaches altitudes of 10,000 feet, and over, close to the sea in the mountains of Lebanon. Farther south, there are fertile plains between the hill country and the sea. The coast stations, illustrated by Gaza and Jaffa, have mean midwinter (January) temperatures of between 50° and 55° F., and mean midsummer (August) temperatures of

[9] There are several published accounts of the climate of Palestine. One of the most recent is that of F. M. Exner, "Zum Klima von Palästina," *Zeitschr. Deutsch. Palästina Ver.*, Vol. 33, 1910, pp. 107. Also J. von Hann, "Handbuch der Klimatologie," 3d ed., Vol. 3, Stuttgart, 1911, pp. 90–99.

75° to a little over 80° F. The hill stations, at elevations of about 1,500 to 3,000 feet, as shown by the records for Jerusalem, Nazareth and Hebron, have from 45° to 50° in January, and from a little over 70° to a little under 80° in August. The effect of the altitude in lowering the mean temperatures is thus seen to average about 5° F. The Jordan Valley, as indicated by the records for Tiberias and Jericho, has mean midwinter (January) temperatures of just under 55°, and mean midsummer (August) temperatures of 85°–90°.[10]

In winter, the lowest temperatures usually fall to freezing, or a few degrees below, except at altitudes below about 1,000–1,500 ft., on the coast, and in the Jordan Valley. In individual years they may even fall several degrees below 32°. Jerusalem has had a minimum of 21.2°. In the 10-year period 1896–1907, Jerusalem averaged 3.6 days a year with temperatures below freezing. The low temperatures rarely last more than a day or two. They usually come in January, with NE. or E. winds, the mountains often being snow-covered at the time. The highest thermometer readings of summer ordinarily reach about 100°–105°, and in the Jordan Valley, 110°. Absolute maxima may run a few degrees higher. Jerusalem has had 108°; Tiberias, 114°, and 122° is said to occur in the lower Jordan Valley. The high summer temperatures occur with hot, dry easterly and southerly winds.

Taking the year as a whole, the prevailing winds of Palestine are westerly. In winter, NE., E., and also SE. directions are frequent; in summer, W. and NW. directions are dominant. The character of the winds depends on the season. The westerly winds are naturally the dampest; the easterly are the driest. In summer, the westerly and northwesterly winds, blowing on to a warm land, are relatively damp, cool and refreshing. They are not rainy, and bring few clouds. The SE. wind of summer, on the other hand, is very dry, hot, depressing and disagreeable. It brings the highest temperatures, and is

[10] The foregoing temperatures are purposely given in "round numbers," for the sake of simplicity. The essential temperature data, for representative stations, are accurately given in the following table:

	Station	January	August	Year	Mean Max.	Mean Min.
Coast	Beirut	54.4°	81.5°	68.9°	95.2°	39.0°
	Gaza	53.1	79.7	67.5	100.4	42.4
Hill Country	Nazareth	49.1	77.2	65.3	106.2	32.4
	Jerusalem	44.6	73.4	60.6	97.2	29.0
	Hebron	43.3	72.5	59.7	98.8	26.6
Jordan Valley	Tiberias	54.7	86.9	72.5	110.5	38.5

often dusty. It therefore closely resembles the Italian *sirocco*. At Jerusalem, 80 per cent. of all the winds blow from W. and NW., and the trees are wind-blown towards the SE., while in winter only 37 per cent. come from those quarters. During the colder months, winds from the E. and NE. are generally dry and exhilarating, but may become so sharp as to be unpleasantly chilling. Autumn and winter storms cause inflows of warm, damp, rain-bringing air from the SW., but "storm winds," in the sense of winds of high velocity, are rare, and occur mostly on the northern coast and at the higher elevations.

Accounts of the climate of Palestine usually emphasize the summer "sea-breeze" as contributing largely to man's comfort during the hottest part of the year. This damp, cooling and refreshing wind blows almost every day along the coast, beginning about 9–10 A.M., and usually reaching Jerusalem about 2–3 P.M., or a little later. After sunset, the sea-breeze usually dies down, but soon springs up again and blows most of the night, making these hours cool and comfortable. When the sea-breeze does not blow, the nights are very hot and unpleasant. It not infrequently happens that this wind fails to blow as far as Jerusalem (about 2,500 ft. above sea level). In such cases, that city has an uncomfortably hot night, while Jaffa, for example, at sea level, is kept cool by the fresh breeze from the sea.

Palestine rejoices, as do Italy and Greece and northern Africa, in the deep blue of the sky; the clearness of the air, the small amount of cloud. The cloudiest season is the winter, while the summers are remarkably clear.[11] The coast is somewhat more cloudy in summer than the interior. Heavy dews are characteristic of the plateau districts, the moisture being supplied by the wind from the sea. The ground is well wet with it, and it even drips from the tent-roofs. Fogs occur at night when the air is sufficiently damp. Jerusalem averages about 15 fogs a year. These are nocturnal, and come in summer. On the coast, also, fogs are noted with about the same frequency.

As stated above, the winter in Palestine is the rainy season. These rains fall in connection with general storms, which come from the Mediterranean. These are similar to but less marked than our own winter storms. The winter rains of Palestine are essentially like those of southern California,

[11] Mean January cloudiness 40–50 per cent. Summer cloudiness generally below 10 per cent. Jerusalem has a mean cloudiness as follows: winter, 50 per cent.; spring, 40 per cent.; summer, 10 per cent.; autumn, 25 per cent.; year, 31 per cent.

of northern Africa, of central Chile. In regions such as these, where the summers are very dry, the amount and distribution of the annual rainfall is the critical control of crops, of water supply, and of the general economic condition of the people. The rainfall at Jaffa and Sarona, and at Gaza, on the coast, is between 15 and 20 inches (In the north, Beirut has over 35 inches). In the hill country, the amounts are a little over 25 but less than 30 inches. In northern Syria, the mountains of Lebanon have as high as 50 in. In the eastern depression, Tiberias has just under 20 inches.[12]

As in all subtropical climates, there are marked fluctuations (15 per cent. to 20 per cent. and over) in the amount of rain which falls in different years. These conditions influence the crop yield, and naturally cause constant anxiety throughout the population. The cause of these fluctuations is doubtless to be found in the varying seasonal distribution of pressure over the eastern Mediterranean and the adjacent land areas. It is an interesting fact that the earliest known rainfall measurements were made in Palestine in the first century A.D. The annual amount at that time was the same as it is at present. The average monthly percentage distribution of rainfall is shown in the following table:

Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
25.3	17.0	12.0	4.9	1.1	0.0	0.0	0.0	0.2	2.4	12.3	24.8

(Mean Annual: 24.40 in.)

About one half of the total annual rainfall usually comes in December and January. These months have both the largest amounts and also the greatest frequency of rain. The "rainy season" proper may be said to extend from the middle of October to early in May. The "normal" rainy season covers the periods noted below at four representative stations.

Beirut	Oct. 3–May 21
Sarona	Oct. 18–May 12
Jerusalem	Oct. 14–May 6
Tiberias	Oct. 24–May 3

[12] Mean Annual Rainfalls in Palestine.

Station	Approximate Altitude (Ft.)	Amount (Inches)
Jaffa and Sarona	130	20.47
Gaza	65	16.53
(Beirut	115	35.67)
Nazareth	1600	27.09
Jerusalem	2460	26.02
Hebron	2900	25.63
Tiberias	— 660	19.17

The duration is about 200 days at the hill stations (*e. g.*, Jerusalem and Nazareth),[13] but this may vary greatly (80–90 days) from year to year. Six months are often practically rainless, but occasional rains do fall in the dry season. In Jerusalem, the rainy season has begun (10-year record) as late as mid-November, and has ended as late as early April. People begin to talk about the coming rains as early as September, and become increasingly anxious as the date of their beginning is retarded into November. There is also considerable variation in the rainfall of the same month in different years. At Jerusalem, for example, it is reported that the January rainfall of one year was 13.39 in., and of another year .12 in., a variation of about 100 per cent. The rains do not as a rule fall steadily on several days in succession, but are interrupted, after a short stormy spell, by intervening periods of fine, thoroughly enjoyable weather. The average number of rainy days a year decreases from north to south along the coast (60 in north; 40 in south); is about 60 on the highlands, and about 50 in the Jordan Valley. Occasional unusually heavy rains cause floods. The terms "former" and "latter" rains, which are used in the Bible, refer to the importance of earlier and later rains in relation to crops. The early rains, of late autumn and early winter, moisten the soil and put it in proper condition for seeding. The water supply of the year, upon which people depend to replenish springs, fill cisterns and supply rivers, comes with the heavy rains of winter. The later, and lighter, rains of spring bring the crops to maturity.

Snow is rare on the coast, but falls on the hills two or three times a year. It has snowed as late as April. Snow seldom lies more than twenty-four hours on the ground. In 22 "rainy seasons" at Jerusalem, 14 brought some snow. In Jerusalem itself there is an average of three days a year with snowfall. Occasional unusually heavy snowfalls are reported. Thus, on December 28–29, 1879, nearly 17 inches fell. In February, 1874, the snow was 8¼ inches in depth. In February, 1898, Hebron had snow from 10 to 13 inches in depth. In mid-March, 1910, there was snow in Jerusalem 8 inches deep. Hail is often mentioned in the Bible. Thunderstorms occur chiefly in autumn, late winter or spring. Jerusalem averages 7.4 thunderstorm days a year, and 2.7 days with hail.

The late Professor A. J. Herbertson gave the following excellent brief summary of the climate and products of Syria and Palestine:[14]

[13] 230 days at Beirut.

[14] "The Senior Geography," Oxford, 1907, pp. 24–25.

On the Mediterranean slopes and on the hills of Gilead, beyond Jordan, the rainfall is sufficient for agriculture. The climate is that of southern Europe. The plains make rich wheat lands. The vine, olive and fig are grown on the hills, but the old careful terrace cultivation has fallen into decay. The climate of the Jordan rift is very hot. Jericho, on the main eastern route from Jerusalem, is still surrounded by palm trees and groves of bananas and oranges. East of Jordan the summer heat increases, and the rainfall diminishes. The country is poor grass land, passing into desert. Ruins of cisterns, tanks, and cities show that it was once irrigated and cultivated. It is now the home of wandering Arab tribes, who keep camels, sheep and goats.

Like other subtropical countries, with a "Mediterranean" climate, Palestine is green and fresh and inviting during its rainy season, but its summers bring drought, and dust, and heat, and its vegetation dries up. As in Mesopotamia, so here. An honest, efficient, progressive government, with careful plans for the future of the country, could by means of education in the best agricultural methods, and by an extensive system of irrigation, make of much of Palestine a rich garden, full of many fruits and other products which find their most favorable conditions of growth in just the climate which is there provided.

Into the climatic conditions which have here been briefly described, the British Army advanced, from the south, in the spring of 1917, having, according to reports, first built a railroad across the Sinai Desert for the transportation of troops and supplies. The season selected for this invasion was the most favorable in the year, for after the winter rains food for both men and animals is then most abundant; occasional showers refresh the ground; the heat is not as great as it is later on, nearer the summer. The reports regarding the Palestine campaign have been very meager, but as far as they go they have laid emphasis upon the part played by meteorological conditions. The first distinct success was the capture of Gaza, a place selected in the foregoing climatic description as representative of the southern coast. On April 2, 1917, Mr. Bonar Law said in the House of Commons that the operations against Gaza were most successful, and if it had not been for a fog which delayed the attack, and a shortage of water, complete disaster would have overtaken the Turks. Major Gen. F. B. Maurice, on April 5, 1917, confirmed this statement when he said that complete British success was only prevented by "a thick seven hours' sea fog." It is an interesting fact that two climatic conditions, fog and lack of water, played so important a part at the very beginning of the British operations in Palestine. A Constantinople despatch dated April 26, 1917, reported that Turkish (doubtless German) airmen on the Sinai front had totally destroyed the water-supply system which the British had constructed for their troops. The capture of Gaza was followed by that of Jaffa, Beersheba and of other less important places. The British advanced more rapidly as soon as the hot, dry summer was over, and the cooler autumn weather, with occasional showers, favored military operations. In the light of what was said above regarding the beginning of the rainy season, it is an interesting fact that the official reports mention "heavy rains," and "bright, cold weather," at the end of November (1917). This is the first mention of rain. The date is very late in the season for the actual beginning of the rains, and doubtless refers to rainfalls so heavy that they attracted attention, and possibly interfered somewhat with the movement of troops and supplies.

Jerusalem fell early in December. It is not an unlikely supposition that General Allenby planned to take that city before the December rains set in. This month usually contributes, as has been seen above, about one quarter of the total annual rainfall. A correspondent with the British troops reported of the weather conditions accompanying the march against Jerusalem:

> A torrential rain made the roads impassable, while a chilly east wind[15] pierced the sodden soldiers to the bone. The problem of supply and transport almost drove us to despair. The camels were unable to keep a foothold on the slippery paths. Nevertheless, the food and ammunition supply was maintained fully.

Further emphasis upon the handicaps resulting from the winter weather conditions of Palestine was laid by Major Gen. F. B. Maurice when he said (January 2, 1918)

> A word of caution is necessary relative to the hopes of an immediate further advance in Palestine. The hills of Judæa are notoriously difficult. The weather is unfavorable, and the roads are impossible owing to the wet season. The transport problem, therefore, is likely to prevent any considerable movement there for some time.

The capture of the Holy City, which naturally produced a great outburst of religious enthusiasm, was of immediate practical significance to the British Army. A strong line of positions had been secured. A good water supply was available. Difficulties of terrain, of weather, and of hard fighting had been overcome. The troops all felt that they "had the Turk beaten."

The Palestine campaign is closely associated with the fighting for the possession of the Suez Canal. For the capture of Palestine by the British is one essential in the protection of the Canal against invading armies. It is, therefore, appro-

[15] This is the coldest wind in winter.

priate that some mention be made here of the fighting which took place, earlier in the war, in the district just east of the Suez Canal. Much was written, in the early months of the war, about the probable invasion of Egypt by the Teutonic Allies. Many contradictory and erroneous statements found their way into print. It was reported that the Turks, with the assistance of German engineers, were pushing a railroad toward Suez, "over 150 miles of desert," and were paralleling it with a pipe-line for water. These mains were to be laid from the nearest wells, and the water was to be driven by powerful pumps. Openings were to be provided at frequent intervals to supply the troops during their march. There was also a report that German engineers were prospecting for water all through this region as far back as 1912. Even with the known, very serious, handicaps of the desert clearly in mind, there is nothing inherently impossible in the construction of such a railroad and in providing water by means of tank cars or pipe line, and food. A far more serious problem than that involved in the construction of a railroad across the Sinai desert has recently been solved in the successful completion of the new transcontinental Australian railroad. In the case of such an invasion of Egypt, the greatest difficulties would pretty surely be encountered in the transportation, feeding and munitioning of the troops over such very inferior railways as those of Asia Minor. As to the water-supply available for a large army during its progress across the desert it is, of course, at present impossible to make definite statements. At the eastern end of the Mediterranean the rainfall along the coast averages somewhat over 20 inches a year. The amount decreases to the south and west, so that even on the west, in the country which an invading army might cross, less than 10 inches fall annually. This is a winter rainfall. Hence winter would be the best season for such a campaign, both on account of the better water-supply and of the lower temperatures. Both seasonal and annual rainfalls are subject to great fluctuations, and can not be predicted in advance. The supply is variable, very scant at best, and very precarious, especially when the needs of the transport animals, as well as of the men, are taken into account. The climatic obstacles are not insuperable, but they are serious. To transport a large body of troops across a desert to a fighting ground in the midst of an arid wilderness, facing the British troops with Egypt close at their backs, presented a problem which even the highly efficient German military staff might have some doubt about solving. In order to reduce the water requirements of the many transport animals which would otherwise be needed, the Germans considered the use of air-cooled motors for moving their artillery and supplies across the desert. In spite of its many disadvantages, a desert does possess one great advantage from the point of view of health: its air is dry and aseptic. Under any ordinary conditions of proper sanitation, widespread epidemic diseases would not be likely to occur. A strong Turkish movement, with heavy artillery, against the Suez Canal was bound in any case to be difficult and slow. Of all the obstacles which may stand in the way of a marching army, a desert, whether it be a desert of sand or a desert of snow, is one of the greatest.

The official reports of the fighting for the Suez Canal were brief and generally unsatisfactory from the point of view of the present discussion. Moreover, there was a lack of the excellent war correspondents' letters, which have thrown so much light on the campaigns in the major war areas in Europe. The essential facts regarding the campaign for the Canal, in so far as they illustrate weather controls, are briefly as follows: Turkish activity near the Canal began toward the end of January, 1915, the enemy clearly realizing that the Sinai desert is more readily crossed in winter than in the heat of the summer. In expectation of the coming of the Turkish troops, the British had filled up many wells in the desert. After the German drive through the Balkans, early in the winter of 1915–16, and the opening of communication between Berlin, Vienna and Constantinople, a Turko-German attack on the Suez Canal was expected in the favorable months of January, February and March, "when white men may manœuvre in the desert." This attack did not materialize. A Turkish attempt to reach the Canal early in August, 1916, failed completely. The troops advanced in the face of the greatest difficulties. The men were transported on camels. For the guns, small parallel trenches were dug, to fit the wheels of the gun carriages. These trenches were filled with scrubby plants, and in some places, where the sand was too loose and deep for the track, planks were laid lengthwise under the wheels. Water was carried on the backs of camels and of donkeys. The Turkish despatches mentioned a "gigantic sandstorm," which impeded their left wing. Taking advantage of this phenomenon, the British made a successful surprise attack. The routed Turks met terrible hardships. In some cases the men were reported to have suffered so much from thirst that they killed their camels for water, and even drank the blood.

A NATIONAL PARK POLICY

By Professor FRANK A. WAUGH

MASSACHUSETTS AGRICULTURAL COLLEGE

LET me say at the outset that when I speak of a national park policy I wish to be understood with reference to all public reservations of land for recreation purposes, not merely with reference to the national parks legally so called.

Our national park system, while it is just emerging into being, has already assumed the forms of permanency. The whole people are committed to the idea—heart and soul. It would be almost as hard even now to alienate any portion of the national park holdings as to move the capitol from Washington or give Texas back to Mexico.

Yet the public is hardly beginning to recognize what the national parks are or what they mean. Through a considerable effort the public is slowly becoming conscious of their physical magnificence, their wide extent, their unsurpassed scenery, their overpowering grandeur. Still there is little popular appreciation of the significance of the national park idea itself. Nothing like this system of recreation grounds was ever established in any country in the world before, nor was there ever any similar undertaking of such tremendous reach, such high human possibilities. In the old days when we used to think that Europe was civilized, we were in the habit of making self-abasing comparisons between her art galleries and ours, between her national musical enterprises and our drug-store phonographs. Yet with all the unquestionable achievements of Europe in these fields, it is still true that no undertaking was ever broached in that Old World which had such noble possibilities of esthetic culture and spiritual upbuilding as our national parks.

Physical Equipment

The national parks, strictly so-called, now number 17 and have a total area of 9,773 square miles, an area larger than the state of Massachusetts. This does not include the Grand Canyon of the Colorado, which is practically one of our greatest national parks, and which soon will be legally included in the list.

The Grand Canyon, near Bright Angel Trail, Arizona.

While the extent of these park holdings is something impressive, the quality of the landscape is much more properly a matter of national pride. The wild mountain solitudes of Glacier Park, the steaming Geyser Basin of the Yellowstone, the unsurpassed loveliness of the Yosemite, and the overpowering wonders of the Grand Canyon are not to be matched anywhere else on this earth.

But our national equipment of landscape and of opportunity for out-door recreation is by no means limited to national parks. The entire area of the national forests is also open to us. In mere superficial expanse they far surpass the national park area. As at present constituted the national forests cover approximately 155,000,000 acres, or more than 242,000 square miles, roughly three and one half times the area of all New England. If we regard this also as a part of our national park equipment—and in the broad sense we have every right to do so—it brings our total resources up to almost exactly a quarter of a million square miles. This is more than a princely park allowance. It is a democratic provision for the entertainment, protection and salvation of a free people.

Nor is this quite the end of the story. Congress has also instituted a somewhat anomalous group of holdings known as national monuments. These exist under a curiously mixed and somewhat provisional form of administration. There is, however, one perfectly clear idea standing out of the whole group, and that is to reserve important areas of landscape or national curiosities for the entertainment and inspiration of the public. The national monuments are definitely reserved in perpetuity for the public, and are protected from all sorts of commercial exploitation. The idea is essentially and emphatically that of the national park. Some of these national monuments are of serious importance and all of them together constitute a substantial addition to our national recreation equipment.

The government also holds considerable areas in widely scattered neighborhoods as Indian reservations. While there may be a danger that the press of tourists on these areas may interfere to some extent with their primary purposes, it is clear that in other places the tourists rather help than harm the Indians. Indeed some Indian tribes have grown to be decidedly keen in the exploitation of the tourist traffic. Possibly this sort of intercourse provides the best means for the education and civilization of the aborigines.

Certain it is that several of these Indian reservations pre-

STORM ON THE GRAND CANYON.

sent the most attractive possible excursions for transcontinental tourists. Assuming that the interests of the Indians are properly safeguarded in the premises, there is no objection to counting these reservations as a very substantial addition to our national park system. The education which the Caucasian can draw from the Indians is certainly as great as that which passes in the opposite direction.

Of military reservations this country has an honorable minimum. There are a few which have some local interest, but at any rate this type of national property may be mentioned to exemplify the principle that practically all holdings of public land have their recreational value. In other words, whatever land is held by the public, whether national parks, national forests, national monuments, Indian reservations, military reservations, or what not, it is practically all a part of a national park system broadly conceived.

When it comes down to practical utilization no one ever makes any distinction between national and state property. When we take a purely practical view of the situation, therefore, we are compelled to consider state holdings along with national land as a part of our total landscape resources.

Now the idea of state parks is only just getting under way in this country. A few scattered state parks have been established. A larger number of so-called state forests have been set aside, but as a rule the name of state forest is a very thin camouflage for a heavy emplacement of park defences. Without any violence we may count into one category the state parks, the state forests, a certain number of watershed protection areas, with here and there other nondescript holdings which have a public recreation value.

Taken altogether, these state lands already constitute a considerable resource. New York State, Pennsylvania and Massachusetts have notable holdings of this character. From the standpoint of consistent legislation Wisconsin and Connecticut probably have the best-conceived state-park system. Other states are showing signs of intelligence and may be expected to come into line as fast as civilization moves and opportunity offers. The state-park idea is one of great importance, and the state parks must be looked to as the next field in which great progress is to be expected.

We have still to reckon with some of the municipal park systems which have more than local significance. A few enterprising cities have adopted the policy of securing large country parks, sometimes at considerable distances from the city itself. Such parks are acquired and maintained primarily if not quite exclusively for the benefit of the immediate citizens of the municipality. Wherever they come to be real country parks, however, the beauties of the natural landscape and the joys of outdoor living may become a genuine addition to our national park resources.

Taken altogether, these various holdings aggregate nearly 200,000,000 acres, possibly a little more. This is nearly two

COMMUNITY DWELLING, RITO DE LOS TRYOLES, BANDELIER MONUMENT.

Mount Ranier from Alta Vista.

acres per capita for the present population of the United States. When it is remembered that the ideal of park superintendents and social workers has been one acre of park for each hundred population in our congested cities, it will appear that our national provision is something altogether notable. Moreover it is certain to increase. As soon as the various commonwealths of America can be aroused to their opportunities we may look forward to more substantial additions in the form of state parks. As has already been intimated, this is the one point at which our system needs most to be expanded.

Now it ought to be perfectly clear that, so far as actual use goes, all these enormous, widely scattered and differently administered areas are essentially one system. They are used by the same people for the same purposes. From the national point of view we ought to have one comprehensive policy for dealing with this entire situation. That is what I would call a genuine national park policy.

Questions of Policy

The moment we begin to think about the extension, the development and administration of such a magnificent park system, some very big questions come up. As for instance:

How shall we secure a consistent policy wherein all these various holdings effectually cooperate toward the one main purpose for which they are all created?

On what principles and at what points shall the system be extended? Shall we insist upon more state parks? Shall we introduce county-park systems? Shall we extend our national parks? Shall we extend park uses on the national forests?

On what principle shall future national parks be established and delimited?

To what extent and how shall the park uses on the national forests be developed compatibly with the specific economic purposes for which they were first established?

To what extent may the recreation uses of Indian reservations be developed without infringing on the rights of our national wards?

What policy and administrative system may be applied to the national monuments?

On what principles may state parks be established and delimited?

Should a state park system include state forests, state

Cathedral Peak, Tirolumne Meadow, Tioga Road, Yosemite National Park, California.

watershed areas, and all similar territory capable of recreational utilization?

What form of administration is best adapted to a state park system?

What adjustment should be made within a state to secure consistency of policy and cooperation in use between state parks, county parks, and country parks held by cities?

These are big questions. Some of them are more important for the future of the nation than any questions of tariff or navigable rivers usually debated in Congress.

It is not my purpose now to answer all these questions, if indeed I could ever answer any of them. The most important thing from the public standpoint is to gauge the extent and seriousness of these questions, to realize the gravity of these unsolved problems. If we can propose some means by which these questions can be met and answered we shall have made a substantial contribution to modern politics.

A National Recreation Commission

Obviously the big broad fundamental questions here involved can not be adequately met by the National Park Service acting alone, nor by any state park commission, nor by any other one of the several bodies involved. Since any truly national park policy must comprehend all these agencies it will be necessary to form some sort of commission with sufficient independence and breadth of view to bring all these elements into one national enterprise. The ideal approach would be through a national commission formed by act of Congress and composed of a few men of talent, liberal training, technical equipment, and sufficient experience in public affairs to handle questions of national magnitude. Unfortunately at this moment the difficulties of securing thoughtful consideration and wise action upon such a project in Congress seem insuperable. While we would all willingly await the end of the war for such action, it is certain that the immediate post-bellum years will bring so many problems of reconstruction that questions of park policy, no matter how urgent, will hardly secure the attention necessary to such action as is here proposed.

Under these circumstances it has seemed to me possible that the present National Commission of Fine Arts might possibly in the days immediately following the war take up these questions of a national park policy. The National Commission of Fine Arts is well constituted for that undertaking and if the

Camp Resort among the Live Oaks of Southern California in the National Forest.

question could be fairly brought to them as belonging to their specific duties it seems likely that they could give it liberal and adequate treatment.

Failing more distinctly official study of the problem, it is possible that something might be done by a voluntary commission if constituted of men of national reputation and acknowledged ability. Some discussion has been going on amongst the directors of the American Civic Association, for example, as to the advisability of forming such a voluntary commission.

Certain broad conditions may be specified here as neces-

A Camp in the National Forest of Southern California.

sarily governing the work of such a committee. There appear to be five of these elementary requirements as follows:

1. A broad general view of public policies which will bring questions of national park policy into their proper perspective. Any crank unable to see anything in national welfare except parks would be a nuisance on such a committee.

2. A sympathetic knowledge of social service principles.

3. A keen appreciation of the esthetic value of landscape.

4. Some proper comprehension of the technical problems and methods of landscape architecture.

5. Some measure of the difficulties and limitations of administration through government bureaus, federal or state.

On the Main Trail at Sugar Loaf, a Massachusetts State Park.

Certain Points in Policy

It is impossible to do more at the present time than to indicate some of the more essential features of a national park policy. Although these are only beginnings even these simple principles have not yet been widely understood and accepted. The following propositions will, however, give some idea of the direction in which much future study must be given before we can begin to realize the tremendous range of possibilities inherent in our national park system:

1. A permanent national recreation board will be needed for

A Wayside Camp Grounds in the Blue Ridge Mountains of Virginia in the National Forest.

the study of policies and the coordination of activities. Such a board should be created and supported by Congressional action. As here conceived, this permanent board stands in addition to the somewhat temporary commission already suggested above for an initial study of national park policy. Of course it may be perfectly feasible to begin with a permanent board.

2. Future national parks should be created and delimited only upon recommendation of such a board. The Grand Canyon of the Colorado forms a conspicuous exception to this statement, inasmuch as the desirability of including this in the national park system is everywhere recognized. Beyond that point, however, grave dangers already impend. There is a somewhat ridiculous rush to create national parks everywhere without reference to the national interest. In fact many of these schemes are purely local log-rolling enterprises. There is grave danger of discrediting the entire national park system along this line of activity.

3. Early action should be taken to give a more definite status to the national monuments and to provide for them a logical form of administration.

4. The development of park uses on the national forests should be given a definite status, consistent on the one hand with other forest utilities, and on the other hand with the administration of the national parks in another branch of the government service.

5. Means should be devised for the progressive development of all these park resources. Such an attempt demands especially the application of the best technical knowledge of landscape architecture—a form of assistance generally lacking up to the present time.

6. Plans should be laid at once for the training of a park personnel in a manner parallel with the technical training given to foresters in Germany and America.

7. Provision should be made for the dissemination of public information covering the entire field. At present each special group runs its own propaganda, and since policies are not uniform and interests sometimes conflict, the statements which reach the public are partial and confusing.

8. Certain administrative questions require liberal study, the most immediately urgent being the status of the concessionaire on public recreation land.

9. International cooperation should be developed, inasmuch as Canada is already building up an important national park

system of her own, and one which will be extensively used by the citizens of the United States. The most immediate and typical problem in this field lies in the international protection of Niagara Falls.

Conclusion

I hope it will be clear that in this article I have been trying merely to indicate what are the problems confronting us in the matter of a recreation policy to cover the needs of the nation, and very roughly to suggest possible means of approaching a solution. It is already fairly clear what the solution ought to be for some of these problems; others will require years for their full answer. What we need now is a national conception of these problems. We need to see the case as a whole, with all parts in a just relationship. The public should be generally interested and widely informed.

Perhaps it is not going out of the way to hope that the effective development of this truly national park system under the guidance of a thoroughly national policy may come soon and that it may be one of the most useful elements in the national post-bellum reconstruction for which we are all so fervently longing.

THE RESEARCH COUPLET: RESEARCH IN PURE SCIENCE AND INDUSTRIAL RESEARCH

By WILLIAM ALLEN HAMOR

ASSISTANT DIRECTOR, MELLON INSTITUTE OF INDUSTRIAL RESEARCH, UNIVERSITY OF PITTSBURGH

PURE research, the morning dream of the scientist, has been referred to as the region of the scientific sublime; for, high and clear above all the necessary but prosaic activities of technology, far removed from the pettier aims of mere financial betterment, investigational accomplishment in pure science may be said to point one way to a goal of academic loftiness. Indeed, in the past, those devoted to pure research encouraged the impression that pure science, "a sort of preserve for intellectual sportsmen," was esoteric and distinctly apart from the ordinary affairs of life, and made no effort to disclaim the implication that pure scientists necessarily brought to their inquiries a higher and subtler intellect than those who were engaged in applying science to the needs of the community.

This adopted aloofness and lack of sympathy with respect to municipal and industrial practise have undoubtedly been prominent in retarding the solution of a number of the great problems of both chemical and mechanical technology, and have, moreover, acted as a barrier to needed cooperative effort.

It is certain, however, that, with the recent elaborate development of industrial research and the general recognition of the high quality of work which it demands, this view of the relation of pure and applied science has now entirely disappeared. In fact, while pure science ever has been, and ever must be, the safeguard of industrial research—the wellspring of experience and wisdom—it is generally conceded that the industrial investigator always will be the translator of the language of pure science to the manufacturing world, and in many cases, where necessity arises, the originator as well as the applicator of scientific method. Both pure and applied research are of the same order of importance, and each has its own related field.

Industrial research has for its immediate province the scientific extension of manufacturing. It should be borne in mind, however, that a discovery made in pure science to-day may find application in manufacturing operations to-morrow, and that such industrial application, though its precise form can not always be foreseen at the time, has come to be an expected incident in the after-life of the discovery. The wide view is now taken that, in considering the needs of industry, pure-science investigation has as essential a contributory function as that specifically devoted to the attainment of some technologic objective. Such pure researches may provide raw material for industrial research, and, owing to the interdependence of modern scientific investigations, progress in one subject may have a marked bearing on development in others. There is thus provided a distinct industrial stimulus for research in pure science. To illustrate, the investigational activity in physics in the pure field has been incited by the development of electrical and mechanical engineering; the departments of physics in our universities are unquestionably more productive because of the stimulating influence of the accomplishments of the engineering profession. Mathematics and astronomy have not had this direct encouragement from industry, but geology and botany have been immensely benefited by the researches indicated as desirable by technical chemistry.

The principal differences between those investigations which are undertaken for the purpose of furnishing material for industrial development and those conducted by scientists with the object in view of widening the boundaries of human knowledge are as follows:

1. Industrial research utilizes economically the unapprehended inspirations of the pure scientist; for applied science reasons retrospectively, employing the observations of pure science. Because of this fruitful dependency, pure-science research is nurtured by industry in its own well-directed laboratories as well as in those of our universities.

2. Industrial research is, therefore, likely to be more spontaneous and to depend more upon the initiative of the workers in its field.

The fundamental differences between pure research and industrial research are, indeed, traceable to the differences in the poise and personality of the representatives of each type of scientific investigation. Success in genuine industrial research presupposes all the qualities which are applicable to success in pure science, and, *in addition*, other qualities, masculine and personal, more or less unessential in the pure research laboratory. The late Robert Kennedy Duncan appropriately suggested that the difference between industrial chemistry and pure chemistry might be compared to the difference between poetry and prose, in the sense that in order to write good poetry it is essential to possess all the qualities of the prose writer, together with others superimposed upon them.

3. As the result of these recognitions, industrial research is rapidly becoming definitely organized to cover certain fields in the domain of science.

Applied science, the essence of industrial research, has been alluded to as bilateral in that its inquiries, conducted in the service of public welfare, may, when it is found to be necessary through a dearth of required information, eventuate in the discovery of scientific data as well as furnish and interpret the findings of the pure scientist; but, invariably, the original scientific work of the industrial investigator results from the realization of the requirement for a sojourn in the field of pure science. There are not, therefore, two sides to applied science, but two divisions of science which are difficult to define with constant accuracy because of their proximity. The needs of industry are so varied and so numerous that its research men are frequently crossing the flexible border to pure science, but time is the main factor in all industrial investigations and these visits are as brief as they are repeated.

Research in Chemistry

These facts are clearly indicated in the history of chemistry, "the eldest sister of all sciences and parent of modern industry."

The great triumphs of pure chemistry are philosophic achievements—the product of an antecedent experience in physical investigation of the widest and most searching character; and all of the conspicuous accomplishments in the domain of chemical industry—in fact, its actual growth and development—are the outcome of the application of these and other channels of knowledge explored by the investigators in pure chemistry. Indeed, we must welcome as one of the most fortunate advances in the direction of a solution of the important problems of chemical technology the fact that of recent years there is a growing tendency to recognize the two paths which alone lead thereto—experience and research. The recognition of the national essentiality of chemistry has thus profoundly modified the once combatant situation respecting pure and industrial research; while both groups of investigators, regarding the idealistic counsel of Schiller,

> Does strife divide your efforts—no union bless your toil?
> Will truth e'er be delivered if ye your forces rend?

have pressed onward, in their different paths, they have found a common aspiration, the development of social and industrial economy, and therefore constantly draw nearer to a knowledge of highest efficiency in mutual covenant.

Classification of Research in Pure Chemistry

Research in pure chemistry is to-day conducted in three distinct fields; these classes follow:

1. Investigation after facts or principles of theoretical interest or importance, and which have decidedly no direct bearing on or relation to present-day chemical technology.
2. Research conducted from a similar viewpoint, usually academic, and for the same purpose—namely, to add to the knowledge of pure chemistry—but which is also of technical interest. Original work of this type has, in fact, constituted the basis of many successful techno-chemical processes.
3. Scientific inquiry of largely or entirely a theoretical nature, resulting from or as a by-path of industrial research: research of this nature may only be classed as pure, but not infrequently it directly enriches technology. Investigatory work thus classified has indeed been active in elevating industrial chemistry by continuously infusing scientific spirit therein.

It is clear that the last two classes are closely related to the purposeful study of manufacturing problems; for research of the second type contributes to industrial progress by its suggestive import, while the third class may be of no greater significance, notwithstanding the fact that it is the outcome of planned industrial research; the one is a helpful adjuvant to, the other a by-product of, techno-chemical investigation.

Classification of Research in Applied Chemistry

Investigatory work in applied chemistry now mainly pertains to the intensive study of three types of problems, namely:

1. *The Preparation of Chemical Products.*—The techno-chemical research of this class is either synthetic or engineering. It is in synthetic chemistry that pure chemical science receives the most due in industry, particularly because of the synthetic production of pharmaceutical substances. Many of the noteworthy accomplishments in this field have been effected in laboratories of factories. The chemical engineering

division of this class of investigation relates to the improvement of existing processes and to the discovery of new procedures of manufacture.

2. *Research Having for Its Object the Ascertainment of Uses of Manufactured Products.*—In the pharmaceutical products industry, research of this type is conducted in intimate cooperation with pharmacology, chemo-therapeutics, bacteriology, and commercial science. In the heavy chemical industry, the line of inquiry is, of course, almost entirely chemo-economic in nature.

3. *The Elaboration and Perfection of Analytical Methods,* the indispensable aids in the control of manufacturing operations.

The Development of Industrial Research

Stupendous developments in industrial research have taken place during the past decade, particularly as the result of the realization by manufacturers of the functions of applied chemistry. Manufacturers who have been benefited by the application of science to industry have not been content to await chance discoveries, but have established well-equipped laboratories and strong research staffs. Further incentives in this direction have been provided by the industrial progress achieved in Europe by similar means and by the influx of many scientifically trained men, principally from Germany. Then, too, a tendency toward national economy and a fear of the depletion of certain natural resources have directed attention to the importance of the scientific conservation of these unreplaceable assets. Moreover, some large industrial corporations have found it expedient to keep before the public the fact that investigations on a large scale ultimately bring considerable benefit to the community generally; that every scientific discovery applied in industry reacts to the public gain; and that consequently great industrial organizations are justified, since it is only where there are large aggregations of capital that the most extensive and productive research facilities can be obtained. There are a large number of manufacturing corporations and associations of manufacturers whose annual expenditures on research range from $50,000 to $500,000, and the tendency for each important industrial firm is towards the establishing of its own research laboratory. Certain of our research laboratory forces have been increased from 250 to 400 per cent. in the last ten years, and, since August, 1914, the staffs of a number of the largest laboratories have been enlarged from 25 to 100 per cent.

The research work thus commenced by corporations appears to develop through certain more or less well-defined stages, according to the character of the industry.[1] These stages may be presented as follows:

1. *Research Applied to the Elimination of Difficulties in Manufacturing*

In every industrial organization difficulties regarding materials and processes employed inevitably arise, tending to prevent smooth working and desirable economy. To overcome these troubles, investigation is necessary, which, if well planned and conducted thoroughly, locates the exact cause of the difficulty and eventually leads to its elimination. Some manufacturers may be content in such cases to apply rule-of-thumb methods, which, while occasionally effecting a temporary alleviation, do not preclude a fresh outbreak of similar trouble in the same or some other form. Progressive firms do not, however, resort to empiricism, but provide organized means for investigating and eliminating manufacturing difficulties, and the extent to which it is necessary to apply science to this end depends upon the nature of the product and the complexity of the manufacturing processes involved. In the largest manufacturing firms of every industry there is now usually ample scope for a scientific staff and laboratory facilities to deal with techno-chemical troubles. At least six American organizations have sixty or more research chemists engaged in this field of industrial research.

2. *Research Having Some New and Specific Commercial Object*

This variety of industrial research involves an intelligent appreciation of the trend of development of manufacture and the possible applications of a product, and a close study of the scientific features and new discoveries that will pave the way for its successful manufacture. Frequently the appreciation of the need in industry, for some new tool, method, or material, stimulates a deliberate search for means to satisfy that demand. Or, again, the development of manufacturing methods for producing commodities heretofore brought to a high state of perfection in some other locality or country may involve the development of appliances and processes of which no previous experience has been obtained.

[1] On the development of research, see Fleming's "Industrial Research in the United States of America," a report to the Department of Science and Industrial Research, London, 1917.

Many captains of industry have been sufficiently far-sighted to provide extensively for research of this character, and such facilities have been turned to very profitable account in connection with new industries developed since the outbreak of the World War. In many cases these laboratories not only supply the works with new inventions and discoveries, but are used to carry on the manufacture of products with which the works themselves are not well suited to deal. In fact, the research laboratories of a number of corporations pay their own way out of the profits arising from the sale of commodities thus produced.

3. *Researches in Pure Science with no Specific Commercial Application in View*

Among the most progressive firms there is a growing appreciation of the fact that almost every discovery in science ultimately may have influence on industry. The General Electric Company, the Eastman Kodak Company, and other American organizations devote increasing attention to research of this character, and in some cases special laboratories for this purpose have been installed which are quite distinct from the main research laboratories. This may be viewed as a very far-seeing business policy, directed to outstripping competition by the continuous provision of discoveries, which may sooner or later be turned to industrial account. It is recognized that in such cases there is a probability of a great deal of the new scientific knowledge thus obtained being only of limited use to the particular industry concerned. On the other hand, one successful discovery may result in such important industrial gains as to outweigh by far the cost of all the abortive research.

Researches of this type have carried a broader scientific spirit into the field of industrial investigations; and, while there is still much room for improvement in this direction, the signs of the times are encouraging. Important industrial research laboratories are taking a continually wider point of view with respect to the early publication of scientific data.

4. *Research Applied to Public Service*

Many industries and public utility companies find that the market for their products can be increased by a careful investigation of their customers' needs. Especially does this appear to be the case with electrical power supply companies, some of which maintain research laboratories for the investigation of new uses for electrical energy.

5. *Research for the Purpose of Establishing Standard Methods of Testing and Standard Specifications Connected with the Purchase of Raw Materials*

Large firms and associations carry out a considerable amount of investigation mainly with this object in view, and efforts of this kind are to a considerable extent rendered of common value through the channels afforded by the American Society for Testing Materials, of which the leading corporations are members. The Refractories Manufacturers Association, the United States Steel Corporation, the Barrett Company, the Gulf Refining Company, and the Barber Asphalt Paving Company are among those which are active in research of this nature.

An examination of the methods of industrial research must start with the admission that the most important discoveries have arisen from the work of men of science who have drawn their inspiration from the "supreme delight of extending the realm of law and order ever farther toward the unattainable goal of the infinitely great and the infinitely little." Wöhler, a pure investigator, by his classical experiments on the synthetical production of urea, originated a new branch of science, organic chemistry, which has constituted the basis of the great industries connected with dyes, foods, drugs, petroleum, explosives and other commodities An English chemist, Sir William Perkin, discovered in 1856 the first aniline dye, "mauvine," and thus laid the foundation of an enormous chemical industry. The late Sir William Ramsay remarked that it would have been impossible to predict, when Hofmann set Perkin as a young student at the Royal College of Chemistry to study the products of the base aniline, produced by him from coal-tar, that one dye factory alone would at a later date possess nearly 400 buildings and employ 350 chemists and 5,000 workmen. Other examples in the chemical field are the work of Schönbein, a Swiss schoolmaster, whose investigation into the action of nitric acid on paper and cotton resulted in the production of nitrocellulose; and, in the physical field, Faraday's work on induced currents, upon which are based electric lighting and traction and the utilization of electricity as a motive power and for the transmission of energy.

The history of science shows, however, that the work of the "pure" scientist generally breaks off at a point before the industrial application of his discoveries is reached, either because he has no interest in or aptitude for this aspect of the work, or because the industrial application has to wait for some scientific advance in another direction. The chemist who discovers a new organic compound may not consider himself under any obligation to investigate its utility in medicine; or the discoverer of a new rare earth may have no interest in its applicability in the manufacture of incandescent gas mantles. Some pause between scientific discovery and its industrial application is indeed almost inevitable, except in laboratories where the pure-research department hands over discoveries immediately to the industrial-development department. It is appropriate in this place to consider the history of aluminum, which was discovered by Wöhler in 1827. For some twenty years, the new element remained of academic interest only. In 1855, Henri Sainte Claire Deville's study of the metal, encouraged and subsidized by Emperor Napoleon III., reduced the cost of production to $90 a pound; and, by improvements in the method of manufacture, the price was further reduced to $12.50 a pound in 1888. In that year Castner's new process for the manufacture of sodium brought about a further reduction of the price of aluminum to $4 a pound. But this success was soon eclipsed, for in the following year the electrolytic method of producing aluminum revolutionized the industry. The American consumption of aluminum produced by this method is estimated at over 100,000,000 pounds a year, whereas it amounted to but 283 pounds in 1885 and about 1,000,000 pounds in 1895. Another often-quoted example comes from the artificial production of indigo. The pure research of Liebig and Baeyer on the constitution of indigo was elucidated and developed through Kekulé's theoretical work in 1869 on the arrangement of the atoms in the molecule of indigo; and in 1880 Baeyer discovered a method for the industrial production of the dye. The problem was taken over by a famous firm of chemical manufacturers—the Badische Anilin-und-Soda-Fabrik, of Ludwigshafen. It is said that twenty years of patient investigation and an expenditure of about $5,000,000 were devoted to the work. The artificial production of indigo is now carried out on a large scale, both here and abroad.

The scientific worker occasionally undertakes the commercial exploitation of his discoveries. The establishment of the celebrated Jena glass works at Leipzig resulted from the investigations of Abbe, assisted by Schott, on the chemico-physical principles which underlie the manufacture of optical glass. Abbe recognized from the first that the position of the optical glass industry, which depended at that time on a few individuals, was unsatisfactory, in view of the possible stoppage of supplies indispensable to many of the sciences; but he doubted whether private initiative, without strong backing, could meet the case. The researches were, however, subsidized by the Prussian Bureau of Education and the Diet of the Kingdom; and, when completed in 1883, the necessary capital was forthcoming and an important industry was established. The attempt to establish a dye factory in England, at the time of Sir William Perkin's discoveries, ended disastrously. The real reason why the industry left that country, according to H. A. Roberts,[2] was the death of the prince consort, who had induced Hofmann to accept an appointment at the Royal College of Chemistry in London. After the death of the prince, Hofmann was attracted back to Berlin; his companions followed him, and took with them much of the expert knowledge of aniline dyes. W. F. Reid has controverted this opinion with respect to Hofmann's influence on the dye industry. He is authority for the statement that at that time English chemists controlled the dye manufacturing business by their patents, and made so much money out of it that they ceased to care whether the industry developed further or not; and that, when the matter dropped, the Germans took it up, and, by skill and patience, developed it to an enormous extent. The United States now has a firmly established dye industry, the result of activity during the past three years.

Enough has been said to indicate how important is the part which the academic worker has taken in the development of applied science. It should not be inferred, however, from the examples quoted, that valuable results are obtained only from scientific workers of the highest intellectual powers. Many examples could be given of discoveries by young and inexperienced men of factory processes of great commercial value, but comparatively simple in character.

THE LURE OF INDUSTRIAL RESEARCH

From all of our prominent institutions of learning, the combined lure of great research opportunities and of much larger financial returns has taken from academic life many of the promising young men on whom the country has been depending for the filling of university chairs as the older men now holding them gradually age and retire. Unless prompt measures are taken there will result in a few years such a dearth of first-class tried material for professorships that second-rate men will be placed where the national welfare needs the best, and

[2] Paper read before the Royal Society of Arts, February 28, 1912.

third- and fourth-rate men will be occupying positions wherein there should be young men of the highest promise in the period in which they are reaching full maturity. Indeed, it is greatly to be feared that even now we are witnessing a gradual lowering of standards in the science departments of our universities. It would be futile to appeal to the manufacturers not to call the men they need, although in the not distant future they will suffer most severely from the situation which is developing, if the present tendencies remain unchecked; for while our industries can provide for any urgently required research in pure science, it will never be safe for the nation to depend on the industrial laboratories for its progress in science, and men gifted with the genius for investigation must also be trained in and secured from the universities. The only possible source of relief lies with the presidents and trustees of our great universities.[3] The authorities should recognize the fact that their institutions have now entered a period of severe competition between the industries and academic life for research chemists and engineers of the highest type and greatest promise. They have already learned the only method of meeting this competition successfully, for they have faced the same problem in two other professions, medicine and law: because of the tremendous financial attractions of the practise of these professions, the most progressive universities have simply put their law and their medical faculties on a higher, more nearly professional scale of endowment of professorships than obtains for their other faculties. They must take the same measures with their science staffs; it is primarily a question whether they can be awakened to that need now or whether they will let the country suffer from their lack of foresight and let us learn from the most efficient of our teachers, bitter experience. Wise provision now would not only safeguard our present standing in a critical period of our history, but in this time, when the importance of science and especially of chemistry has been brought home to our young men as never before, the new attitude, properly announced, would attract a large proportion of the men of brains, talent and ambition, who enter professional life, but prefer to study law or medicine as holding out much greater opportunities for the satisfying of their ambitions.

The manufacturing world will, however, always attract from our universities able investigators of pronounced energy who are anxious to do things on a large scale. On the other hand, those who are profoundly interested philosophically in the

[3] See Stieglitz, *J. Am. Chem. Soc.*, *39* (1917), 2095.

nature of things will plan and conduct their researches without *special* thought of pecuniary or practical outcome and without serious regard for exigency, and from such investigations must come primarily any great discoveries of new principles which still remain to be made—and many such are still in the future. Researches of this type will always allure men of thought as contra-distinguished from men of action; and the real home of these investigators is the university because the time factor is there of secondary consideration. The volume, range and quality of industrial research are certain to continue to increase largely in the immediate future and the relative amount of time spent on pure research may decrease. It is not thought, however, that there will ever be any diminution in its absolute amount, and the leading advocates of industrial research are the first to urge the encouragement of pure research. Any general curtailment of research in pure science would be a most serious calamity. Scientific laws can not be reasonably applied until they are understood; therefore, research in pure science, which establishes the underlying foundation of the applied sciences, essentially precedes any efficient application of these laws. Hence, at least chronologically, the fertile investigator in pure science must also come first.

A NEW SITUATION IN THE ORIENT

By SUDHINDRA BOSE, Ph.D.

FORMERLY OF CALCUTTA, INDIA

LECTURER IN ORIENTAL POLITICS, STATE UNIVERSITY OF IOWA

WHAT will be the effects of the war on the future of America and Europe? Answers to this question are so vital to us just now, that it is little wonder we have all but forgotten the Orient. The Revolution in Russia seems to be so closely connected with the fortunes of the war that we feel its every throb; at the same time, it was only the day before yesterday that monarchy was overthrown in China and a republic established. The capture of Jerusalem was celebrated yesterday; it will be forgotten to-morrow.

Out of the wrecks of the World War will arise a new situation in the Orient—a situation in which the people of the Orient will be free to direct the development of Eastern culture along the lines of their own peculiar genius. Can any one imagine that the nations which have been fighting for the independence of the small states of Europe will after the war permit themselves to interfere with the peaceful progress of the people of the Orient? As by a great tidal wave the world is being swept of the notion that it is given to some nations to rule and to exploit, and others to be ruled and exploited. The Great War is surely lifting the white man's burden in the Orient. Our war-time sympathy for the Russians, the Poles, the Serbs, and even the peoples of Austria-Hungary and Turkey, has increased our respect for the non-military or what Tagore calls the no-nation peoples of Asia. It is hardly to be imagined that after the war this world will be a very comfortable place for those who attempt the exploitation of the weak nations of Europe or the no-nation peoples of Asia. We refuse to believe that after this titanic struggle any outside power will be permitted to take possession of Kiachow, because of the killing of two German priests by a band of irresponsible ruffians; or that Port Arthur will be seized, because a foreign navy finds the winter there not quite so severe as at Vladivostok; or that the gateway to a "foreign" park in Shanghai will be decorated with such a sign as "Chinese and Dogs not Allowed."

It is a fact that in political organization, in militarism, and in some other respects the peoples of the Orient have not kept pace with the peoples of the Occident. But in this hour of reconstruction—or, shall I say, destruction—it may happen that some of our tests of progress and culture will be discarded. In the light of new standards the civilization of the Orient will be rejudged. The peoples of the East may yet come to be regarded as the equal of any other people in culture and in physical fiber. An Asiatic renaissance is due. And what an opportunity awaits the critical historian! The mystery of the Orient will turn out to be little more than the mystery of ignorance—the awe of things unknown. "The East is East and the West is West" promises to become as obsolete as it is meaningless.

Those who undertake the impartial investigation of Oriental culture will be impressed with the fact that Asia has made many significant contributions to world civilization. Take China as an example. It has been the custom in certain quarters to speak patronizingly of the "long sleep" of China; but China's "long sleep" was one of enlightenment, while Europe was engaged in warfare and bloodshed. "In invention, mechanical and engineering aptitudes the Chinese have always excelled," says Professor Herbert A. Giles in his work on "The Civilization of China," "as witness—only to mention a few—the art of printing, the water-wheels and other clever appliances for irrigation; their wonderful bridges (not to mention the Great Wall); the taxicab or carriage fitted with a device for recording the distance traversed, the earliest notice of which takes us back to the fourth century A.D.; the system of finger prints for personal identification, recorded in the seventh century A.D. . . . Add to these the art of casting bronze, brought to a high pitch of excellence seven or eight centuries before the Christian era, if not earlier . . . the cultivation of the tea plant from time immemorial; also the discovery and manufacture of porcelain some sixteen centuries ago."

The Chinese invented the mariner's compass in the eleventh century B.C. It was used by the Arabs in the ninth century A.D., and later it was employed by the Europeans. Gunpowder was first made in China. The idea of paper originated in China in the year 75 A.D. The Middle Kingdom was the first country to weave silk with a pattern. In 166 A.D. the Roman Emperor Marcus Antoninus sent an embassy to China by sea to get Chinese silk. Moreover, China constructed a really wonderful canal system. Indeed, the Grand Canal in China is perhaps the oldest canal in the world. The Chinese commenced to dig this big ditch in 486 B.C. and they did not complete the task till eighteenth century A.D. While the Panama Canal, of which we are so justly proud, is about 50 miles in length, the Grand Canal is a thousand miles long. It is still used for commercial purposes. Then there is the Great Wall, which has long been considered one of the seven wonders of the world. This wall, built against the inroads of Mongol horsemen, is two thousand miles long. It has been carried over precipitous hills and almost inaccessible mountains. "No other work of man," says Professor Albert Bushnell Hart in his "Obvious Orient," "compares with the Chinese Wall for the human labor which it cost. It contains the mass of a hundred pyramids; its masonry would build a dozen Romes or fill six Panama Canals."

Nor should one forget the immense debt which the world owes to Asia Minor, Mesopotamia, Persia and India. But the space at my command compels me to limit myself to a few observations on India. Of the many things of lasting value which Hindustan has contributed to civilization I can mention only a few. The world owes the decimal notation to the Hindus. Without a decimal notation arithmetic as a practical science could not have been of much value. The Hindus developed algebra to a very remarkable degree.

> Arabian writers translated Hindu works on algebra in the eighth century, and Leonardo of Pisa learnt the science from the Arabians, and introduced it in modern Europe.

Geometry was first discovered in India. It was the necessity of constructing Vedic altars according to fixed rules that gave birth to this science. Mr. R. C. Dutta in his monumental work, "History of Civilization in Ancient India," says that "the Hindus had discovered the first laws of geometry in the eighth century before Christ, and imparted it to the Greeks." There is reason to believe that the earliest teachers of trigonometry were also the Hindus. That they had developed a high degree of civilization will be evidenced from the fact "that the exact anatomy of the human body was known to the Hindus so far back as the sixth century B.C., that surgery was an applied science in India during the early centuries of the Christian era; that the first hospitals of the world were built by Hindu scientists and philanthropists, that the application of minerals to therapeutics is very old among the Hindu medical practitioners, that zinc was discovered in India before the time of Paracelsus, and that circulation of blood was known before Harvey."

India knew something also of the theory of evolution "centuries before Spencer established it scientifically, or Darwin applied it to man's story, or Huxley bore down with it so aggressively on faith. It was the cardinal doctrine of the sages in India." Dr. R. Heber Newton in his article on "The Influence of the East on Religion" published in an issue of *Mind* not long ago wrote as follows:

> Confirmed idealist as was the Hindu philosopher . . . he could speak of the material world only in terms of mind. Evolution became the doctrine of the progressive unfolding of life through the action of an Infinite and Eternal Spirit. It was, it is, the history of the Divine being. It was, it is, a religion. And this Eastern wisdom our Western world can not reject as an alien conception when not alone idealist philosophers like Berkeley hold it, but savants like Huxley confess that, as between the two conceptions of idealism and materialism, they would have to take the first theory.

To enter upon an extensive discussion of the various phases of Hindu culture is beyond the scope of the present paper; suffice it to say in the words of Professor Rawlinson that "there is scarcely a problem in the science of ontology, psychology, metaphysics, logic, or grammar, which the Indian sages have not sounded as deeply, and discussed as elaborately, as the Greeks." It may therefore be confidently said that from Asia came the sparks of science and literature which opened the way for Europe's material progress.

Important as all these contributions are, they are but trifles compared to Asia's gift to the spiritual welfare of the human race. The East is the home of religions. All the great religions of the world, which have stood the test of time, have come from the East. Hinduism, Buddhism, Confucianism, Zoroastrianism, Mohammedanism—all had their birth in the East. Real Christianity—that is, Christianity uninfluenced by Greek speculation, Roman institutionalism, and medieval scholasticism—is an Asiatic religion. The Nazarine Christ himself was an Asiatic of Asiatics.

No one need conclude, however, that Asians were all abstract thinkers, closet philosophers. Careful students of Oriental history know that the Asian is both a religious and a political animal. It is a fact that the "Hindus had developed republican city-states of the Hellenic type and clan-commonwealths and village institutions of the folk-moot type, that the first, most extensive and centralized empire of the world was the Hindu empire of the Mauryas (fourth to third century B.C.), that a census of a people according to social and economic status was actually undertaken in the fourth century B.C., that the Hindu generals could organize and manipulate a regular standing army of 600,000 infantry, besides a vast cavalry and an efficient camel-corps and elephant-corps." From the earliest times down to the twelfth century A.D., Hindus, Chinese, Mongols, and Saracens made themselves rulers and conquerors wherever they went. Indeed, Asian Charlemagnes, Fredericks, and Napoleons are almost countless in number. In the beginning of the thirteenth century Genghis Khan and his followers went into Europe and conquered Russia. The Russian princes became the dependents of the great Khan, and had frequently to seek his far-distant court, some three thousand miles away, where he freely disposed of their crowns and sometimes their heads. For over two centuries Russia paid tributes to an Oriental potentate. It was not until about the close of the fifteenth century that the princes of Moscow were able to free themselves from the Mongol yoke. And yet as late as in 1547, writes a modern historian,

> Ivan the Terrible assumed the Asiatic title of Tsar, which appeared to him more worthy than that of king or emperor. The costumes and etiquette of the court were also Asiatic. The Russian armor suggested that of the Chinese, and their head dress was a turban.

Consider again another race of conquerors from Central Asia, namely, the Turks. The Osmanali Turks started in their career of conquest in the thirteenth century. They advanced to southeastern Europe, and captured Constantinople itself in 1453. At its greatest height in 1683 the Ottoman state extended its sway almost to the very gates of Vienna.

Professor Benoy Kumar Sarkar in his scholarly work, "The Chinese Religion through Hindu Eyes," rightly said:

> The darkest period of European history known as the Middle Ages is the brightest period in Asia. For over a thousand years from the accession of Gupta Vicramaditya to the throne of Pataliputra down to the capture of Constantinople by the Turks the history of Asia is the history of continuous growth and progress. It is the record of political and commercial as well as cultural expansion—and the highest watermark attained by oriental humanity. . . . It was the message of this orient that was carried to Europe by the Islamites and led to the establishment of medieval universities. In describing the origin of Oxford, Green remarks in the "History of the English People": "The establishment . . . was everywhere throughout Europe a special work of the new impulse that Christiandom had gained from the Crusades. A new fervor of study sprang up in the West from its contact with the more cultured East. Travellers like Abelard of Bath brought back the first rudiments of physical and mathematical science from the schools of Cordova or Bagdad.

Some may say that the Oriental system of government was not democratic. The charge is perhaps true. One must remember, however, that the democratic state is after all of very recent growth. It is safe to assert that there was no true democracy in Europe before the French Revolution. Germany still bends her knee before a divine-right kaiser. Although the formal constitution of modern Italy dates back to 1848, the Italians did not have a national government till 1861. France suffered from horrors of untold chaos and confusion, and waded through seas of blood before she was able to establish a stable government in the Third Republic in 1870. The English government in the eighteenth century was praised with great enthusiasm by Voltaire in his "Letters on the English" and by Montesquieu in his celebrated work, "The Spirit of the Laws"; but after the French Revolution, the same English government was found to be medieval in its backwardness. The English Parliament of that time, says a historian of modern Europe, was "only a council of wealthy landlords and nobles who often gained their seats by bribery and could not be said to represent the nation, which had, indeed, little to do with their election. The English law was still shockingly brutal; citizens who did not accept the Thirty-nine Articles were excluded from office; and education was far from the reach of the masses." It is also a matter of common knowledge that universal manhood suffrage did not exist in Europe even during the first half of the nineteenth century.

These facts are sometimes lost sight of by European critics when they pass judgment upon the Oriental system. With their eyes fixed on their own time, they pass upon the entire history of Oriental culture extending through thousands of years. The comparison is unjust and unscientific.

A comparison of the civilization of Europe and Asia people by people, epoch by epoch, century by century, reveals the truth that up to the time of Napoleon "the East and the West were practically equal in science and sociology and other branches of human thought and endeavor." The question may now be asked, What caused the divergence in development in the modern period? The answer is clear: it was the industrial revolution, due to mechanical inventions, which led Europe to follow a different course. Steam was first applied to industrial uses in England in 1815. It was not applied to industries in France and Germany till 1835 or later. This industrial revolution in the nineteenth century had no counterpart in Asia.

Because Asia had not advanced along modern industrial lines, Europeans have sometimes been inclined to consider themselves as belonging to an inherently superior race. But this assumption of racial superiority is open to serious doubts.

Indeed, the verdict of modern ethnological science seems to be that there is no such thing as an inherently superior or an inherently inferior race. History frequently has the unpleasant knack of repeating itself. "Yesterday Asia stood on the heart of Europe; to-day Europe stands on the heart of Asia." The masters of to-day may be the slaves of to-morrow. It is, of course, freely admitted that there are differences between the East and the West; but these differences are superficial, and not fundamental. At the same time it must be admitted that there is a fundamental identity of the human ideals of Asia and Europe. It must be conceded by unprejudiced observers that for all practical purposes the peoples of these two continents, given the same conditions, are essentially equal in intellect, in ethics, and in martial prowess. I am willing to go even further, and admit without argument that in all cardinal virtues Asians and Europeans stand on the same footing, and that in all cardinal vices they are equally degenerate and equally to be condemned. To an Asian who has not lost his historical perspective it is unthinkable that the white countries are superior just because they are white: to him such a theory is a myth or a fable.

It is in the modern epoch that the people of Asia have been confronted with a really gigantic problem—the problem of foreign domination. With one or two exceptions, almost all Asia and its adjacent islands have been brought either under the direct control of Western nations or within their spheres of influence. According to Professor Hornbeck the total European possessions in Asia are 9,500,000 square miles with a population of 400,000,000. And we are told by Dr. Paul S. Reinsch, the present American ambassador at Pekin, that most of these territorial gains have come through "deceitful selfishness, rapacity, and bloodshed." In the year 1900, the "mailed fist" Kaiser invented the crude slogan of the "Yellow Peril"—a thing which exists only in imagination. Professional warmakers, however, both in America and Europe have been industriously bombarding their countrymen with pamphlets, addresses, and newspaper articles in an effort to prove that the hosts of Asia threaten to overrun Europe and America. It is safe to say emphatically that the Yellow Peril does not now and never did exist. On the other hand, the White Peril did exist—at least when at the time of the Boxer rebellion in 1900 the German Kaiser instructed his troops to "be as terrible as Attila's Huns," or when in 1914 the same Kaiser of the "mailed fist" addressed his Army of the East in these words:

Remember that you are the chosen people! The spirit of the Lord has descended upon me because I am Emperor of the Germans. I am the instrument of the Almighty. I am His sword, His agent. Let them perish, all the enemies of the German people! God demands their destruction; God who, by my mouth, bids you do His will.

To be sure there were critics who held that the European domination of Asia was justifiable because the European system of government and industry is characterized by order, discipline, and efficiency. But since these attributes—order, discipline, and efficiency—have appeared as the chief virtues of the Prussian system—a system which the whole civilized world has pledged itself to destroy—this argument has indeed faded a bit.

We must never forget that Asians are human beings. They, too, have "eyes, hands, organs, dimensions, senses, affections and passions." They could not possibly be kept in bondage forever to any foreign power. Autocracy in this second decade of the twentieth century, whether in the East or in the West, is opposed to science, reason and ethics. Autocracy is the sworn foe of democracy. Autocracy is dramatized barbarism. Can it be that the thousands upon thousands of Asians who have given their lives and their all in this war of civilization since August, 1914, with the expectation of bringing democracy into all parts of the world have died in vain?

Our great President, the acknowledged spokesman of the allied nations, has declared that we are in this struggle to make the world a safe place for democracy. These words of hope and cheer have been acclaimed by the nations of the Orient as those of a prophet. Who shall now say that the "world" to which our President referred in his immortal message does not include the continent of Asia—Asia which is inhabited by more than half of the human race? Is not the Orient with its teeming millions really a part of this world which is visioned for democracy? At the close of the great conflict, for which the Oriental peoples have made great sacrifices, will they not have the right to ask for an assurance of the Westerners that they are really their friends and brothers? Nationality is being accepted everywhere as a principle. Not only Roumania, Servia and Belgium, but all countries, great and small, all peoples, white or yellow, have a right to a national existence. In our relations with the Orient shall we deny this principle which has become the mainspring of our action?

Asia is already proceeding on the theory that after the war there will be the most friendly understanding and cooperation between the East and the West. Moreover, at this parting of ways Asian leaders of thought are prepared to take a leaf from the book of American experience. Asian statesmen are considering nothing less than a Monroe Doctrine for Asia—a doctrine which will declare that the Asian continent shall not be considered a place for future colonization by European powers, and that any attempt to extend the European system to any portion of the Orient will be considered an act of deliberate unfriendliness. And just as the American Monroe Doctrine checked the intervention of the Holy Alliance in the affairs of the New World in the nineteenth century, so the Asian Monroe Doctrine will be expected to stop the exploitation of unholy imperialism in Asia in the twentieth century.

The countries of Asia by their fundamental identity of economic, social, religious, and intellectual life are a unity. The nations of the Orient by geographical proximity and by natural sympathy are friends. They are natural allies. Being conscious of their common interests, they are willing to act together. They insist that trade and commerce should not be used as a cloak of unscrupulous financial imperialism; they declare that taking possession of their property under the disguise of building railroads, operating mines, and otherwise exploiting their natural resources are not and can not be the final judgment of justice.

It is, therefore, highly significant that the people of the Orient with a view to their own security and well-being, as well as for world peace, are prepared to assert a Monroe Doctrine for Asia. This would not mean the expulsion of all Europeans from Asia—as the Jews, for instance, were driven out of Spain. It will only imply the end of foreign domination in the East, the indefinite continuance of which spells Asian degradation, Asian bankruptcy and Asian suicide. Any wrongs that may have been perpetrated in Asia, of course, must be redressed; but not by the commission of similar wrongs. A policy of revenge, of vindictive action, will not be in keeping with the traditional character of the Orient, which is generous and forgiving. Asian-European problems should be solved not through bloodshed, but through mutual understanding, sympathy, friendship, and enthusiasm for humanity.

The Hon. Iichiro Tokutomi, a crown member of the House of Peers of Japan, in explaining the object of this proposed doctrine of Asian public law in the *Japan Chronicle* of January, 1917, writes:

By the Asiatic Monroe Doctrine we mean the principle that Asiatic affairs should be dealt with by the Asiatics. . . . We do not hold so narrow-minded a view as to wish to drive the Whites out of Asia. What we want is simply that we become independent of whites, or free Yellows of the rampancy of the whites. . . . The Asiatic Monroe Doctrine is the principle of Eastern autonomy, that is, of Orientals dealing with Eastern questions. . . . We are ready to leave the Europeans to attend to European affairs, and the Americans to American questions, but we demand that they should leave Orientals to attend to their own questions.

The natural leader of this Pan-Oriental movement is Japan, which Professor Roland G. Usher in his "Challenge of the Future" rightly describes as "the trustee of the liberty of all Asiatics, the only state capable of loosing the greedy clutch upon the Asiatic future." Nippon is to Asia what England is to Europe—what the United States is to all America. Japan by universal consent has been admitted to the rank of world's foremost powers. And Japan, having the modern constitutional government, would be best fitted to guide the nations of Asia in their new awakening. Possibly the island empire, by reason of its military preponderance, may insist upon a certain centralization of power in herself as the chief factor. This may cause temporary friction among the nations of the Orient; but if that be the road to the ultimate goal of Asian emancipation, Japanese leadership will not be questioned, neither will there be wanting willing, voluntary cooperation.

Speaking of Japan's leadership in Asia, Sir Rabindra Nath Tagore writes in the *Modern Review* of Calcutta: "It does not surprise one to learn that the Japanese think of their country's mission to unite and lead Asia. . . . Japan can not stand alone. She would be bankrupt in competition with a United Europe, and she could not expect support from Europe. It is natural that she should seek it in Asia, in association with a free China, Siam, and perhaps in the ultimate course of things a free India. An associated Asia, even though it did not include the Semitic West, would be a powerful combination."

The ex-premier of the Republic of China, the Right Hon. Shao-Yi Tong, in his thoughtful introduction to the book, "Is Japan a Menace to Asia," gave expression to about the same views as Tagore. "China is struggling to be free and she should accept cooperation from any quarter that is truly friendly," said Mr. Tong. "Japan is China's disciple of the past, and all far-sighted Japanese believe that 'Japan without China and India is, in the long run, without legs.' I would say that China without Japan and India is without legs. . . . Some Western author has recently said: 'Japan is an international nuisance and she may easily grow to be an international peril.' We, however, do not look at a rising Japan in the same spirit. We wish only that China and India be equally strong, that Japan hold her own on the Asiatic continent against European aggressors. Then the international nuisance, charged to Japan, but really traced to other outside forces, will cease to exist, in Asia."

It is interesting to note that, although in certain Western countries Japan is sometimes made to appear as a menace to China, by no means all Chinese share that view. Chinese, as well as other Asians, realize that Japan has a paramount interest in China. And if Japan's "stake in China is as great as that of England in Belgium, we must regard her interests there as important in a diplomatic sense as those of England in Belgium. What justifies the island empire in one continent should be held to justify the island empire in the other." Moreover, responsible Japanese officials have always disclaimed any ulterior design upon China on the part of the Mikado's government. Of the many articles which have appeared on the subject in the recent Japanese periodicals, the one by the Hon. Heikichi Ogawa, a member of the Japanese Parliament, may be considered as representative. Writing in the *Japan Magazine* of Tokio, October, 1917, Mr. Ogawa said in part:

> Japan's policy in China involves the territorial integrity of that country. China is to be the most powerful friend of Japan in this policy. No Western Power must be allowed to do in China what Germany is doing in Turkey or what England is doing in Egypt. Those who hold that Japan entertains motives ulterior to these as regards China need not be answered, as they have no proof of their suspicions. When Japan has secured western guarantees as to the above policy peace will be assured and friendship between China and Japan will be permanent. When Japan brings China to a position when both can work together for their mutual independence and protection the ideal will have been attained and accomplished. . . .
>
> Japan has to see that no part of East Asia becomes a rallying ground for western treasure-seekers; the western nations must be prevented from dragging the Far East into the squabbles. To carry western troubles and disputes into East Asia is to endanger the peace of the Orient and sow the seeds of future misfortunes. . . . China is apt to misunderstand Japan's keenness of interest in the matter; she is disposed to read into Japan's policy something of selfish designs. This will be less so as China becomes more independent of western powers. When the Far East is free from the danger of outside interference it will be more free to develop its own civilization and cultivate better forms of government. Japan and China are destined to contribute jointly to the progress of civilization in the Orient; and the result will be favorable to commerce and industry in all countries as well as those of East Asia.

If there be still any one who harbors the suspicion that, under the disguise of championing Pan-Asianism, Japan contemplates destroying, or will be permitted to destroy, China, he should read carefully the terms of Ishi-Lansing Agreement of November, 1917, and President Wilson's words of January 22, 1917. The Agreement, which specifically provides for the maintenance and the guarding of the independence and territorial integrity of China, was entered into between the Tokio and Washington governments after the President had declared to the whole world "that the nations should with one accord adopt the doctrine of President Monroe as the doctrine of the world: That no nation should seek to extend its policy over any other nation or people, but that every people should be left to determine its own policy, its own way of development, unhindered, unthreatened, unafraid, the little along with the great and powerful."

In conclusion, it may be stated that whatever happens one thing is certain—Asia is slowly finding herself politically. The leaven of democracy is working. The principles of liberty and democracy are permeating the Asian continent. The Orient is advancing toward a new light. There may be stumbling and staggering on the way; but surely there will be no permanent halting in her progress—it will be steadily forward. Asia asks only for security and justice for herself, and betterment for the world. She has nothing but a desire to live and work on a plane of love and equality with all people. Europe should govern her course by the knowledge that she can not be in Asia for all the future. Asia will insist on being the mistress of her own house. The problem of the relation between the East and the West can be satisfactorily solved on only one basis, and that is: "justice for all, love for all, and for all, liberty."

It is our hope that from the present welter of frightful destruction and bloodshed there will come substantial gain. It is not easy to prophesy; but it is permitted to us to hope that this dark calamity will usher in the dawn of a brighter and a happier day for the world. And when that happens, may we not expect to see arise out of the ruins of this World War a superb structure—a structure of common brotherhood of the races of the world, brotherhood of international justice, of equal liberty and freedom?

LANGUAGE REFORM AND THE PROGRESS OF ENGLISH PEOPLES

By Dr. JOS. V. COLLINS

STATE NORMAL SCHOOL, STEVENS POINT, WIS.

ENGLISH-SPEAKING peoples have accomplished great things in the world's history in the past. They now have the opportunity of rendering a service of the highest value to the whole world, and of benefiting themselves by the act. If the English language were simplified so that it might become the international language, English peoples would profit by the saving in time and labor, and their international relations would be stimulated and aided.

The idea of the English language becoming the world language is far from being a dream. To a certain extent it is the world language now, being more widely spoken than any other tongue, its nearest competitors, the German, French and Spanish languages, being far outclassed. In 1801 the English language was spoken by 21 millions, the German by 30, and the French by 31 millions; by 1901 there had taken place an amazing change in the figures, they then standing English 130, German 84 and French 52 millions. There can be no doubt that after the present war is over, the English-speaking peoples will take an even more prominent place in world history.

The English language has one immense advantage over every other in that it is made up essentially of about equal parts of the languages of the two greatest races of the world, the Teutonic and the Latin. It has, moreover, the finest literature and a magnificent vocabulary admitting of the fullest and most accurate expression. On the other hand, it has several points of weakness, one of which is very grave, namely, its spelling. The language has an excessively large number of irregular forms, it has a rather loose and overlapping set of prepositions, and is unnecessarily inflected as regards subject and predicate agreeing in number. Making these improvements would not be a difficult task at all. A committee formed to represent all classes of society most affected, including business men in both the domestic and foreign trade, newspaper men, authors, scientists, scholars, specialists in spelling reform, typists, stenographers, linotype men, and stenotype operators could frame a report, which could then be officially adopted and substituted for the present form of the language, very much as many countries adopted metric reform, which at first apparently presented insuperable difficulties in the way of its substitution for the old weights and measures.

The idea of a world language is, of course, not new. We have had Volapük (1879), Esperanto (1887), and since then seven or more artificially constructed tongues for world use. A simplified form of one of the languages now in wide use, with a minimum number of characters, and each character standing always for the same sound, with no unnecessary inflections and irregularities, so that it could be learned with a minimum of effort, would naturally have great advantages over an artificially constructed language.

Heretofore the study of language reform has been confined to scholars, even though many among their number are violently opposed to any change. However, when men like Mark Twain, William Dean Howells, Professor William James, Colonel T. W. Higginson, George W. Cable, R. W. Gilder and John Burroughs favor spelling reform, there must be something in it. Now, apparently the scholar reformers from no fault of their own have come about to their wits' end as to what to do next. In their despair these reformers turned to primary education for relief, expecting the children to do what their elders had failed to accomplish. Spelling reform seems to have come to a point where it can neither go forward nor back. Editors, no matter what their personal predilections, are compelled either to ignore the reform altogether or to use the new forms in the most sparing way. Every time a reader accustomed to see "through," for instance, spelled in the usual form comes across the word in some publication in the unfamiliar form thru, he gets an unpleasant shock. Highly educated readers can stand this; it is good for them; but for the masses it is likely to establish an aversion to the new spelling in general. What seems to be needed is that, besides the scholars, large classes of our population, which are vitally interested but do not know of it, should have the whole question brought to their attention in such a way that they will be disposed to make a study of the reform from their own standpoints.

There are three great aspects of this proposed language reform: (1) That of its relation to internationl matters and the progress of the race already referred to. (2) That of the saving in printed and written matter. If there is a chance for a ten per cent. economy here, then in a country whose printed matter each year costs more than a billion dollars, over 100 million dollars can be saved. (3) That of the saving in elementary education. The saving here might be even as high as twenty-five per cent. of the children's time. These matters will be discussed a little more fully after the character and amount of the saving has been set forth.

It seems clear that the alphabet adopted should conform to the following requirements: (1) Every sound in the language should be capable of expression by it. (2) Every letter or combination of letters should have but one sound equivalent. (3) The number of characters should not exceed the number now in use, so that they could be put on any typewriter or linotype machine. (4) The accent should be given in printed words. This could be done by some device, as by leaving a slight space before the vowel of the accented syllable when it is not on the first syllable. (5) Words having the same sound with a different meaning and often different spellings should be changed so as not to duplicate each other in sound. This should be done in the interest of clarity of oral speech, and might be accomplished by introducing an additional letter. (6) Double letters should be replaced by single ones, as runer for runner, except when both letters of a double consonant or vowel are plainly heard in ordinary speech.

The changes just suggested raise the whole question of a natural attitude of mind of the great majority toward reform of any kind; men may be divided generally as well as politically into conservatives and radicals. The majority at first is overwhelmingly on the conservative side, but as the evils become more and more apparent under discussion, larger and larger numbers swing to the radical side. Most men understand a few things well, but the vast majority are conservatives the moment they come upon a matter they have not carefully investigated. Their minds are wrapped in intellectual swaddling clothes, so to speak, and of this fact they are totally ignorant. No one is so foolish as he who accepts palpable untruths on fallacious grounds, and no one is so wise as he who knows what he does not know. Most men would think they understood the subject of language reform when they really do not. The people of America think their system of weights and measures as good as any, whereas people of metric countries know they are wrong. Illustrations of this sort might be given *ad libitum*. In considering language reform, especially, the foregoing must be kept in mind. Even children may be wiser than their elders, as was hinted at by Christ in one place. Children say, The sheeps is in the field, and The horse runed away. By agreement these forms could be used just as well as those now in current use. If anything were gained by retaining the irregular forms, the case would be different.

When we come to pronunciation, we know that there is a wide variation in the pronouncing of both consonants and vowels, especially vowels. Doubtless the number of distinct vowel sounds now in use might be somewhat reduced by using the same character to represent those so close together as to be difficult to distinguish from each other. The vowel a in dance is pronounced all the way from short a in hat to broad a in all. This shows a natural tendency to shade pronunciations, and ought to indicate the possibility of compressing the number of vowel sounds at least a little.

There are 26 letters in the alphabet, of which 6 are vowels and 21 are consonants, y being both a vowel and a consonant, as y in yet and y in my. This last fact suggests the possibility of using some of the other consonants in the same way. The desirability of this is apparent when it is remembered that six vowels represent at one time or another sixteen different sounds. If we are to have every sound represented by a single character so as to remove all ambiguity, there will evidently have to be some doubling up in the use of the letters.

Merely to show what is possible, and with no intent to specially advocate the proposals which follow, suppose that y and six other letters function both as consonants and vowels, part modified somewhat in form and the others unchanged. By this course there is secured a one-sound-one-letter alphabet which satisfies the conditions already stated. Thus, by cutting a small piece out of the vertical line in q, it can answer well for both qu in quit and a in far without ambiguity. In case of uncertainty the consonant could be marked. By this simple plan the 62 letters come to represent 33 different sounds.

A somewhat haphazard search showed these 33 sounds now spelled in over 200 different ways, not considering the spelling of proper names. It showed nine of these sounds each spelled in over a dozen ways! Examination discloses that out of the 200 spellings of 33 sounds, perhaps 170 are of more or less common occurrence and must be learned by every one who pretends to read even newspapers. Thus, the difficulty of learning these spellings is more than five times as great as it would be with the one-symbol alphabet, and that on the assumption that it is as easy to learn an absurd spelling as a rational one. Psychological experiments show that it is ten times as hard to learn disconnected syllables as to learn those found in connected speech. Thus the difficulty of learning these spellings might easily be fifty times as great as to learn the one-sound-one-spelling language. It is almost past belief that English-speaking peoples should not cry out against the infamy of asking generation after generation to learn all this rubbish when it is not in the least necessary.

Examining the Twenty-third Psalm we find that in the ordinary spelling there are 455 letters and in the new form 49 less, or a saving of 10.8 per cent. Similarly the First Psalm shows a saving of 10 per cent. and the Beatitudes 11.1 per cent., the first three stanzas of Longfellow's Psalm of Life 9 per cent.—these all being composed mainly of Anglo-Saxon words. A column of newspaper matter contained 3,556 letters, of which 286 would be saved in the new form, or a little over 8 per cent. It happened here that a large number of proper names appeared, nearly all spelled as they were pronounced, which brought the per cent. down somewhat. Where there is a preponderance of words of Latin origin, the per cent. is lowered, since Latin words are spelled about as pronounced except for double letters and certain endings.

In 1909 the printed matter in this country cost 737 million dollars. Ten per cent. of this sum is close to 75 million. At the present time undoubtedly the value of printed matter must run well over one billion dollars annually, and thus offers a saving of over one hundred million from this source alone. An estimate of the saving from business letters based on the number of pieces of first-class mail, places the saving on them at perhaps ten million annually; we ignore the loss in social letters, as it is hard to estimate this in dollars and cents.

Let us now consider the educational aspect of the subject. When a child starts to school he is already in possession of a very considerable vocabulary. As soon as he can master the sounds of the 26 letters as found in familiar words, he would immediately make available all his knowledge gained through oral language. Instead at this point he must begin to learn by forced memory the large number of common words which he must know in order to read ordinary stories. All his other studies begin by being rational and continue to be rational throughout his course, namely, nature study, science, mathematics, history, etc. Why should language demand the irrational? It comes as a shock to the child's mind when he first meets the irregular spellings. Thus, if he has learned that o has a certain sound in the words he has met, he is surprised to find that the word though is spelled with the ugh tacked on to O.

Probably half the time of the eight years of the elementary course is given to reading, writing and spelling. If this four years could be cut to two by an improved language expression, it would undoubtedly result in two years more of general education for all the children, that is they would all be two years further along in the course than they now are when they leave school. The value of the increased earning power acquired by the more extended education could not possibly be less than two or three hundred million dollars annually.

No great reform was ever instituted that did not meet with difficulties in its way. A word or two concerning the two or three greatest objections to language reform. One of these is that libraries, the product of ages of effort, would be made useless. The answer to this is easy. All persons over ten years of age would know both the old and the new spelling and could read either form, the one as easily as the other. Those under ten, if they wanted to be scholars and a very small percentage of the whole population could read books out of print, would have to learn the old alphabet and spelling. Of course, all important literature, histories, science, and important works of learning would immediately be printed in the new form of the language, so that the masses would not need to use the old language. A second objection to reformed spelling is that the derivation and therefore the meaning of many words would be lost. The reply to this is that perhaps only one or two per cent. of all persons have sufficient education to make this knowledge of any value to them. Dictionaries would naturally give the old spellings instead of the pronunciations as now as parts of the etymologies. The small per cent. could well afford to be willing to look up in the dictionary the derivation of all words they could not recognize. Vast masses of children now look up such words as receive and believe and forthwith forget what they took pains to find out, because it is so easy to be confused in this way, especially for minds that do not hold spellings well.

The third objection, that the plan is impracticable, is the easiest of all to answer. The new form of the language is so much like the old, having precisely the same sounds, so many letters used with exactly the same value, and is so simple, that trained linguists could actually learn its elements in a few minutes and read the language with facility in a few hours. The ordinary constant reader would be able to master the alphabet in a couple of hours, and with a few days of practice would be reading the new form with considerable ease. Other readers would shade off into all gradations of progress as now with the old form. Learning the new language would be like learning a foreign language and would occupy a distinct pocket in the brain, so to speak. It would thus be possible with a brief period of preparation to actually pass over to the use of the new form exclusively. However, a period in which both forms of the language would be in use, the new in a limited way would be advisable.

In this intervening period the international language would be employed for all international correspondence. Special dictionaries and instruction books would have to be prepared for all the important languages. In all our school dictionaries in use, the new alphabet would be used as a key to pronunciation, and the new spelling would be given as the pronunciation form of spelling of all words different from the old form. Then the children would be taught the new form of the language as a regular part of their education. Persons of maturer age would naturally want to know all about this new language, and would gradually become more and more familiar with it. In truth it would be no more difficult to read than many dialect books now found in our literature. When the immense advantage of the new form of the language over the old should come to be generally understood and the time became ripe, the transition could be made to the new form, preferably by government enactment.

Certainly more discussion is needed of this question which has been shown to involve the loss of something like millions of dollars annually. We have had now for some time a great cry for more efficiency, and our merchants and manufacturers scour the earth to find means of saving. They are trying to introduce more system everywhere. Yet here is a loss of energy and a lack of system, and one that involves not merely the affairs of every merchant and manufacturer, but of practically everybody, and still no effort is being put forth to even investigate this subject. If all the classes vitally interested could but take hold of this reform which our scholars alone have brought to so lame and impotent a conclusion, a new era would dawn.

THE HEALTH OF COLLEGE ATHLETES

By Professor C. E. HAMMETT

MEADVILLE, PA.

HOW do athletics affect the health of college men? Like Banquo's ghost this question will not down, notwithstanding the publication from time to time of convincing testimony from authoritative sources. Although the appearance and action of the college athlete in training proclaim vigorous health, there are people who believe that the strenuous exercise in which he engages saps his vitality and shortens his life. Let us see if this is so.

In 1904 Dr. Geo. L. Meylan, of Columbia University, published in the *Harvard Graduates' Magazine* the results of an exhaustive investigation of the effects of rowing upon Harvard crews from 1852 to 1892 inclusive.

> Rowing was selected because it is the most strenuous of all sports and for that reason is said to overtax the heart and kidneys more than any other.

The investigation was conducted in the most thorough manner, Dr. Meylan personally examining a large number of the men, and where that was impossible, securing a report from the oarsman's family physician. The testimony was taken ten years or more after the men had quit rowing "in order that the after effects, good or bad, should have had a chance to show themselves."

There were 152 men on Harvard crews from 1852 to 1892, of whom 123 were living in 1902. Six of those deceased were killed in the civil war, two died through accidents. Dr. Meylan secured data from 106 of the survivors. He found:

First, that these men exceeded the expectation of life as tabulated by the American table of mortality "1.06 years for each man, including those who were killed," and 5.39 years per man "if the life expectation of the latter were added."

Second, that only two of the 152 oarsmen had died of heart disease and one of consumption.

Third, that "eighty of these men became successful professional and business men" and "twenty others men of national and international reputation," that, whereas the percentage of college graduates who earn a place in "Who's Who" is 2.1 per cent., and that of Phi Beta Kappa men 5.9 per cent., of the living oarsmen 8.3 per cent. were placed in this book. (The charge that athletics unfit a man for intellectual activity does not appear to have much force in the face of such evidence.)

Fourth, that but two of the men considered themselves in poor health at the time of the investigation, one of these 57 and the other 66 years of age.

Fifth, that but two of the men believed rowing to have had an injurious effect on their health in after life.

Sixth, that out of 35 men who were examined for life insurance, only one was rejected; that "94 per cent. of the oarsmen were, as far as they knew, free from any affection of heart, stomach or kidneys" eleven years or more after they quit rowing; that "over 97 per cent. appeared to be in good health when seen by him"; that "over 37 per cent. have not consulted a physician for more than ten years; over 50 per cent. have not been sick in bed for one week since leaving college and 37 per cent. have been sick only once during that time."

His conclusions, amply justified by the evidence, were, that "college athletes do not die young of heart disease or consumption, as is so often asserted; that the hard training and racing does not dull the mind and exhaust the mental and physical energy of the oarsmen; that the health and vigor of the oarsmen is so far above the average that if rowing has any effect on the health, the effect can not be otherwise than beneficial."

I now invite attention to data obtained by Dr. Wm. G. Anderson, of Yale University, in a study of 807 Yale athletes who won the coveted "Y" in crew, football, track and baseball between the years of 1855 and 1895. Of these 807 men, who underwent the severest kind of training, only four died of heart disease. Four men out of 807 in half a century. And two of these were 68 and 70 years old!

Dr. Anderson states that during these years there were 10,922 students in the Academic and Sheffield classes at Yale, with 1,406 deaths, or 12.9 per cent. The percentage of deaths among the athletes was 7.2 per cent. Granted that the athlete is an exceptional man physically, the discrepancy is too great to be thus explained away.

Statistics like the above carry weight. They can not be ignored. They are worth reams of argument based on limited data. They justify Dr. Anderson's conclusion that "compared with the Select Mortality Tables of the Actuarial Society, which are made up from the mortality averages of thousands of lives all over the country, the Yale athletes show remarkable longevity" and "judging from the investigations it is reasonable to say that there is no undue strain put on the athletes while they are in training and their later history seems to show that they were benefited rather than harmed. Proof is conclusive that high Yale athletes do not die young and that heart disease is not a chief cause of death."

Some years ago the writer investigated the effect of Distance Running upon college men, consulting athletes from all parts of the country, men who had quit running years before, and who had had time to note in their own persons the after effect of their training and racing.

There were only three cases of permanent injury among 167 men—functional heart trouble which manifested itself during unusual exertion. Ninety per cent. of the men claimed to have derived permanent benefit, in many instances of inestimable value, from their training. In general they declared this benefit to be in the nature of increased vital and constitutional strength. Many were emphatic in their statements, for example:

> My father, who is sixty-two years of age, and an old distance runner, can now run a quarter mile consistently under sixty seconds. He has not been ill since he was a young man, and is as hale and hearty as a man of thirty.

A famous distance runner writes:

> I have been running for over twenty years now, and feel in perfect physical condition. Have won races from seventy-five yards up, and have run over one hundred miles quite often. My heart has been examined by specialists in London, Paris, Boston and other places, and all say it is in perfect working shape.

Another man writes:

> Cornell University is distinguished above all other institutions for the development of runners at the distances you mention. I am in touch with all the 'varsity distance men graduated in the last ten years, and there is not a case of physical debility in the whole lot. Most of them are much more alive than the average man.

Of especial bearing on the inquiry we are pursuing is the fact that 112 of the athletes broke training abruptly, to enter mercantile or other pursuits which afforded no opportunity for indulgence in athletics, yet all but one were in perfect health years after. These men experienced none of the tissue degeneration or functional disorders which are supposed to follow the exceptional development of heart and lungs resulting from athletics. One is forced to conclude that degenerative changes of tissue do not follow. When they occur in an athlete I venture to assert that investigation will show them to have been induced by bad habits, dissipation or close confinement. I have a case in mind now, an athlete of national reputation who drank himself to death at an early age.

I have just finished analyzing data obtained from daily records for ten weeks of men on the Allegheny College basketball team, champions of Western Pennsylvania in 1915–16. There was nothing revealed by the statistics, nor anything in the appearance or actions of the men, to indicate that the strain was greater than they were able to bear without injury. Evidently it was not, as three of the quintet recently passed rigid physical examinations for commissions in the army, and the remaining two are still in college on the team, all five in perfect health to-day.

Baseball so obviously improves the health of the men who play that investigation is superfluous and football is technically perfect as a physical exercise—it is played in the open, under the stimulating influence of sunshine and fresh air; periods of strenuous activity alternate with long periods of comparative repose; it develops strength, speed and agility; it builds up the red corpuscles and enriches the blood; it tones the muscles and fortifies against disease, for "a healthy muscle cell is immune to the attacks of disease-bearing germs." For the past twenty years my football teams have averaged a net gain of five pounds a man during the season and occasionally individuals gain eight to ten pounds. Weight is an index of condition. Trainers do not worry when an athlete holds his weight. But when he begins to lose weight and does not "come back," they handle him carefully, for they know that he is "feeding on himself" and liable to go stale or to "crack" in a hard race.

For years I have been impressed by the appearance of football men as they drop in occasionally to see me after the close of the season. They fairly bloom with health and vigor—the clear eye, ruddy complexion and elastic tread proclaim it from the housetops.

That strenuous exercise has a beneficial rather than an injurious effect upon the organism is further indicated by statistics concerning the jinrickisha man of Japan. He performs infinitely harder work than the college athlete, "is subjected to all kinds of temperature, drenched in perspiration one hour, shivering with cold the next, hauling his ricksha in all kinds of weather," inadequately fed, smokes and dissipates, yet Mr. E. G. Babbitt, American vice-consul at Yokohama, wrote me that in 1907 there were in Tokio alone more than twelve hundred men over fifty-five years of age (in active service) and that most of them were healthy and strong.

The data which have been given shows that an overwhelming majority of college athletes derive substantial benefit from their participation in college sports and that the percentage of serious injuries is small. There is ample corroborative evidence. For nearly twenty-five years the writer has been in intimate personal association with school, college and university athletes. Some thousands of men and boys have been under his control, in all branches of sport. In all these years, among all those boys and men, I recall but two who to my personal knowledge were permanently injured, and there is every reason to believe that in them athletics aggravated, but did not originate, the diseases from which they suffered. My experience is not unique in this respect: it is that of almost all men who direct college athletics—I have questioned many. Injury that handicaps the career of the athlete, that saps vitality or produces organic lesion is extremely rare. I have never met an athlete who would admit that he had been injured by athletics. I have never met a middle aged or elderly man who said so. On the contrary, I have met many who attributed their health through exacting business or professional duties to the stamina stored up on the athletic field. I hear occasionally of men who have injured themselves by over-indulgence in athletics and though hearsay evidence is unreliable I am confident there are such, for there are always men who overdo in activities which interest them, be it in athletics, in business, or in other pursuits. But there must be comparatively few, or one who has been in touch with athletes and ex-athletes for as many years as I have, would have met more of them.

There is no doubt in my mind as to the effects of athletics upon college men—I have seen too many strengthened in heart, lung and muscle; too many developed into splendid specimens of physical manhood, to doubt. They induce good habits of living: regular hours, cleanliness, systematic care of the body —habits which promote health and which become second nature. They tone and strengthen the entire physical organism—the lungs expand more deeply, inhaling a greater volume of pure air and expelling residual air that lurks in remote cells like stale atmosphere in a poorly ventilated room; the heart speeds up, sending the blood swirling through vein and artery to bring fresh nutriment to bone, muscle and sinew, to sweep up fragments of wornout tissue and bear them to the excretory organs; the skin exudes effete matter; the digestive and assimilative systems open wide the throttle and signal full speed ahead; liver, kidneys, and stomach take up the refrain, until the remotest cell in the organism feels the surge and drive of a mighty, vivifying impulse. The athlete knows real health, tastes the heady flavor of perfect physical condition. His nerves tingle with energy, his muscles with vigor. Day by day he builds his body anew. It becomes a beautifully coordinated neuromuscular machine, endowed with vigor and energy far beyond the ordinary and built to endure.

THE HABITS OF THE FISHES OF INLAND LAKES[1]

By Professor A. S. PEARSE
UNIVERSITY OF WISCONSIN

AGRICULTURE has progressed to the point where a farmer can readily secure reliable scientific advice as to what crops are adapted to his grange. Such counsel is usually based on studies concerning climate, soil analysis, bacterial counts, depth of water table, prevailing pests, and other factors. Scientific aquiculture is far behind agriculture, and those who attempt to harvest crops from the water must proceed without much help from science. During the past few years there has been a quickening of interest in aquiculture in the United States, and attempts are now being made by commercial and scientific men to increase the yield from fresh water. The Bureau of Fisheries is constantly increasing the production of our inland waters by improving methods of propagation and by exploiting new sources of food. Professor E. A. Birge is making notable scientific contributions concerning the conditions in lakes and their value as habitats for fishes. Professor S. A. Forbes has made similar studies relating to rivers, and also published eminent works on our fresh-water fishes. Recently Cornell University has established a course in aquiculture for the purpose of training young men to take up aquatic farming. Several commercial fish hatcheries, which have relations to aquiculture comparable to the seed houses in their relations to agriculture, are now successfully rearing trout and other fishes to be sold for stocking purposes. At Oshkosh, Wisconsin, Mr. C. B. Terrell operates an enormous aquatic farm in the swamps around Lake Buttes des Morts and does a thriving business in aquatic plants and seeds. He also gives advice to fish culturists, game clubs, and others interested in aquiculture as to how to set out and harvest crops of aquatic plants, fishes and fowls.

The writer has been attempting to solve three fundamental problems relating to aquiculture—(1) why certain species of fishes are abundant in some localities and not in others, (2) why a certain kind of fish may reach maximum size in one body

[1] Published by permission of the United States Bureau of Fisheries.

of water, but remain small in another, and (3) how many fishes a body of water may support. The present paper summarizes studies made during the past five years in the inland lakes of Wisconsin.

In order to determine which species of fishes were most abundant in these lakes and which habitats were most densely populated, two years were spent in general collecting, and all the methods commonly employed by fishermen were used (spear, dip net, gill net, seine, hook). About 1,700 fishes of 33 species were collected, and the following information, which of course relates primarily to lake fishes, was secured:

1. *The important factors in the selection of habitats are associated with food, shelter and breeding.* Food is more important than shelter, for there are more species and individuals in situations with much food and little shelter than in those with abundant shelter and little food. More fishes are found in the shore vegetation, which furnishes both food and shelter, than in any other habitat. Breeding activities dominate all others at certain seasons, there is then usually more or less fasting and disregard for usual protective measures, but this condition lasts only for a short time and the major activities of a fish are usually devoted largely to seeking and securing food.

2. *Each species of fish selects particular foods from those available.* Though different kinds of fishes often feed on abundant available foods, each has its preferences—fishes are not indiscriminate feeders. For example, on July 3, 1915, fishes of about the same size and belonging to four different species[2] were taken in a single short haul of the net. Ten fishes of each species were examined and striking differences were found. The black bass had taken 21 different kinds of food; the bluegills, 16; the shiners, 14; and the top-minnows, 11. The particular item of food taken in largest amount by each species was as follows: black bass, 25 per cent. damsel-fly nymphs; bluegill, 47 per cent. cladocerans (*Eurycercus*); top-minnow, 49 per cent. amphipods; shiner, 43 per cent. Daphnia. All the species had eaten *Eurycercus*, which must have been abundant, but only a single one had eaten damsel-fly nymphs or daphnias. Many other facts show that competition between different species for particular foods is usually not very keen.

3. *The most important foods of the lake fishes are: insect*

[2] The scientific names of those were *Micropterus salmoides* (Lacépède), *Lepomis incisor* Cuvier and Valenciennes, *Notropis heterodon* (Cope), *Fundulus diaphanus menona* Jordan and Copeland.

larvæ and pupæ, microscopic crustaceans, fishes, amphipods, plants, bottom ooze, molluscs, and crayfishes. Young fishes feed largely on insect larvæ and microscopic crustaceans. Though some fishes eat the same kinds of food throughout life, adult fishes have rather specific feeding habits (the bass prefer insects; the sheepshead, molluscs; the pike and gar, fishes; the darters, midge larvæ; the silversides and cisco, micro-crustacea; the bullhead is omnivorous).

4. *The most abundant fish of economic importance in the large, deep lakes studied was found to be the yellow perch; in the smaller lakes the perch were also abundant, but the black crappie and two sunfishes were also present in considerable numbers.*

After these preliminary studies the perch and crappie were selected for careful investigation, the first being the most abundant and representative fish in the large, deep lakes, and the latter appearing to thrive best in small, shallow lakes. The food, migrations and breeding were studied. During this work at least ten individuals were usually examined every week for a year. The perch were studied carefully in two lakes: Mendota (7 miles long, 84 feet deep) and Wingra (1 mile long, 12 feet deep), but weekly examinations of the crappie were made only in the latter.

The perch is probably more abundant than other species of food fishes because it is more versatile. It feeds among the shallow-water vegetation on insect larvæ, fishes, snails, and other shore foods; it digs out the abundant larvæ and clams from the soft sedimentary deposits in deep water, and even feeds on the ooze itself; with its slender gill rakers, it strains plankton organisms from the open waters. It can compete with the basses, sunfishes, gars, pikes and bullheads which run along the shore; it does as well in the open lake as the specialized ciscoes, and is able to share the deeper waters with suckers and lawyers.

It is easy to see why perch are abundant, but when we try to understand why they have a characteristic maximum size in different lakes, the problem is somewhat more difficult. The investigation of differences in feeding or available food supply offered one probable field which might throw some light on the question. However, the food of the perch in the two lakes investigated was found to be much the same. Fishes, insect larvæ, and some other items were eaten in somewhat larger quantity in Lake Wingra, but that would be expected because there was proportionately more of shore habitat. The important foods were abundantly present in both lakes and enough difference in the quality of the foods eaten was not found to account for the constant difference in the size of the fishes.

One fact was noted, however, which gave a clue for further work. The perch in both lakes were often found to be empty during the breeding season, and this was easily accounted for by supposing that the excitement incident to the mating activities led to neglect of feeding. At all other seasons the perch in Lake Mendota were stuffed with food. Those in Lake Wingra, however, were often *empty during the warmer parts of the summer*. This difference between the two lakes led to the conclusion that the smaller size of the perch in Lake Wingra was due to the fact that there was less opportunity to feed in the small, shallow lake. This view was supported by other evidence. For example, during windy weather, more perch could be caught in Lake Wingra with hook and line from a drifting rowboat than in a gill net, while the opposite was true on quiet days. The perch were present and ready to feed, but did not move about much when the water was disturbed.

To test the opportunities for feeding in the two lakes it was necessary to study the migratory activities of the fishes. The comparative distribution of fishes at different times was judged by the catch per hour in gill nets of standard size. The nets were set simultaneously at various depths and comparisons could thus be made. The perch remained in the deeper parts of the lakes, except for two or three weeks during the breeding season. There was a slight migration into shallower water at night.

In late summer a fish can not remain permanently in the deeper waters of Lake Mendota because the thermal stratification of the lake causes the lower water to stagnate. During August, September and October the water below thirty or forty feet contains no oxygen. It was noticed, however, that, though perch were most abundant just above the level where oxygen disappeared, often when nets were set below a number would be caught. There are enormous quantities of food in the stagnated region[3] and, if perch are able to go down there for food, they can draw on supplies which other species of fishes can not attain. The only other fishes caught in deep water were occasional suckers.

[3] Recent unpublished investigations by Birge and Juday show that there may be as many as 13,000 midge larvæ per square meter in the mud at the bottom of Lake Mendota.

At first the catches of perch in deep water during the period of stagnation were thought to be "accidental," but they recurred with such regularity that tests were finally made to see if the fishes were able to live without oxygen. Perch were enclosed in wire cages and let down on lines into the stagnant water. Most of them lived for an hour without apparent difficulty and many survived for two hours. In considering how they were able to live in water without oxygen for such a long time the possibility of the use of gas reserves in the swim bladder was suggested. The content of the swim bladder in normal perch was found to be about 63 per cent. nitrogen, 36.8 per cent. oxygen, and 0.2 per cent. carbon dioxide. After a perch had remained in the stagnant water for an hour the oxygen decreased to about 20 per cent., showing that the swim bladder serves as a reservoir for oxygen which may be used when the fish is in stagnant water.

All these things have some relation to the differences in size between the perch in the two lakes under consideration. The supposition that the perch in Mendota are larger because they have better opportunities for feeding appears to be justified. To state the case briefly, the perch in Lake Wingra do not feed during very hot weather, probably because the shallow water all becomes warm, nor are they able to feed readily when the wind blows because the water is all disturbed; but the perch in Lake Mendota can feed at all seasons because they may always retreat into the cooler depths to escape heat and the disturbances due to wind, and, as they are able to live for some time in water without oxygen, they may utilize the abundant food in the deeper water without danger of suffocation.

After some idea had been gained as to why the perch are larger and more abundant in Lake Mendota than in Lake Wingra, an explanation was sought as to why crappies were more abundant in the latter. It is well known that crappies are suited to shallow muddy waters, but, so far as I know, no one has ventured to state why. In the present investigations it is apparent that more crappies are to be expected in Lake Wingra because there is proportionately more shallow water. In this lake perch and crappies live together; the former does not do very well, but the latter is highly successful. When the food, migrations, and breeding habits are compared the reasons for the differences become apparent.

The food of the crappie is more limited in range than that of the perch—less variety is necessary; the feeding takes place largely at night or in early morning or evening; whereas the perch feeds by day. The crappie easily finds all the food needed in shallow water among aquatic plants and it does not need to fast during hot summer days. It also breeds during July and August when the water is very warm, and apparently suffers no inconvenience in a shallow lake which becomes warm very rapidly in the spring. To summarize, the perch is a rather generalized fish of great versatility and is at its best in a large lake where there is a variety of habitats and where there is always cool water for breeding and for retreat during windy or warm weather; the crappie is a specialized fish suited to live among vegetation in shallow water, is adapted to feeding when there is little wind or heat and to breeding under conditions which would be unfavorable to most fishes.

In connection with the studies on migrations some evidence was secured which indicated that there must be a very large number of fishes in Lake Mendota and later some attempts were made to obtain approximate figures. Such estimates are highly speculative, but give some idea of the fish population a lake may support.

Most of the fishes in a lake do not stay in one locality, but keep moving about continually. There are many observations which support this view. During certain experiments gill nets were anchored in particular spots and the catch was removed from them at four-hour intervals for twenty-four hours. If the fishes were all taken ashore, just as many were caught during the next four hours as when all were thrown back. During the summer of 1917 about a thousand perch were tagged during one month. Though fishing was always done at one of three stations, only one of the tagged perch was caught a second time. Such observations give some idea of the vast numbers of perch present.

Some data have also been collected which bear on the number of perch that the available food of Lake Mendota can support. By feeding perch weighed amounts of various natural foods and noting the time required for digestion it has been determined that an average individual at 25° C. eats an amount equal to about 7 per cent. of its own weight daily. In winter (2.5° C.) digestion is only one third as rapid as in summer. Recently Dr. R. A. Muttkowski made an extensive survey of the invertebrates in Lake Mendota and has computed the numbers present in the whole lake. For example, he estimates that there are enough chironomid larvæ in the lake to feed 16,675,447 perch to capacity each year. This single instance gives some idea of the capabilities of a lake seven miles long and four miles wide as a source of food.

In order to discover how many fishes were taken from Lake Mendota, statistics were collected from fishermen. The number of men fishing each day was counted at different seasons and their catch per hour ascertained. By compilations from such data it is estimated that 424,540 perch are caught each year. Computing from the comparative catches per hour in gill nets (a method open to certain obvious errors) the numbers of other species caught would be: pickerel, 2,208; bluegill sunfish, 1,238; white bass, 615; rock bass, 613; pumpkinseed, 428; large-mouth black bass, 305; silver bass or crappie, 183. Probably none of these numbers is too large and some are undoubtedly too small. They at least give some notion of the capacity of an inland lake for producing fishes. It is hoped studies now in progress will give more definite information.

Perhaps only one conclusion is justified from the observations discussed in this paper—aquiculture is certainly a promising field for research and commercial development. Scientific men may profitably attack the many problems to be solved with reasonable assurance of results of importance to science and to the welfare of the human race. Those interested only in the economic aspects of aquiculture may also look for increasing rewards as aquatic farming develops.

THE WORK OF MUSEUMS IN WAR TIME

By HARLAN I. SMITH
GEOLOGICAL SURVEY, OTTAWA, CANADA

Introduction

THE work of museums in war time, instead of being stopped or curtailed to effect economy, should be speeded up and directed from the usual paths into those that will help most to win battles, to provide and save food, and to teach us to fight with other than physical weapons. Only a comparatively few suggestive examples of the many war-time museum activities can be here given.

Part of the work of many museums, especially overseas, was suspended sooner or later after the outbreak of the war. Economy was enforced in museum explorations and publications. It is true that there was little interference with the care and preservation of specimens and such routine and scientific work as could be carried on by the remaining permanent staff with reduced funds, but many museums were closed to the public. As the war progressed, however, the extreme shortsightedness of this policy of supposed economy was realized. Experience in military and economic matters, especially in the providing of munitions, the preservation and salvage of the lives of the soldiers, and the securing of sufficient food for the soldiers and civilians of the world, has shown how vital the work of museums can be in war time.

The organization of the educational interests was found to be one of the most important factors in the defense of a country. In war time, museums, instead of being closed, should be open for longer hours. Museum work, instead of being reduced to effect economy, should not only be increased but directed into the most useful channels. If not already represented, a historic section might well be added in war time. Another section illustrating the broader features of progress in transportation and engineering should furnish inventive minds with a stimulus for productive work. The great value of a medical and surgical department is obvious. The most important phase of all in war time, perhaps, would be exhibits illustrating the necessity of conserving and extending our food supply.

Discoveries in pure science and exhibitions making generally known such discoveries are more far-reaching in their beneficial results than narrow economic explorations. To close museums and schools in these modern war times is like beating all the plowshares into swords—sacrificing essential wheat for an antiquated and little-used weapon.

The education of soldiers, Red Cross workers, relief workers, miners, factory workers, farmers and many others has had to be undertaken during the war on a hitherto unsurpassed scale. It was found that unusual minerals had to be examined and new deposits had to be sought in order to make munitions; new antiseptics and appliances had to be studied and exhibited to those who were to use them; sanitary contrivances had to be seen; methods of increasing or protecting the food supply had to be developed and made known to millions of people. All this work could not be carried on economically and effectively without exploration, laboratory experiments, exhibits, books, lectures, photographs, lantern slides, moving pictures, demonstrations, publicity, newspapers and travelling exhibits. Modern museum work includes practically all these activities and has to do with all these things.

Expeditions to show their results must adopt the museum method. The laboratory makes discoveries but does not permanently exhibit them to the public unless it does museum work. Schools teach by the descriptive method. Museums show the actual objects, which, usually are merely described or pictured through the medium of school and library. Museum moving pictures are censored for the good of the people rather than for the swelling of box-office receipts. Museum publicity is to acquaint the people with beneficial facts.

Science began to come into its own as the war progressed. England appropriated more for scientific research in one year than in all her previous history. At first many men were allowed to go to the front whose work was more valuable at home in war time. Now the French government will not even allow the inventor to experiment at the front because so many men who could not be replaced were lost by the former method.

The American Museum of Natural History in New York made special exhibits relating to the war. One of these showed various food plants used by aboriginal people, some of which might be developed for feeding our own people.

Most museum work is of a philanthropic nature. It nourishes, benefits and saves mankind, and even its war activities are of value in days of peace.

Every kind of museum can help in war work. For instance, art museums might assist in "camouflage." The scenic painters and artists of France and the United States have done much in this line. Natural History Museums have experts on the protective coloration of birds and insects. They know that a shore bird with dark back and white belly is less conspicuous than one which is uniform in color. They might plan a spotted uniform of unnoticeable colors so as to make a man crawling on an enemy trench at night as invisible as a grouse among autumn leaves.

Historical museums are important in war time as in no other period since they can stimulate the true patriotism that is so essential to success. In such a time collections of war material may be made that would be harder to secure at a later time.

A transportation and engineering museum should be a source of inspiration to potential Fultons, Faradays and Edisons. Medical and surgical museums could give great help in training doctors in war-time surgery. During war they have opportunities which might never recur for securing invaluable surgical material, such as is only to be had from the regrettable casualties of war, and though some of it may not be used until after the war, it should by all means be secured. Dr R. W. Shufeldt, of Washington, D. C., having made application for duty on the active list of the Medical Corps of the Army, has been assigned by General Gorgas to the Army Medical Museum. His work will consist in modernizing the present collection and preparing for the incoming medical and surgical material from the front.

The scientific or research museums, university museums, school museums, children's museums, kindergarten museums, public museums, recreation, tourist or vacation museums, farmers' museums, commercial museums, national museums, and many other kinds of museums all have opportunities to do war work.

Every department of a museum can do something to assist in war work. A few examples of what such departments as ornithology, zoology, entomology, herpetology, botany and geology can do may not be amiss here and examples of what can be done by the departments of art and archeology are mentioned elsewhere in this paper.

When the demand for more men for the battle-front comes at the same time as a demand for more food from agriculture and the other food-producing industries, it is essential to keep food from being wasted. Museum work can here be of great help. To save wheat from being destroyed by insects or rodents saves the planting of the necessary amount of land to make good that loss and releases just that many more men for the firing line. Killing birds that eat insects and weed seeds helps the enemy. Museum exhibits can be made to teach such things. The annual food loss in the United States from the ravages of insects on crops, according to the United States Department of Agriculture, exceeds a billion dollars. No doubt the loss in Canada is proportionate. Every careless person who kills a bird that is less injurious than it is valuable as an eater of weed seeds and insects is helping the enemy by killing our bird allies and is giving security and comfort to the weeds and insects that reduce our food supply. Most of our birds are of this beneficial class and are really our allies. Robbing their nests is also an aid to the enemy. One can hardly go into the country without seeing boys and even men killing birds. Doubtless many of these persons would be surprised to know that they were practically traitors and, if they realized it, would gladly stop aiding the enemy. For many years museum exhibits have been teaching such facts about birds and how to conserve the beneficial varieties. Surely these efforts should not be relaxed in war time but rather increased.

In conserving our food supply, so essential during the war, the depredations of rodents should not be overlooked. Plagues of these animals have troubled us from time to time since prehistoric days. In 1907 and 1908 meadow mice overran 80 per cent. of the culivated area of the lower Humboldt valley, California, necessitating the replanting of much of the alfalfa needed to produce meat food. Over $6,000,000 worth of grain, and that, too, at the former cheap pre-war prices, are destroyed annually by ground squirrels in North Dakota alone. Every year rodents destroy 15 per cent. of the crop in Wyoming. Something like $12,000,000 worth of food, at pre-war prices, is destroyed by rodents annually in Kansas and a greater amount in Montana. It is estimated that over $100,000,000 loss of food is due to rodents in the Pacific states alone. The losses in Alberta, Saskatchewan, and Manitoba are probably in somewhat similar proportion to those of North Dakota and Montana. At present prices the losses to the allies would be much greater. Rodents set at naught the labor of regiments of farm hands.

Domestic rats and mice also cause fires that burn both buildings and food. The present annual cost of these rats and mice alone to the United States is probably over $400,000,000, which must be added to the losses by wild rodents above mentioned. If we did not have this loss the farm hands, needed to replace it, could enlist. Our zoologists in museums of natural history share the responsibility for the control or destruction of injurious rodents. They understand how to do this without injuriously disturbing the balance of nature. Our food controllers need their services now as never before. To a certain extent information from museum men has already been used by the Canadian Food Controller.

The firing line in the greatest struggle for human existence is not "Somewhere in France" but in our fields and forests, in our domestic animals, and in our own bodies. This supreme struggle is not between autocracy and democracy, but between man and the lower forms of life. Insects keep men from large parts of the world as much as bullets keep them from No Man's Land. They keep these parts much freer of men than the submarines do the "verboten" zone. They levy this enormous tribute on all mankind, friend and foe alike. Some day the world may issue liberty bonds to clear the lines of communications in other parts of South America as the United States has opened those of Panama, and to give us liberty from the tribute we are forced to pay not only to the mosquito but also to the Hessian fly, the gypsy moth, the San Jose scale, the Mexican cotton-boll weevil, the English sparrow, the Colorado beetle, the German carp, and a host of other invading and native marauders.[1]

Zoological exhibits in natural history museums may be made to teach that every toad is worth over a dollar a month, or about twenty dollars a year as a worker in war gardens and fields to protect the growing plants from destructive insects. If a hundred toads are worth a hundred dollars a month to a country's food supply surely this is worth teaching to small boys and others who kill toads. The savings by toads would buy many liberty bonds and contribute much to the Red Cross. To teach this through the medium of the museum exhibit may easily save the lives of many thousands of toads and so increase our crops, thereby releasing men from farming for fighting—from forking for firing.

[1] Compare Eigenmann in SCIENCE, 1917, p. 303.

Wood and other forest products have almost innumerable uses in warfare. The War and Navy Departments, the Emergency Fleet Corporation, Committees of the Council of National Defense, and manufacturers of war orders have all demanded exact knowledge about forest products and never before has this demand been so urgent. Much of the need for knowledge has concerned aircraft material and problems relating to the construction of wooden ships and vehicles. Hardwood distillation plants have needed information in order to increase the production of acetone and other things needed for munition making. Museum botanists can make exhibits and otherwise give publicity to the fact that wheat rust must die out where there are no barberry bushes because it lives part of its life in a form not recognized by the average farmer, on a barberry bush. Had this been done it would have been easier to secure the consent of the farmers to cut their prized ornamental barberry bushes.

What the geologists of a museum can do in war time is well illustrated by the following single statement made by one geologist:

"My work is to be concerned with the location of trenches and dugouts. We must have trenches into which the country will not drain. These slashes in the earth can be made so that they will do their own draining. Mud, mud, mud! That is the trench curse which brings on trench feet and puts the soldier out of business."

And then on a sheet of paper he drew the slope of a hill and explained how if located in one place, because of the peculiar stratification of the earth, the trench would act as a cesspool or reservoir, gathering in all the waters of the neighboring terrain, while if placed elsewhere it would be immune from this disadvantage and through certain strata furnish a natural waste pipe for the superficial waters.

The uncertainty of action in the Mexican oil region and the increased need of oil for the navies of the allies has created a great demand for geologists to cooperate with business men in locating oil fields. Museum geologists are now lending a hand here.

The general knowledge of museum men may be applied to war work and in some instances be of greater service than scores of men. For instance, as related to hospital work, museum men have drawn attention to a method of treating shell shock, first published in literature read by museum men but not yet seen by the heads of army hospital work. Another example, relating to naval work, is the use of man power instead of modern conveying machinery for coaling war ships when the delay of a few seconds in reaching the place to fire a shot might decide a battle and when the machinery would be so useful in peace times that its installation would pay, war or no war. A third example, relating to the defense of a naval base, is where scores of men were used to guard its water supply. Here it was demonstrated by a museum worker that the reservoir could still be contaminated with poison or disease germs by one person without danger of capture by the guards and that the suggested remedy for this war-time danger was also necessary in peace times to protect the city from inadvertent pollution.

General Activities

The methods used by museums in times of peace may be used in war time. What is needed is that every museum worker should think of what museum work is most necessary in war time, and that he should lay aside less important work to give precedence to this war work.

In war time, as in peace time, a museum is not a haven or place to provide a living for those who can not get the opportunity to do research work or teaching at a living wage elsewhere. It is not a place where museum work may be neglected in order to do a pet piece of research or teaching, but one where research and teaching may be a legitimate part of museum work just as museum work may be a part of the work of research or teaching.

In war time, as in peace time, museum heads should stop merely hoarding curios or specimens given them or which they get on expeditions. They should plan first of all what they wish to accomplish and then use every means to accomplish it. The various means would include explorations, researches, scientific publications, guide books, newspapers, exhibitions, casts, models, labels, maps, photographs, charts, diagrams, lantern slides, moving pictures, temporary exhibits, travelling exhibits, and many others.

In peace times some museums send out exploring expeditions to explore the unknown in both distant and near-by regions. One museum expedition during the war undertook to collect designs, dye stuffs, native foods, fabrics and costumes of significance in view of war conditions. Many museums also carry on scientific research in their own laboratories. One laboratory affiliated with a museum was the only one in a whole country which had the apparatus for making a certain substance of vital importance in the making of a much-needed high explosive, and this laboratory has made tons of this substance for the allies. Specimens to be used for research are stored in scientific museums and here they are available for war research. From here vast numbers of publications are issued, so the machinery of distributing the results of the research is already at hand. One man experienced in this work became editor for the U. S. Red Cross. Some museums confine their attention to the locality where they are situated and from nearby river-bottom to nearby hill-top enough natural-history specimens may be collected to fill them. Others are for little children, and kindergartners are employed to instruct the children by means of the museum specimens. Some are chiefly for recreation, although their exhibits are all instructive.

In war time, recreation is especially needed to relieve the unnatural strain. The exhibits in some museums are priceless. In others they are inexpensive by-products of other work, but these latter may be as useful as expensive exhibits. In some the exhibits are made by experts. In others useful exhibits may be prepared under expert direction by local carpenters and laborers. However, such work as painting the backgrounds of exhibits, making glass models of parts of flowers or representations of objects in wax required for exhibits in some wealthy museums can not be done by untrained men. Some museum cases cost hundreds of dollars, but a useful exhibition case, suitable at least for schools or temporary exhibits, may be made for ten dollars wherever window sashes are available. The cost of cases is, therefore, no argument for not making temporary war-time exhibits. Police and fire protection which can not well be had for objects in private homes is to be had for specimens deposited in any large museum. Specimens of mammals and birds were formerly stuffed, but in modern museums they are now mounted according to a model, just as a house is built according to an architect's plans and specifications. In this way groups are made representing the specimens of animals and plants as if they were actually alive in their natural homes. These peace-time activities of museums were discussed at some length and were illustrated in my article on the "Development of Museums and their Relation to Education," in THE SCIENTIFIC MONTHLY for

August, 1917. The illustrations here given show still other phases of museum work that may serve in both times of peace or war.

Work Shops

Skilled mechanics are required in the shops of a museum where all kinds of museum work is to be done. Many exhibits

Skilled Mechanics are Required in Museum Shops. In the Museum of the Geological Survey, Canada.

needed in fighting a war can be made only by such very specially skilled men.

Exhibits

The pedagogic exhibits so useful in peace time, such as those showing the characteristics of moths and butterflies, may give place during war to exhibits especially appropriate for the time. For instance, a war-time aeronautic museum has recently been established in a temporary building near the Smithsonian Institution. This is at present solely for the aeronautic experts of the United States War Department, and provides facilities for the assembly and study of all types of aircraft machines and appliances. After the war it may be opened to the public.

In peace times an exhibit of inexpensive specimens such as a lump of lime, a pail of tangle-foot, and common birds with labels and pictures, all from the city of Ottawa and made at no further cost except for the cutting of branches from various nearby trees, label writing and photographs, helped to save the shade trees of the city. These exhibited common specimens from nearby instead of expensive specimens from afar and formed as useful a natural-history exhibit as a diamond or dinosaur costing thousands of dollars. So in war time an exhibit that is cheap may be as useful as one that is expensive.

PEDAGOGIC EXHIBIT. Showing the characteristics of moths and butterflies, in the Geological Survey Museum, Canada.

The Division of Exhibits of the United States Food Administration, Washington, offers to assist any museum to develop a special exhibit to illustrate the need of conserving foods. A handbook on "Graphic Exhibits" has been printed. Mimeograph copies of plans for larger exhibits have been prepared. Copies have been secured of a series of 13 charts, designed and written by Elizabeth C. Watson, under the title, "Why Food Conservation is Necessary." All these are sent to any museum upon request. Food-conservation exhibits have been made in Chicago, New York and Washington.

Museums might show the various fish, shellfish, muskrats, voles, and many other foods not supposed to be edible or not much used, but which are not only good food but especially excellent. At least one museum made such an exhibit which also included illustrations of methods of preventing the average waste of about 10 per cent. of our food.[2]

Exhibits showing the close ecological relationships of all plant and animal life and of the links connecting up our food

[2] See *American Museum Journal*, 1917, pp. 188 and 295.

Saving the Shade Trees of Ottawa by an Exhibit of Inexpensive Specimens composed of a Lump of Lime, a Pail of Tanglefoot and Common Birds with Labels and Pictures, all from the City of Ottawa. In the Geological Survey Museum, Canada. Useful specimens from nearby instead of expensive specimens from afar.

If an Exhibit made at no cost except for the cutting of branches from various nearby trees, label writing and photographs can help to save the shade trees of a city, it is as useful a natural-history exhibit as a diamond or dinosaur costing thousands of dollars. In Geological Survey Museum, Canada.

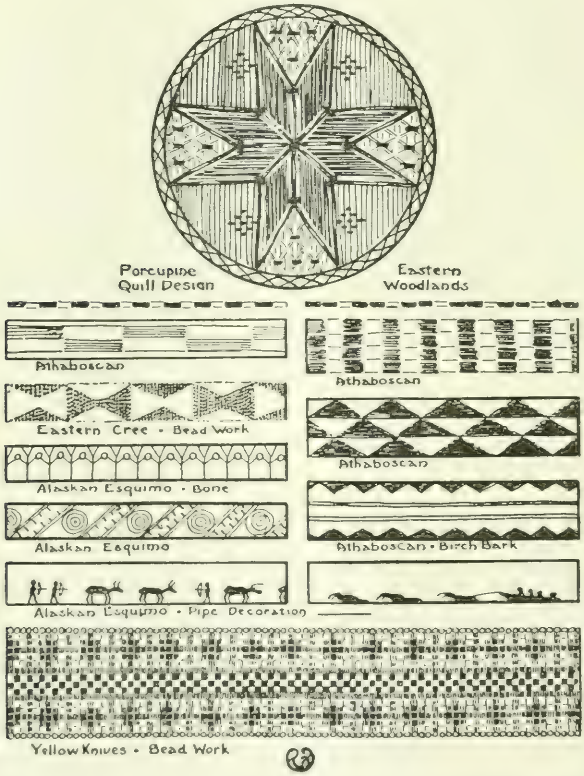
supply with the inorganic world would be desirable features in a food exhibit. Such an exhibit should also display the bacterial causes of food decay and the most approved means of preservation—drying, canning, cold storage, pasteurizing, etc.

During the world's food emergency brought on by the war, the diseases and the fungi, smuts, rusts, rodents, and similar enemies that attack cereals may be fought by means of museum exhibits of specimens, enlarged drawings, methods of sterilizing seeds, fertilizers and the like. Displays of posters and museum publicity through the usual channels of the press may also be used to advantage.

Such things as gas masks, helmets such as are used for protection against rifle and shrapnel fire, medical officers' belts for carrying emergency medicines, dressings and similar things, an operating room fully equipped, outfits for sterilizing water, filters, equipment for fitting railway cars for the transportation of the wounded, and many similar things of use in informing prospective soldiers and manufacturers of army supplies have been exhibited in the United States National Museum by the Medical Department of the United States Army.

Museum Specimens as Motives for Designs

Designs from Indian exhibits in the Museum of the Geological Survey, Canada, were used long before the war by all the Ottawa school children in their art work. The war has cut off the sole supply of designs from many manufacturers of both Canada and the United States which need new designs constantly. There are over 300 different industries or about 1,000 factories in Canada alone which use designs. To meet this sudden stoppage of the foreign-design supply and the demand for distinctively Canadian designs so useful in building up and holding Canadian markets the archeologists of the Geological Survey have selected from all museums a very complete series of specimens of the prehistoric art of Canada suitable as motives for designs and trademarks for the use of manufacturers and hope to issue an album of them. Meanwhile some manufacturers are inspecting them in the museum and photographs of the specimens are being sent to others. Animals, plants, minerals, fossils and other museum specimens, especially historic Indian art, may be of similar service. A good design is worth thousands of dollars. A lecture on the subject illustrated with lantern slides is available. Articles have been prepared for the press and a travelling exhibit has been made and will go first to the commercial museum of the Department of Trade and Commerce. All the Canadian artists and art schools have been asked to cooperate by using the material for over fifty manufacturers listed by the museum as anxious for these designs. The distinctive Canadian motives have already been used in decorating curtains, art pottery, tiles, pipes, electric-lamp stands, and dresses, and also in the art schools.



Designs from Indian Exhibits in the Museum of the Geological Survey, Canada, are used by all the Ottawa school children in their art work. In war time the manufacturers requiring new designs and unable to get them in the usual way resort to such museum specimens.

Notable success in this use of material by industries has also been made since the war began by the American Museum of Natural History in New York. There specimens from Peru, Mexico, Siberia, etc., have been used extensively by the designers for the silk mills in replacing foreign designs.

Signs and Labels

Classifying and case signs and encyclopedic species labels are needed in war time and were all too scarce in times of peace.

CLASSIFYING AND CASE SIGNS AND ENCYCLOPEDIC SPECIES LABEL. Sheep and Goat Group. Rocky Mountains Park Museum. These mounted animals were assembled by local labor at regular wages under supervision.

THE GUIDE BOOK TO ROCKY MOUNTAINS PARK MUSEUM, a Recreation, Tourist or Vacation Museum, is appreciated by Indian visitors.

Guide Books

Some guide books of certain museums are appreciated by visitors in peace times. In war time the aid of every large or small part of the population is desirable. For example, those Indians unable to go to the front and those generally having leisure may be instructed by means of publications, lectures and

Publishers are Encouraged to Make Postcards of the Rocky Mountains Park Museum, and in this way, through the natural channels of trade, knowledge that the museum is maintained by the government, for research, education and recreation, and that it is free is spread far and wide without any expense to the museum.

other information from museums as to what products were imported from enemy countries that are of a kind Indians naturally make well, as to the technique and decoration of these objects and the places to market them. In this way the Indians may be rallied to assist in providing manufactures to replace those cut off by war during and after the war.

Postcards

Publishers have been encouraged to make postcards of the museums and the exhibits in them. In this way, through the

IN PEACE TIMES GENERAL VISITORS COME TO THE GEOLOGICAL SURVEY MUSEUM, CANADA, for recreation. In war time recreation is necessary to relieve the strain on both civilians and soldiers.

NORMAL-SCHOOL STUDENTS STUDYING IN THE MUSEUM OF THE GEOLOGICAL SURVEY, CANADA. On graduation they scatter and each one spreads what he has learned among his scholars. In this way a knowledge of those museum subjects of use in war can be spread far and wide.

natural channels of trade, such knowledge as that a certain one is maintained by the government, for research, education and recreation, and that it is free is spread far and wide without any expense to the institution. Such methods may be well used in war time. The Chicago Art Institute was the first museum to obtain from the United States Post-Office Department the excellent right that any one might mail its bulletin to soldiers by the simple means of affixing a one-cent stamp to the cover. To the soldiers, as to the average reader, some museum publications are more interesting than others, yet there are few that would not have an interest for a soldier or a prisoner of war from the town in which it was published.

MUSEUMS HAVE LIBRARIES USED BY BOTH STAFF AND VISITORS. Geological Survey Museum, Canada.

LIBRARIES

The libraries used by both staff and visitors often contain books not to be had elsewhere. For instance, one book containing drawings desired by a number of large manufacturers in Canada, now that the supply of designs from Europe is so nearly cut off, was only to be seen in a few museum libraries and other copies could not easily be secured, as the book was published in Holland.

(To be concluded)

THE PROGRESS OF SCIENCE

SAMUEL GIBSON DIXON

Dr. Samuel Gibson Dixon, late president of the Academy of Natural Sciences of Philadelphia and commissioner of health of Pennsylvania, who died on February 26, was born in Philadelphia on March 23, 1851. He was admitted to the bar in 1877, but after some years of successful practise he determined to devote himself to the scientific side of the other great profession—medicine—and entered the medical department of the University of Pennsylvania, graduating in 1886. Two years later he was appointed professor of hygiene and pursued courses of special study in London and Munich under Crookshank, Klein and Pettenkofer, devoting himself especially to the rapidly developing science of bacteriology. In 1889 he discovered the branched form of the tubercle bacillus and conceived the possibility of developing a serum for the cure of tuberculosis, to a certain extent antedating Koch in the discovery.

Leaving the university in 1890 in order to devote more time to original research, he established a laboratory at the Academy of Natural Sciences in Philadelphia. Here he became interested in the work and development of the academy, and was elected curator in 1893 and president in 1895.

His research work was now abandoned for the administrative work of the academy and the management of certain estates of which he was executor. The academy at about this time received the munificent bequest of the late Robert H. Lamborn and the development of the institution which this made possible was carefully and intelligently directed by Dr. Dixon.

Mainly through his personal efforts he secured several appropriations from the State Legislature for the enlargement and remodelling of the museum. To all of the details of this work he gave his personal attention and the present condition of the historic collections and library of the academy are a monument to his memory.

In 1905, Dr. Dixon was made head of the new Department of Health of Pennsylvania, and the last twelve years of his life were mainly spent in developing this undertaking into probably the largest and most efficient health department in any of the states of the Union.

The organization of such a staff of men as constitute the department, the building and equipment of sanitoria, the distribution of antitoxin through all the communities of the commonwealth, the immediate handling of epidemics, the guarding of the water supply, and the establishment of a model bureau of vital statistics are a few of the achievements of Dr. Dixon. His training as a lawyer, a student of hygiene and sanitation, an executive and a man of affairs rendered him peculiarly adapted for the multifarious duties of his office, while an indomitable energy enabled him to handle details which for many men would have been impossible.

Every Governor since the department was created recognized the unusually good fortune that the state of Pennsylvania enjoyed in having a public servant of such a high type, and reappointed him without question.

The strain that he placed upon himself however was too great, and he broke down; insisting to the last on carrying on his work, he literally died in harness.

Samuel Gibson Dixon

THE GEOGRAPHY OF THE ITALIAN FRONT

An important article by Professor Robert DeC. Ward, of Harvard University, printed in the February issue of The Scientific Monthly, treats the weather controls over the fighting in the Italian war zone. The number of the *Geographical Journal* for the same month contains an address of equal interest before the Royal Geographical Society by Major De Felippi on the relation of the geography of the region to the war. In discussing this address, the president of the society said that if the conduct of the war should be placed in the hands of the Royal Geographical Society, he doubted whether they would succeed in doing anything better than making a very considerable muddle of it. But it is none the less true that weather, climate and topography are fundamental factors in military operations.

Major De Felippi pointed out that the Italian-Austrian political frontier is 470 miles long, and the boundary line is so drawn that Austria holds the headwaters and upper courses of every one of the Italian rivers. There is not a small valley which is not held by Austria to within a short distance of its opening upon the plain. Austria possesses the whole basin of the Isonzo from its source to the sea. The political boundary bears no relation to any of the geographical features of the land. An equally important topographical feature of the frontier is the fact that with the longer stretch extending in a general direction from the west to east and the shorter section extending from north to south, the Italian army was always in danger of a flank attack.

When Italy attacked Austria, it could only advance in the Isonzo region, but every door leading into Italy was open to Austria. Thus in May, 1916, Austria attacked the Italian left flank on the tableland of Asiago, where, if it had succeeded, the rearguard of the Italian army would have been cut, with Venice only forty miles away.

With the exception of this attack on the Asiago plateau, the military effort has been continuously employed on the eastern front. It was by far the most important, for here only was it possible to accomplish the objects which the Italians had in view. But the whole Isonzo basin was interposed between the frontier and the watershed and the advance could be made only with the greatest difficulties. The character of this region is shown in the two photographs which were exhibited by Major De Felippi and are reproduced from the report of his lecture. It was in the region of the Isonzo, shown in these pictures, that the German and Austrian troops attacked at the end of last October. Above Gorizia the Isonzo flows from north to south in a long narrow winding defile, which widens out at three points where side valleys reach it at Plezzo, Caporetto and Tolmino. These widenings of the valley were the scenes of the Austrian and German attack, through which their armies moved forward into the plains of Italy.

AERIAL PHOTOGRAPHY AND THE WAR

Plans have been completed for the great enlargement of facilities for training and equipping the aerial photographic force for photographing the German trenches from the skies and keeping up to the last minute the large composite picture of the whole German front. Future facilities will be three times those at present existing and will be in full operation in April.

The three schools now operating at Langley Field, Fort Sill, and Cornell will be consolidated into one large school of aerial photography

VALLEY OF THE ISONZO AT TOLMINO.

Valley of the Isonzo at Plezzo.

at Rochester, N. Y., where all the primary training will be done. Special equipment has been provided, with over 100 instructors. The present schools will be used for special and advanced training, particularly for the photographic intelligence officers who will accompany the planes into the air on special occasions. The bulk of the training, however, will be for the developing and printing work which must be done on a standardized plan, under processes specially developed during the war, and often in great haste on special motor lorries close to the front and to the staff. After a month's course, the men will be given a short advanced training and immediately sent overseas for operation in the American sector.

Aerial photography has greatly developed during the war. During the single month of September, British official reports state that 15,837 aerial photographs were taken by the British alone. No new trench can be dug, no new communication system opened up, no new batteries placed, but the ever-present and infallible camera above records it for the examination of the staff below. So piercing has been this work that camouflage has been developed as a protection, thus forcing aerial photography to even greater ingenuity.

Every sector of the front is divided into plots about half a mile square, each one numbered and intrusted to a squad of photographers who become fully familiar with it. As fast as the photographs are made they are developed, printed, reduced or enlarged to a standard scale, and then fitted into their place on the large composite photograph of the sector. This work requires a force of experts in developing, printing, and enlarging, as well as in map reading and interpretation. Cases are on record where only 20 minutes have elapsed from the time a photographer snapped his camera over the German trenches until his batteries were playing upon the spot shown. In that time the airman had returned to his lines, the photograph been developed and printed, the discovery made, and the batteries given the range and ordered to fire.

SCIENTIFIC ITEMS

We record with regret the death of Dr. Edmund Arthur Engler, for twenty years professor of mathematics at Washington University, and for ten years president of the Worcester Polytechnic Institute; Dr. Henry Maudsley, the British alienist and psychologist; of Sir John Wolfe Barry, the British civil engineer, and of Dr. Maryan Smoluchowski de Smolan, professor of physics at the University of Cracow.

Bonds and cash amounting to $1,693,000 representing the trust fund established by Drs. Charles H. and William J. Mayo, of Rochester, the distinguished surgeons, for carrying on medical research work at the University of Minnesota, have been turned over to the state treasurer.—The Rockefeller Foundation has appropriated $125,000 to continue the war demonstration hospital of the Rockefeller Institute, $50,000 for the work of the medical division of the National Research Council of the Council of National Defense and $12,281 for other medical war research and relief work.—It is expected that the new Field Museum, Chicago, for which ground was broken in the summer of 1915, will be ready for the transfer of the contents of the old museum in Jackson Park by August, 1919. The new building is situated south of Twelfth Street and east of the Illinois Central Station. It is of Georgia marble, and, exclusive of the porticoes, will measure 756 feet long and 350 feet wide. It will cost $5,000,000.

THE SCIENTIFIC MONTHLY

MAY, 1918

CONCERNING THE MUTATION THEORY

By Professor T. H. MORGAN

COLUMBIA UNIVERSITY

THE mutation theory of evolution has met with a stormy reception, despite the fact that De Vries, and most of its supporters, have avowed themselves adherents of the doctrine of natural selection. Some of the older followers of Darwin have insisted that the large steps, which they still believe are the only kind that the mutation theory postulates, could not give the small continuous stages through which evolutionary changes take place. Now, the mutation theory has never made any such "large" claims. On the contrary, it has been pointed out repeatedly that the mutational changes may be extremely small. The theory does claim that the genetic factors are discontinuous, although the characters that they stand for may or may not be discontinuous. De Vries himself has said in the "Mutation Theory" (Vol I, page 55): "Many mutations are smaller than the differences between extreme variants," meaning by the latter term fluctuating variations, pointing out by way of illustration that the constant species of *Draba verna* "differ less from each other than do extreme variations in the same characters." While De Vries's work on the evening primrose, *Œnothera Lamarckiana,* is generally conceded to be the starting point of the modern mutation theory, nevertheless, the peculiar way in which Lamarck's primrose produces its new and recurrent types, which De Vries regarded as the real mutative process, has been difficult to harmonize with the way in which practically all other forms give rise to mutants.

The genetic behavior of the evening primrose is so well known that it is superfluous to describe it here in detail, especially since we are, for the moment, more concerned with the critical treatment of the results than with their exposition. It will suffice to recall that De Vries found an escaped European garden plant known as *Œnothera Lamarckiana* that produced new types in sufficient numbers to furnish numerical data of unusual value. Some of these new types bred true, although some of them continued to give further evidence of "mutation." Immediately the question arose: Is *O. Lamarckiana* a wild species, or a product of hybridization; and if the latter, is not its mutation process only the resolution of the hybrid into its components? The search for the wild type in America led practically to failure, but the search led to the important discovery that other wild species of the same and related genera were also mutating. Into the vexed question as to whether most or all wild types may not themselves be hybrids, it is not necessary to enter here; for if the point of view that I wish to present is correct, the behavior of *O. Lamarckiana* would be outwardly nearly the same whether it arose by the union of two species, each bearing lethals, or whether its present "balanced lethal" condition arose within the plant itself, no matter what its origin may have been.

That the situation in *Œnothera* is complicated will be clear, I think, to any one who has followed De Vries's latest work "Gruppenweise Artbildung," Davis's experiments with forced germination, Geerts, Gates and Lutz in their cytological work, Stomps and Bartlett on mutability in other species of the genus, MacDougal, Heribert-Nilsson, G. H. Shull and Honing in their analytical work on the genetics of *Œnothera*.

Recently a case apparently similar to the mutation phenomenon of *Œnothera* has been worked out on the fruit fly, *Drosophila melanogaster*, by Dr. H. J. Muller, which, I venture to think, gives us the clue that we have needed so long to show what takes place in Lamarck's evening primrose when it throws off, in definite percentages, characteristic mutant types. This evidence makes it not improbable that this type of behavior of *Œnothera* may be due to the presence in it of *lethal* factors, so closely linked with recessive factors, that only when the linkage is broken do the recessive factors come to light. Here we have a remarkable situation, one that would have seemed, *a priori*, highly improbable, but now that we can at will make up stocks that give the same kind of results as does *Œnothera* the behavior of this plant can be brought into line with mutation, as seen in other animals and plants.

The history of the discovery of a balanced lethal stock in *Drosophila* and its interpretation by Muller is as follows: An early observed mutant of the fruit fly, *Drosophila* had Beaded wings. Beaded stock was bred for several years, and persisted in throwing some normal offspring. Selection produced no advance until suddenly a time came when Beaded no longer threw any normals; or so few as to be negligible. Why had it not been possible to make pure the stock in the first instance? And what happened when it became pure?

Muller took up the work at this stage and has solved the problem as follows: He found that the factor for Beaded is dominant for wing character, but lethal in double dose. As in the case of the yellow mouse, only the hybrid (heterozygous) combination exists, and consequently when two Beaded flies mate they produce two Beaded to one normal fly, as shown in Fig. 1. Here the first pair of vertical lines stand for the pair of third chromosomes present in the egg before its reduction. The two factors here involved, that for Beaded and its allelomorph for normal, are indicated at the lower end of the vertical lines. The two corresponding chromosomes in the male are represented to the right of the last. After the ripening of the germ cells each egg and each sperm carries one or the other

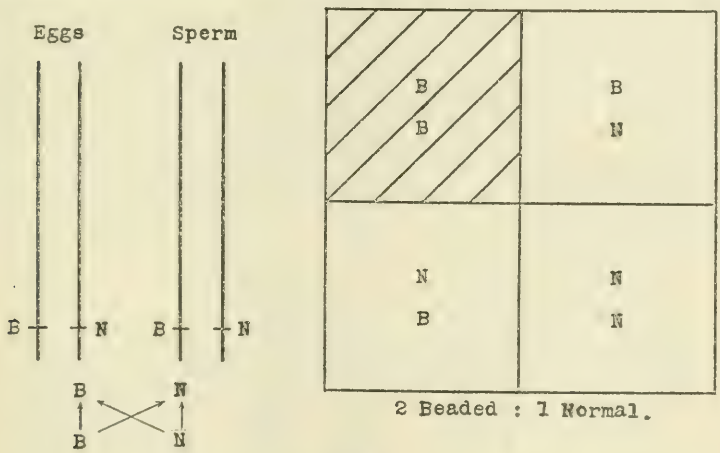


Fig. 1.

of these chromosomes. Chance meetings of egg and sperm are indicated by the arrow-scheme below in the figure, which gives the combinations (classes) included in the four squares. The double dominant BB is the class that does not come through. The result is two Beaded (heterozygous) to one normal fly.

The Beaded stock remained in this condition for a long time; although selected in every generation for Beaded, it did not improve, but continued to throw 33 per cent. of normal flies. Then it changed and bred nearly true.

The change must have been due to the appearance of another lethal factor (now called lethal three or l_1 in the diagram), because a gene for such a lethal was found in the race when studied later by Muller. The lethal factor is recessive; it is fatal when in double dose. It behaves as do other lethals which Bridges and Sturtevant especially have demonstrated to be frequently present in *Drosophila*. In fact, lethal factors appear to be the commonest type of mutation, which is not surprising when one recalls that most of the mutants are deficient types, whose defects, carried a step further, would in many cases be fatal to the individual. It is only in this sense that the term lethal factors is used by us. They are not supposed to be poisons or any special kind of modification, but only factors that cause some structural or physiological change of such a sort that the individual does not begin its development, or, if it does, it perishes somewhere along the road. In fact, we have lethals that affect the egg stages, the larval and pupal stages, the newly hatched flies, and semi-lethals that weaken the adults, although they do not necessarily kill.

The lethal gene that appeared in the Beaded stock was also in the third chromosome, and in the chromosome that is the mate of the one carrying the gene of a Beaded, *i. e.*, in the *normal* third chromosome of the Beaded stock. The lethal gene lies so near to the level of the Beaded-normal pair of genes that almost no crossing-over takes place between the levels occupied by the two pairs. These relations are illus-

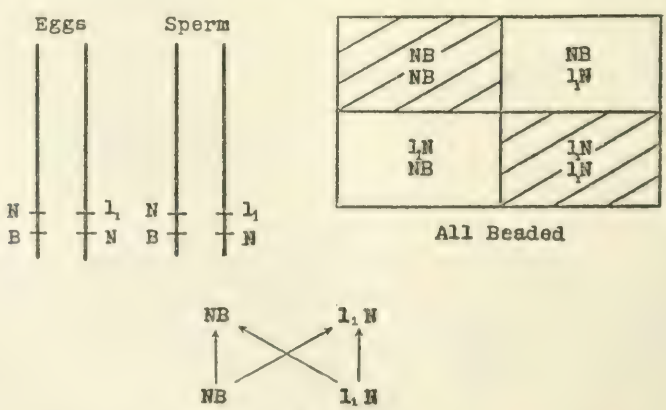


FIG. 2.

trated in the next diagram, Fig. 2. Here again the two pairs of vertical lines to the left represent the two third-chromosome pairs in the female and to the right the male. The location of the two pairs of genes involved, N — l_1 and B — N, are indicated. These combinations give the four classes in the squares, of which two classes die, viz., NNBB (pure for Beaded) and l_1l_1NN (pure for lethal three). The result is that only Beaded flies come through, and since all these are heterozygous both for B, and for l_1 the process is self-perpetuating.

If the preceding account represented all of the facts in the case, the stock of Beaded should have bred perfectly true, but it has been shown in *Drosophila* that crossing-over between the members of the pairs of genes takes place in the female. Hence we should expect a complication due to crossing-over here unless the level of the two pairs of genes was so nearly the same as to preclude this possibility. In fact, in addition to the Beaded flies the stock in this condition would give 10 per cent. of crossing-over, *i. e.*, it would still produce a small percentage of normal flies. It so happened, however, that there was present in the stock a third gene that lowers the amount of crossing-over in the female to such an extent that, for the two "distances" here involved, practically none takes place. When it does a normal fly appears, but this is so seldom that such an occurrence, if it happened in a domesticated form of which the wild type was unknown would be set down as a mutation like that shown by the evening primrose.

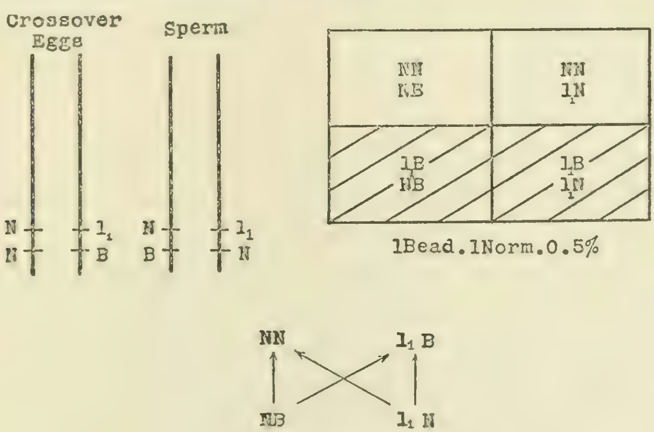


FIG. 3.

The third factor that enters into the result is not unique, for Sturtevant has shown that crossover factors are not uncommon in *Drosophila*. The analysis that Muller has given for

Beaded, while theoretical, is backed up by the same genetic evidence that is accepted in all Mendelian work. It makes an assumption that can be demonstrated by any one who will make the necessary tests. Lest it appear, however, that this is a special case depending upon a very unusual situation, let me hasten to add that with the material that we have in hand it is possible to produce at will other balanced lethal stocks that will "mutate" in the sense that they will throw off a small predictable number of a mutant type—a type that we can introduce into the stock for the express purpose of recovering it by an apparent mutation process.

Dichete is a third chromosome dominant wing and bristle character and like Beaded a recessive lethal. In a certain experiment flies with the gene for Dichete in one of the third chromosomes and with a gene for the recessive eye color peach in the other were inbred for several generations. A lethal appeared by mutation in the peach-bearing chromosome very near the level of the Dichete gene in the opposite chromosome.

The order of these genes is shown in Fig. 4. This is then a

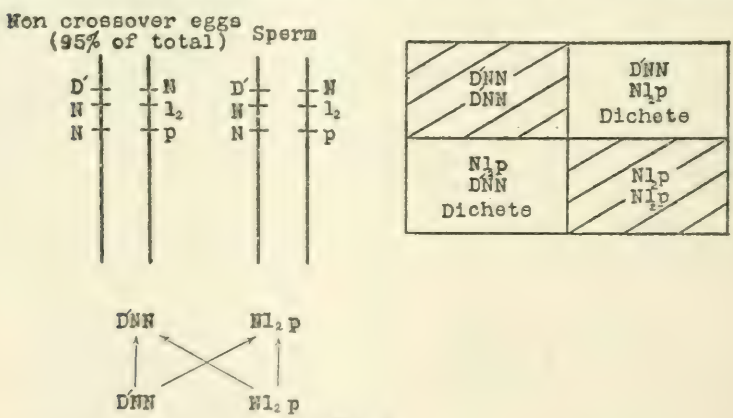


FIG. 4.

balanced lethal stock that throws only Dichete flies,[1] except for a small percentage of Dichete peach flies due to crossing-over. The result for the non-crossover classes is shown in the next figure, Fig. 5. Only two of the four classes come through; the two that die are the one pure for Dichete and the one pure for lethal. The surviving classes continue to produce the same kind of offspring since they are, like the parents, heterozygous for the two lethal factors. But the factors are not near enough together to prevent crossing-over. This occurs in about 5 per

[1] Very rarely a crossover not—Dichete fly will appear.

cent. of cases between the lethal and peach genes. The next diagram, Fig. 5, shows how when crossing-over takes place in

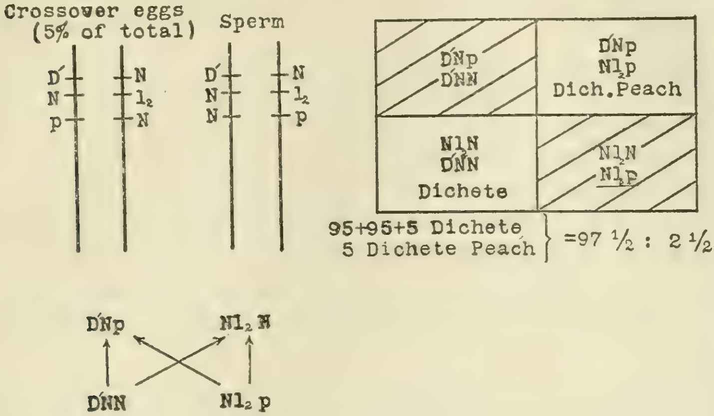


FIG. 5.

the female, there result (see squares) four classes of which two die (as before), and of the two that survive one is Dichete peach. Taking both non-crossover and crossover results together, the expectation is 95 + 95 + 5 Dichete to 5 Dichete peach or 97½ to 2½. This stock then breeds true for Dichete without showing the gene it carries for peach eye color except in a small percentage of cases, and if the peach-eyed fly should be unable to establish itself in nature, like some of the *Œnothera* mutants, the stock would not be changed by it, but continue to throw off a few "mutants" with peach-colored eyes.

Now this process is not what is ordinarily meant by mutation, for we mean by the latter that a new type has suddenly arisen in the sense that some change has taken place in the germ plasm—a new gene has been formed. The process here described is one of recombination of genes shown by Mendelian hybrids, the only unusual feature that all the phenomena involved do not come to the surface because many classes are destroyed by lethals.

The results are interesting also in another way. It has been assumed by those who think that *O. Lamarckiana* is a hybrid that the mutant types are only the segregation products of the types or combinations that went in to produce the hybrid. But the *Drosophila* cases show that balanced lethal stocks may arise within stocks themselves by the appearance in them of lethal factors closely linked to other factors—new or old ones. When new genes arise in such lethal stocks the process may be one of true mutation, but the revelation of the presence of the gene is hindered by the lethal factors, so that when the *character* appears, it appears in a much smaller number of individuals than would be expected for a "free" mutant due to recombination of mutant genes that had arisen in an earlier generation. As a matter of fact, the first appearance of even ordinary mutants, unless they be dominant, must come two or more generations after the mutation has taken place, for the evidence indicates that mutation appears in only one chromosome at a time.[2] In the case of sex-linked genes, however, any mutation that takes place in one of the X-chromosomes of the mother is revealed if the egg containing it gives rise to a son, because he has but one X-chromosome and that comes from his mother.

The delayed occurrence then of mutants in balanced stocks is not different from the delay in other stocks,—only when the recombinations occur in balanced lethal stocks they must have been preceded by crossing-over which diminishes the number of mutants that appears. The number of mutants that appears is determined by the distance of the genes for the character from the nearest lethal gene.

One of the most interesting features of the evening primrose arises when it is bred to certain other species or varieties. It gives rise to two kinds of offspring called Twin Hybrids, to one pair of which De Vries gives the names *læta* and *velutina*. Now it is a feature of balanced lethal stocks like Beaded that

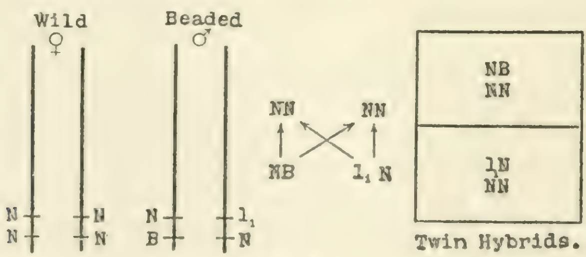


FIG. 6.

they repeat precisely this phenomenon. For instance, if a Beaded male is crossed to wild female, two kinds of offspring are produced, viz., Beaded and normal. A similar process would account for twin hybrids in *Œnothera* crosses. There is another peculiar phenomenon that has been described for

[2] If in self-fertilizing forms a mutation takes place far back in the germ plasm the new character might appear at once.

crosses in the evening primroses, viz., the occurrence in F_1 of four types. This phenomenon, too, can be imitated in *Drosophila* by crossing balanced lethal Dichete to balanced lethal Beaded (Fig. 7).

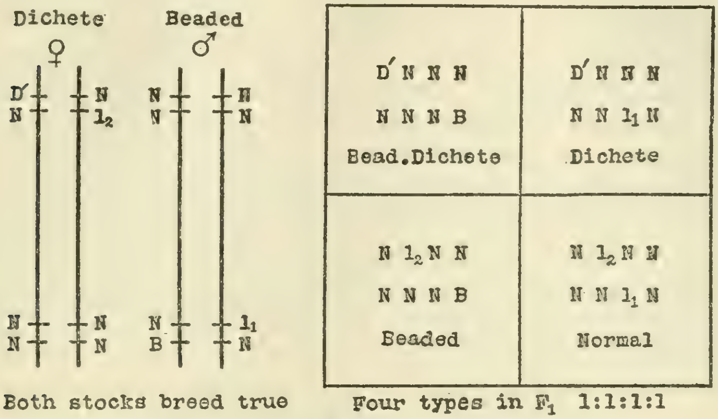


FIG. 7.

Other parallels might be cited, but these, I think, will suffice to indicate very strongly that the discovery of balanced lethal stocks may solve the outstanding difficulty of mutation and inheritance in *Œnothera* and bring it into line with other groups. There are, of course, other peculiarities of the evening primrose that such zygotic lethals will not explain; such, for instance, as the 15-chromosome type; and *O. gigas*. But these cases are already on the road to solution.

The occurrence of other lethals, called *gametic* lethals, that kill the germ cells—gametes—before they are ready for fertilization, has already been invoked by De Vries and others to explain the peculiarity of double reciprocal hybrids. As *Drosophila* has not shown any *gametic* lethals, we have no such parallel to this case, but confirmatory evidence has been found in other cases, as in *Matthiola* (Stock), and it is not likely that De Vries's hypothesis will be seriously questioned.

If this diagnosis is correct, the "mutation" of *Œnothera* is nearer solution than ever before. Much that has been obscure is clearing up. The so-called *mutation process* in *Œnothera* has turned out to be, I venture to think, largely a phenomenon of lethals—zygotic and gametic.

Whether the genes now present in the plant arose by incorporation of mutant types by hybridizing has no longer the same interest that it had before the discovery of the phenomenon of balanced lethals, because the most characteristic "mutation" process of *Œnothera* is difficult to explain even if it arose through hybridization, unless the races that entered into its composition already contained balanced lethals. In which case it is the latter relation that gives the unique feature to the *Œnothera* mutation process, and not its possible hybrid combination. On the other hand, if the lethal and mutant genes arose directly in *Lamarckiana,* its peculiar mutation behavior would be due to their presence, quite irrespective of its history. In other words, it is in either case the balanced lethal condition that gives to this plant its extraordinary propensity to throw a considerable percentage of recurrent mutant types. Possibly I am too unfamiliar with the *Œnothera* work, or too optimistic, but I can not but rejoice at the possibility of accounting for the riddle of *Œnothera* on the theory of balanced lethal factors.

Nature of the Unit of Mutation

Undoubtedly the conception of the gene as a complex organic molecule or group of molecules located in the hereditary materials is the view most easily visualized when dealing with mutational "units," but however attractive and practical such a simple notion may be, we can not afford to accept it without careful analysis of the evidence supposedly in its favor. What is this evidence?

The segregation of the members of each pair of Mendelian genes clearly leads to the idea of independent units. It would be unprofitable to discuss whether these units are material particles or dynamic centers independent of material support. Standing on a chemical basis as physiology does to-day, we may without further discussion take for granted that the genes are some sort of chemical bodies.

The evidence that these bodies are carried by the chromosomes is also on a substantial footing. This evidence has been so fully discussed in recent books and articles that it need not be taken up here.

The assortment of the different pairs of Mendelian genes has been found to be conditioned by the phenomenon of linkage which is now reasonably explained by the assumption that linked genes are those carried by the same chromosome. This interpretation is gaining ground in all fields of genetics and in my opinion has been demonstrated to be true for the chromosomes of *Drosophila.*

The linear order of the genes in the chromosomes—each chromosome containing one linear order—is the only view so far suggested that will account for all the facts relating to linkage with its associated phenomena of crossing-over and of interference.

Beyond this point conclusions become more problematical. How much or how little of the chromosome thread corresponds to a gene can at present be deduced only from the genetic evidence. Some of the possible deductions that can be drawn from this evidence seem to be the following:

So long as a stock breeds true to a given standard, in the sense that its individuals fluctuate about the same mode, the stock bears evidence to the constancy of the genes. This conclusion rests on the assumption that the differences shown by the individuals of such "pure" stock are due to differences in the environment that each has encountered in the course of its life. To prove this view to be correct required the carefully controlled experiments that Johannssen carried out with Princess beans. In this case, through long inbreeding, which its natural self-fertility ensured, the stock had become homozygous for all of its contained factors. Hence individual size difference must have been environmental and this was shown to be the case, for when the large beans and the small beans that came from the same parent were sown, the group of individuals derived from the small beans showed exactly the same distribution as the group from the large beans.

Does this demonstration of the constancy of the gene mean that the gene itself is an absolute quantity? The mutationist has sometimes been reproached on the grounds that he deduces the constancy of the gene in defiance of the plain fact that all races of animals and plants are variable, and that this variability is indeed their chief peculiarity. The answer to this supposed reproach is two-fold: First, nobody claims that Johannssen's evidence demonstrates that the gene is absolutely fixed in the sense of being quantitatively invariable; and second that the expected results for the group of individuals studied would be the same whether the gene were absolute in a quantitative sense or whether its "constancy" were due to its variability about a critical modal quantity. This point has been so little discussed and so often misunderstood that it may be well to consider it for a moment.

Let us use the term, quantitatively fixed, in the sense in which a molecule is said to be fixed. Leaving aside the finer distinctions that might be made on the grounds that some recent work has shown that even the same chemical element may exhibit differences in its atomic weight, it will not be disputed that modern chemistry goes forward on the assumption that the molecule is a fixed quantity. If the gene is a fixed quantity in exactly this sense, results of the kind that Johannssen has found are consistently explained. But there is no evidence that conclusively establishes this view. As an alternative view the gene may be looked upon as a certain amount of material that varies about a modal amount. The amount with which the individual starts might then be supposed to influence the characters of the individual in the plus or minus direction as determined by the starting point. On the other hand, even if individuals started with slightly different quantities, the fluctuations in the amount throughout the process of cell divisions that build up the embryo might be expected to neutralize the initial difference. In other words, the assumed quantitative fluctuations of the gene in the germ-plasm stream might be expected to recur also in the body cells of the individual and "compensate," so to speak, for any variable differences at the start. Before we can hope to make any further advances along these lines it may be necessary to know more about the chemical structures of the chromatin thread and the process involved when it splits lengthwise into two daughter threads. In the meantime it is permissible to use the expression "constancy of the gene" in either sense defined above.

In the course of Mendelian work in general and more especially in connection with the clean-cut cleavage phenomenon behind Mendelian segregation the question has come up as to whether the heterozygous members of the same pair of genes may not contaminate each other either during their long residence in the same cell or in the supposedly more intimate union during the brief conjugation of the chromosome threads at synapsis. We know too little of the relation of the chromatin materials at either of these periods for any *a priori* argument to carry the slighest weight. The decision must come from the genetic evidence itself. If such a phenomenon were of general occurrence it would of course entirely obscure the whole Mendelian idea of segregation. It has not been claimed by any one in a position to weigh the evidence that contamination is general. The appeal has been made only in a few cases in order to account for supposed departures from the Mendelian process of clean separation of the genes. In not one of these cases, so far as I know, has the evidence been convincing, and in none of them has the alternative hypothesis of modifying factors been excluded. Until such evidence is brought forward it seems more probable that the generally admitted process of clean separation of the genes is characteristic of the segregation process. How this result may at times apparently be obscured will be described later when dealing with modifying factors and also with multiple allelomorphs.

The constancy of the gene may be made to appear in a somewhat ludicrous light when a commonly accepted view of mutant genes is brought into the present connection. The presence and absence hypothesis assumes that mutation is due to loss of a factor from the original germ plasm. Taken in a literal sense the absent factor is gone, and there can be no opening for a discussion of quantitative values or of contamination. This and many other difficulties are settled once for all by presence or absence. This might, indeed, be claimed as an advantage for the hypothesis. But on the other hand, the hypothesis has never had any direct evidence to support it. It was proposed as a formal way of expressing the fact that the normal allelomorph and its partner are constant and members of a pair that segregates. Any other formulation that expresses clearly this relation explains the data as well.

It is true that there was behind the idea a form of anthropomorphism that has made a wide appeal. Many mutant characters appear as a loss when considered from the viewpoint of the original character. The great majority of the familiar mutant characters are recessive, and most of them show the character less highly developed in a sense than the same character in the wild form. For instance, white flowers and albino animals appear clearly to be due to a loss of pigment. The paler colors of several mutant races, such as thirty mutant eye colors of the fruit fly, seem less well developed than the red eye color of the wild fly. If it is legitimate to argue from the degree of development of the character to the condition of that mutant gene that stands in causal relation to it, a plausible argument may be made out for presence and absence. There are, however, not only counter arguments that have as much or as little weight according to one's personal inclinations, but in the case of multiple allelomorphs there is evidence against this interpretation, and it is important to insist, that since it is here only that we have any really critical evidence, it is hardly fair to ignore it.

The arguments against the interpretation of absence are as follows: *First,* it is entirely illegitimate to argue from the nature of the character to the nature of the change in the germ plasm that produces the character. Theoretically it must be conceded that any change in the germ plasm should be expected to produce some change in the character or characters of the individual, and if the wild type has been brought to a high stage of development almost any change might be expected to cause a falling away from the highest condition that has been attained. But "any change" need not be a loss in the germ plasm.

Second, in order to account for dominant mutant characters the adherents of "presence and absence" feel obliged to assume a loss of an inhibiting gene, because it is difficult for them to believe that an absence could dominate a presence. There is, however, no *a priori* reason why an absence in the germ plasm might not cause a dominance in the character, for the character is, after all, only the sum total of all of the influences in the germ plasm. The concession made here by the adherents of presence and absence is interesting, however, in so far as it shows how literally they take their absences.

Other *a priori* arguments might be brought forward, but the evidence from multiple allelomorphs is so convincing that it is not necessary to discuss the hypothesis in a purely formal way. In fact, if the hypothesis were understood only as a convenient way of formulating Mendelian results the discussion would resolve itself into one of personal preference, and have no further weight; but as will be pointed out later this interpretation has been used as an attack on the mutation theory itself, for losses do not appear to be the stuff that evolution is made of. Bateson has recently developed a kind of evolutionary scheme that attributes all change to loss, shifting the problem of the origin of the genes to a remote past instead of attempting to solve the problem. It is, however, not this theoretical possibility that I referred to above, but to attacks on the mutation theory on the grounds that the mutation process is different in kind from the changes that lead to the evolution of animals and plants. This point may be next considered.

Does Mutation furnish Evolution with its Materials?

There is a predisposition on the part of systematists, paleontologists, and a few other students of "wild" types to deny that mutants are identical with the variation from which evolution obtains its materials. The reasons for their objections might repay more careful and impartial analysis than they have yet received. The chief contention that evolution has been by means of very small changes does not require further attention, since we now know that some of the genes that are typically Mendelian in behavior produce even smaller differences than those that distinguish wild varieties and paleontological gradations. Unless such small specific and paleontological differences can be studied by the exact methods familiar to students of heredity it is not possible by inspection for any one to make any statement in regard to their hereditary behavior as Mendelian units or as not such units. By way of illustrating how difficult it may be even when genetic material is available to detect the nature of a slight change, I need only recall the fact that some of the mutant differences depend on specific modifiers that act visibly only when the chief factor so-called is itself present. Another illustration is also to the point. Owing to the many-sided effects of single genic differences the *structural* effect of a gene may be only a by-product of other important and essential physiological effects that it brings about. Hence any deductions based on the visible changes in the structure may be entirely misleading.

It is important not to forget that any haphazard change in a highly organized piece of machinery is likely to injure the machine. There must be comparatively few alterations that would improve the adaptive relation of such a system. Furthermore, changes are more likely to succeed if they affect some detail than if they cause sudden and great alterations, for even an extreme alteration, in itself beneficial when considered alone, may be injurious unless the rest of the organism is in harmony with it. It is no doubt this last consideration that is uppermost in the minds of those who contend that evolution must take place by slight advances in directions that do not throw the organism out of harmony in the delicate adjustments already acquired. It is true that many mutant changes are extreme ones and hence will be rejected in general competition, or indifferent, and hence have small chance of getting a foothold. It is, however, unfair to extend this consideration and infer that no mutations will be advantageous. In fact, unless evolution is directed by mysterious Unknown Agents along adaptive lines, by Unknown-chemical-elements, *i. e.*, by some Bion, the chance that any random change will be disadvantageous is inevitable, regardless of whether variations are due to mutations or to some other sort of change. If past competition has raised living species to a high point of efficiency in the environment in which they maintain themselves, the expectation of improvement through any one random change must be very small.

Some at least of the differences of opinion between the mutationist and the systematist may be traced to the above sources. There are also other grounds of disagreement: (1) The fact, for instance, that most of the characters studied by mutationists appear to be deficiencies has prejudiced students of evolution against these characters as a class. (2) The fact that most of the mutant types as well as many of the domesticated animals and cultivated plants can survive only under the artificial conditions of man's care may appear to put them all out of court when comparisons are made with wild types. (3) The fact that many of the mutant characters of domesticated forms are recessive has been supposed to count against their consideration as factors in evolution.

These "facts" undoubtedly call for consideration. Let us attempt to give them their full value and see if they really invalidate the view of the mutationist who believes that the mutations that he meets with throw light on what kinds of variations contribute to evolution.

In answer to the first (1) objection, that many mutant types are deficient, *i. e.*, less complicated, it should be pointed out that the objection would hold only if all mutants were deficiencies. This is not the case, for some of them are actual additions or further developments of the original structures. No one would pretend to maintain that the majority of mutant changes have a survival value. But mutationists do think that mutant changes having a survival value arise in the same way as do others that have no such value; for, they can point to actual cases where such mutants have survived and replaced the original type, and they have found no evidence that supports the view that useful and useless characters arise in entirely different ways. The opponents of the mutation theory have occasionally tried to make it appear that mutationists believe that most of the deficient mutant types that they study represent, or might represent, possible stages in the evolutionary process. I do not know of a single advocate of such a view—it is palpably absurd.

The second objection, viz., that mutant types survive only under domestication, has really no bearing on the question unless it could be shown that all mutant characters are unfitted for survival. As a matter of fact, numerous cases are on record where mutant differences characterize wild races and species of animals and plants.

The third objection is more difficult to meet because the relation of dominance to recessiveness is always a relative matter, and also largely a matter of definition. The following considerations have nevertheless a bearing on the supposed difficulty: (*a*) Dominant mutants, if they introduce an advantageous change, have a better chance of survival than recessive ones equally endowed, because the individual that carries the dominant gene has the immediate survival advantage that the character endows it with. (*b*) Since it appears that a large proportion of mutant types are recessive, the chance, that any wild type gene that occurs has arisen as a recessive mutation is increased. (*c*) After genes have been incorporated in the wild type there is no way of knowing whether they arose as a dominant or as a recessive mutation. That they may later be more likely to produce new genes recessive to them is not an argument that they themselves arose as dominants.

There is a further consideration to be noted in the above connection. It is not true that most dominants are superior to the wild type from which they arose. Several known dominant mutants are no better off than other recessive mutants, conversely some new recessive mutants have a higher survival value than some of the new dominants. It is questionable whether dominant mutants as a class are better endowed for survival than recessives.

In conclusion, then, it appears that the objection to recessives is based on the ground that they are mutants rather than that they are recessives.

There still remains a further highly theoretical consideration that may be briefly referred to in this connection. Why so many new mutations should be recessive is admittedly a problem for which we have no solution. It will not suffice to state that the wild type will probably be more stable if the mutant is a dominant, for, so far as we know, the stability of a gene has nothing to do with its dominance. There is evidence that the mutant gene is as stable, in the sense that it is no more likely to mutate again, as is the allelomorphic gene representing the wild type. Suppose, however, that the wild-type gene is a highly complex compound or molecule. It seems plausible to assume that disintegrative changes would be more likely to occur than changes that build it up into higher stages of complexity. Suppose, further, that degradation (loss of complexity) carries with it the likelihood that the character itself is less highly specialized, or developed, or conspicuous (any vague phrase will suffice), it may then appear reasonable that the more highly specialized end product will be the furthest reached and hence dominate the product derived from any degraded stage.[3] Such considerations are highly speculative at the present stage of genetic work and we lack entirely evidence that can give them any special weight. For the present it is better, I think, to leave such difficulties in abeyance. It is, however, not improbable that we may gain some light on this question when we come to know more about the relations of mutant dominant genes to the wild type gene, from which they are derived. Already some important facts have come to light in the behavior of the gene for Bar eyes in *Drosophila*, as shown by Zeleny and May.

It should not pass unnoticed that the preceding discussion takes for granted, by implication at least, that new genes do not appear; in a word, that the most primitive organism had the same number of genes as have the more highly evolved animals and plants. Bateson has shown where the assumption that all new genes are losses of old ones leads. But the opposite point of view is tenable, viz., that new genes arise during evolution, and even that evolution is due to their appearance. How new genes could arise is unknown—whether by a splitting process within the chain of old ones, or by doubling of chromosomes, or duplication of parts of chromosomes, or out of some less specialized substratum in which the existing genes are embedded. If the mutations that we study are really only degradation products (losses if one prefers) of genes that have arisen in a different way during the evolutionary process, it might still be conceded that they are useful in recombination which may be one, even though it may not seem to be the most important, phenomenon of evolution.

It is true that practically all the genes we know anything about are transmitted according to Mendel's laws, and it is only genes so transmitted that are involved in heredity, except in the few cases of plastid transmission. If, then, it should be claimed that evolutionary genes arise in a different way from Mendelian genes, it must be granted that the former behave as partners to the latter in the same way as the latter behave as partners to each other when they meet, as in the case of mul-

[3] Bateson, arguing from character to gene, has suggested that the mosaic distribution of color, for example, is due to a fractionation of the gene. The speculation above has only a remote resemblance to this view. There need be no relation whatsoever between the nature of the change in the gene and the way in which its effects are distributed except that, as here suggested, degradation of the gene may weaken the extent to which some end stage or part of that end stage is realized. For dilution effects the two views are not so obviously different.

tiple allelomorphs. Such a relation can not, however, be used to establish the identity of the two suppositious classes of genes. We must search elsewhere for evidence bearing on this important question.

Mutant Species and Unit Characters

In his original definition of the Mutation Theory, De Vries regarded the change, however slight, as one that was far-reaching, producing an individual that was something new throughout. He compared the mutant types to the small species of Draba verna or to other polymorphic groups familiar to botanists. The Mendelian work led at first to a somewhat different conception of the change involved in a single mutation. The emphasis was laid on "unit characters," so-called. It was generally implied that a mutation in the germ plasm led to a change in some particular organ of the body, *i. e.*, its effects were localized, not general. During the seventeen years that have elapsed since De Vries's formulation it has become apparent that the more familiar we are with a given form the more changes we can generally recognize associated with a single mutation, although it is also true that in many cases some one organ often shows the effects more conspicuously, and this organ is chosen as a matter of convenience as the earmark of mutation. On the whole, the evidence has made it clear that De Vries was more nearly right in his diagnosis. The more extreme claim would be that a change in any gene in the germ plasm affects all parts of the resulting individual. The opposite claim would be that a change in the members of a pair of genes affects only a particular part of the body, thus identifying "unit changes" in the germ plasm with "unit characters" in the individual. The evidence that we now have shows that in most cases at least neither extreme statement corresponds with the facts, but that while the particular genes often produce their most marked effects on certain regions or organs of the body, yet it is no less important to recognize the widespread effects of mutant genes. Any attempt to identify the nature of the gene from the changes it produces in one organ can not safely ignore its other effects in other organs. If the products of a gene do not act on a particular organ in its final stage, but through a chain of reactions in the embryo, we should expect more than a single kind of effect.

If, as just stated, each gene may affect several parts of the body, it follows with some probability that the same part may be affected by several genes. A similar conclusion is reached in another way. There are many mutants that show differences in the same organ, each difference dependent on a different gene. In the fruit fly, for instance, there are about 50 different eye colors, 15 body colors and many races with wings of different length, shape and breadth. It is probable that at least several, perhaps all, of the normal allelomorphs (genes) of the eye colors may also take part in the formation of the eye color in the sense that they all take part in building up the body, and the end result is modified according to the substratum that they have produced. Carried to an extreme the view might mean that every part of the body is influenced by the total of all the genes, which means, of course, the entire germ plasm. The conception is exactly the converse of the Roux-Weismann conception of the relation between the germ plasm and the end-product of its activity, which conceived each end result as the special product of one or a few particular genes. The statement sometimes made that the modern genetic conception of the gene is identical with that of Weismann is not even half true. What the two theories have in common is not peculiar to Weismann, viz., that the germ plasm is made up of discrete particles—a view held by Bonnet, Herbert Spencer, Darwin, Haeckel and several other naturalists—and what the two views do not have in common is the special relation between the gene and the character that Weismann, following Roux (who in turn goes back to Bonnet, not to trace the theory to the preformationists themselves), made one of the chief supports of his theory of development.

It is not necessary to advocate the extreme view mentioned above—that every part is influenced by the whole germ plasm. As yet our information is too meager to warrant such a wide generalization, yet speaking personally the view is more sympathetic to me than the one that limits the influence of each gene to a very few regions of the body. I incline more to the other side, because the embryological history of the individual shows that the differentiation of the organs is a gradual process through which successive stages are passed in building up the complicated end product. If each of the stages is under the influence of the hereditary material, any alteration at any stage in the building up might be expected to affect in some degree the end results.

This relation is somewhat similar to another relation, but the two should not be confused with each other A specific gene may be essential to the normal development of a certain organ, which organ through an internal secretion may affect other parts of the body, or even the body "as a whole." If, for example, the development of the thyroid gland were known to be dependent on the presence of a certain kind of gene (amongst all of the others involved in its formation) a change in the postulated gene leading to the arrest in the development of the thyroid gland would, owing to the lack of a sufficient amount of some internal secretion of that gland, produce a malformed child with all of the various stigmata of the cretin. The conclusion that the gene ultimately produces its effect on the body by means of an internal secretion, here thyroidin, does not mean that the gene itself is thyroidin. It is conceivable that it may be, but such an assumption is not a necessary deduction from the evidence, and is not needed for the logical interpretation of the results. We hope of course some day to discover the nature of the materials that we call genes and the way in which they affect the developmental process, but in the meantime the distribution of the materials of the germ plasm during the ripening of the eggs and sperm is the center of present interest to students of Mendelian heredity. While I am aware that this statement may seem to take a too narrow view of the problems involved, separating as it does the mechanism of Mendelian heredity from the later physiological influences of the gene on embryonic development, it has proven in practise premature to base speculations as to the composition of the gene on the physiological processes that take place at some unknown stage in the development of the embryo even although these processes are admittedly due to the presence of a special gene.

THE APPLICATION OF ORGANIZED KNOWLEDGE TO NATIONAL WELFARE

By Dr. P. G. NUTTING

DIRECTOR WESTINGHOUSE RESEARCH LABORATORY, EAST PITTSBURGH

THE highest duty of every nation is to live up to its possibilities. If it performs this duty, its welfare is assured and it will command the respect of all other nations. The greatest problem before any nation is that of developing its resources to the utmost. The solution of this problem involves a thorough knowledge of all resources—natural, intellectual, manual and financial—and thorough knowledge of all means of making the most of them. Since our knowledge is far from complete, fundamental principles must be determined by research, and the application of those principles to special problems investigated. Finally, since productive life periods are relatively short, attention must be given the transmission of valuable accumulated knowledge by education.

Every military upheaval focuses attention on fundamental national problems. The lessons learned during the period of a war constitute its most valuable product. One of the great lessons of this war is the value of highly developed resources in inhibiting warfare and in determining its outcome. It behooves us therefore to give earnest consideration to the problem of living up to our possibilities. We have organized knowledge, judgment and experience sufficient to make a good start and the time appears ripe to consider ways and means of making more effective our efforts to further the interests of our country and of all sound portions of the world at large. This outline of some of the more general problems involved may serve to direct increased attention to such problems. Although the value of the application of organized knowledge by specialists to problems of general interest is a matter of the simplest common sense, we are only beginning to apply organized knowledge in an organized manner and the results to be anticipated from such an application are almost beyond conception.

Problems directly concerning the welfare of the nation fall chiefly into six groups: (1) Problems concerning the relation of this to other nations, (2) national problems, (3) problems concerning relations between the nation and organizations within it, (4) problems relating to organizations, (5) those concerning the relation between organizations and individuals and (6) problems relating to individuals. More or less common to all groups are certain general classes of problems of such general interest as to be worth special treatment, namely, (7) education, (8) research and (9) the psychology of achievement.

1. *International Relations.*—Problems in international relations have to do with the relation between one nation and another of equal sovereignty and approximately equal strength, between one nation and other lesser nations, between a nation and its dependencies and with the rights of a nation to deal as it will with its own internal affairs.

The fundamental principle governing international relations is simple from a biological point of view. Those principles will in the end prevail which are backed by the greatest bulk and activity of resources; natural, intellectual, manual and financial; in other words, by the greatest sum of potential and kinetic energies. Mere intellect or money alone will not prevail, nor will natural resources or military strength. The creed of national selfishness goes down before the creed of altruism because it is inconsistent with true international democracy. This can recognize no special privilege among nations, since it is not in accord with the biological principle just stated. In these days of international information and activity, international public opinion will have its way, since it commands the bulk of effective resources. Hesitancy to sacrifice industries and individuals and intrigue by a minority may delay a settlement, but the final outcome is assured.

The right of one sovereign state to deal with another as it sees fit has never been explicitly conceded nor denied, since no direct means of enforcing regulations have existed. The problem of limitations is comparable with that of the right of one individual to treat another as he pleases. Common sense says that a policy of amity and equity is by far the most advantageous; common law holds that certain limitations may be exceeded only at the risk of certain penalties. A nation that oversteps the bounds of amity and equity in its dealings with its neighbors must just as surely pay the penalty, for human races the world over detest a bully and love fair play. In the interest of humanity, however, codes should be formulated and should be enforced by an effective international police in order that bullying and wars for aggrandizement should be put an end to for all time.

All political rights of the smaller sovereign states will undoubtedly be guaranteed by the economic majority of other nations at any time the issue is forced. Such nations are entitled to identically the same inalienable rights to exist, develop and manage their own affairs that are possessed by the strongest nations. On the other hand, the non-political rights of such lesser nations are properly proportional to the massed resources of each.

The relations between a nation and its dependencies must be based on the same principle if there is to be development without revolution. There must be such free interchange of resources as will benefit both colony and mother country. A nation whose policy is one of fair play leaning toward altruism will always be successful with her colonies, while a policy of selfishness and condescension will ruin the best of colonies. Finally, as a colony grows there must be continued readjustment of political rights to keep pace with the increasing relative bulk of intellectual and economic resources in the colony.

The basic principle of world democracy politically is the complete abolition of special privileges. The logical application of this principle to international relations means complete autonomy, self-determination, government by and with the consent of the governed. The practical problems in this field relate to the establishment of such limitations to these rights as may be necessary to secure the ultimate greatest good of the world at large.

2. *National Problems.*—The various classes of national problems center about the single one of securing the maximum development and utilization of resources. Progress requires first of all stability and stability depends primarily upon efficiency of administration. Comprehensive surveys of resources —natural, intellectual, manual and financial—are required as the first step in their development, utilization and conservation. Corps of trained experts must say what can be done and how it can best be done. The actual work of development, conservation and utilization falls chiefly upon individuals and organizations, but it is a governmental function to supervise at all times and regulate when necessary. National authority should be asserted in proportion to national responsibility, that is, to the extent to which the interests of the people as a whole are affected.

Administrative problems relate chiefly to resources and are dealt with through various departments and bureaus. It goes without saying that each class of problems should be cared for by a specialist in that class of work and that the leading specialists of the country should be at the service of the nation. In order to secure an adequate supply of such experts, it may be best to reorganize various departments and bureaus to perform somewhat more of the functions of graduate schools than at present. This would attract more and better men to the national service and secure for the nation and for the industries more high-grade experts in the application of organized knowledge to practical problems. Along with the elimination of partisan politics and other kinds of special privilege, it would be in the interest of administrative efficiency to put in effect a national system of advancement—the student becoming a specialist, the specialist with ability and experience becoming an expert and the expert with broad and sure judgment advancing to the higher administrative positions. This is the "Business Method" and is beyond question the best method of securing efficient administration.

A democracy may be either the best and strongest or the worst and weakest form of government, according to the extent to which it adopts business methods, putting its ablest experts in control at the top and having all important problems solved by specialists. Such a democracy will have a considerable advantage over even the best form of autocracy, since in the latter the governing class is not chosen from so wide a selection.

3. *The Nation and Internal Organizations.*—National stability requires that national authority be supreme over every internal organization, whatever its nature; political, industrial, religious, protective or otherwise. And stability is the first requisite of a national organization. The principle is that the interests of the people as a whole (the nation) must be rated higher than the interests of any component part, be it an individual or a powerful state or industrial organization. Biologically, this all-important principle is so simple as to be absurd. Unless parts of our bodies, for example, worked harmoniously together for the common good, we could not long exist.

The practical problems in this field relate chiefly to the proper limitations to be placed upon organizations to secure the greatest possible good to the nation. The Sherman Law aimed to secure the national welfare against the encroachments of powerful organizations seeking only their own selfish aggrandizement. Its enforcement has resulted in serious interference with normal growth. Such growth should be encouraged, but firmly directed toward the national welfare.

Other more sinister organizations seek not only their own welfare and aggrandizement above that of all other people in the nation, but acknowledge a higher allegiance to an alien head than to the nation. This anomaly is of course a serious menace to national stability and could not long exist except under the cloak of secrecy and evasion. There is but one solution for this problem—elimination of such kind or kinds as are applied to cancerous growths.

Labor organizations, on the other hand, are entirely loyal as a rule, but their aims at first sight appear crude and selfish and evidence little regard for the interests of those not within the organization. Every strike, however, is more than a mere demand for higher wages or for greater power through the closed shop. It is a back fire against the equally selfish aggrandizement of capital. Due to its entrenched position, capital has always been prone to claim special privilege and the lion's share of the profits accruing from the cooperation between laborers, capitalists and engineering experts. It will be difficult to solve the problem of fair play in this case, since it involves the equitable distribution of earnings where no general rules are perhaps possible. Such equity depends largely upon lateral conditions, and these vary widely in special cases. The government is confronted with this problem (1) in an advisory capacity in dealings between industrial organizations and labor and (2) wherever it employs bodies of labor.

4. *Relations between Organizations.*—Problems concerning the relation of one organization to others are relatively few and simple. In equity each one, small or large, must be secured the right to grow and develop its resources without other limitations than those demanded by the general welfare. Combination and secession are to be carefully regulated. Combinations to secure greater efficiency and economy are to be encouraged and fostered while side combinations for the purpose of securing exclusive rights are not to be tolerated. Wide latitude may safely be given any organization in the management of exclusively internal affairs. No special privileges can be granted one organization or class of organizations that are denied others.

5. *Relations within Organizations.*—Problems concerning relations between organizations and subordinate organizations and individuals are similar in character to those concerning

relations between the nation and internal organizations—strictly internal affairs are not to be interfered with from outside. Industrial organizations present problems of difficulty. They are essentially triumvirate in nature, consisting of (1) plant, tools and materials representing capital, (2) technical information and skill and (3) operating labor. In the larger older organizations the three are quite distinct; a group of bankers supply the capital, hired experts do designing, testing of raw materials and product and make sales while more or less skilled labor keeps up routine production. The equitable divisions of earnings and losses is a difficult problem. When capital assumes responsibility for losses or contributes valuable ideas it is obviously entitled to a larger share than when it does neither. When technical experts shall have become as strongly entrenched as both capital and labor now are, the working out of the principles of equity may be brought to an issue.

6. *Relations between Individuals.*—The principles governing relations between individuals are already fairly well covered by the ordinary civil and criminal codes, worked in accordance with common sense and equity over long periods of time. Some of the more difficult and but partly solved problems involve the basis for compensation for service and equity in cases in which psychic forces are a factor. Special privilege is to be everywhere denied, that is, equality of rights and privileges must be everywhere secured and guarded.

Nowhere else is the premium on superior strength, skill or activity greater than with individuals. Let the winnings be limited to the winners. Inherited wealth, position, or influence should be regarded as an asset to the nation and a probable destructive agent for the inheritor. Individual talent is by far the greatest asset of the nation and its development and utilization the greatest single problem. That great group of problems dealing with the attainment of the maximum knowledge and skill by the individual relates to the education of the expert. Another important group of problems relates to securing a maximum of achievement; and still another to the increase and application of organized knowledge.

7. *Development of the Expert.*—In a really efficient democracy all important problems will be in the hands of experts for solution. Since men of ability come about equally from all classes, provision must be made to train and select individuals from all classes alike. In a broad sense, every one who applies special knowledge to special problems is an engineer, be he electrician, physician, bridge builder, skilled agriculturist, banker

or teacher. Some specialists, such as the physician and the farmer, require many volumes of special information and years of experience in its application. Other specialists require chiefly breadth and generality of knowledge, picking up their special training in a few months. In each profession preparation starts with the most general academic information, proceeds to "make believe" real problems and ends with problems involving full responsibility.

Interest in the general problem centers largely on (1) equality of opportunity, (2) efficient general instruction and training—mental, moral and physical, (3) age of choice of specialty, (4) freedom to transfer from one line to another, (5) efficient semi-technical education, (6) technical instruction and training through practical work and research, (7) state and national coordination in aims, methods and standards and (8) government boards of specialists to investigate and advise as to efficiency in methods and enhanced quantity and quality of output.

Our present mobile, ill-defined policies in education have been well adapted to our period of rapid national development, but the time is at hand for systematized improvement under the guidance of trained experts. The preliminary development has been well done—our educational system, such as it is, is "close to the ground" and already approximates roughly to our requirements. We need chiefly unity and refinement of methods. The rigid elimination of educational weeds and all similar glaring defects long tolerated should come first of all. Our racial stocks of raw material are excellent—able and eager to learn. It must be admitted, however, that our methods are slack and our typical product a "slacker" until caught in the whirl of real life. Our greatest problem with our own sons is to put "sand" into them, to fire them to achievement. Lax school discipline and low standards do not help; in fact, the results of lax school methods frequently persist through life.

Our engineering schools and other methods of developing experts are as a rule excellent in aims, methods and results. Perhaps the greatest need is for increased attention to thorough knowledge of fundamental principles. It should be continually emphasized that the chief factor in the standing of any engineer or professional man is his command of fundamental principles. We are a practical nation and are too prone to pick up knowledge by experience and let it go at that, paying too little attention to the results already achieved by others. The mere quack is the extreme type of deficiency in knowledge of fundamental principles. The problem of the complete elimination of quackism involves modification of curricula in some instances, but is chiefly dependent upon our instructors and leaders in each line.

Finally, some sort of supervision might well be exercised over the process of education that continues through middle and later life. All real experts continue to acquire further knowledge of fundamentals and additional skill through experience as long as they live. The problem is to make such knowledge more available and to increase opportunities for professional intercourse for the interchange of ideas and experiences.

8. *The Increase of Organized Knowledge.*—Man's inquiring mind is forever prying into things and frequently dislodges an idea worth exhibiting and preserving. Some of these either alone or built into a structure of previously discovered ideas prove highly useful or instructive or entertaining or otherwise contributory to his well-being. To achieve certain desired results, he searches the general storehouse for an idea or principle applicable to the purpose. That failing, he digs in the unknown to find one. Research uncovers new ideas, engineering applies to special problems general principles already known. Research shades off into engineering on the one hand and into creative art on the other. It ranges from the very general and fundamental to the special and practical. Without it we should have had none of the sciences and none of the products of the sciences.

The bulk of the research work is done either in (1) educational institutions, (2) the administrative departments of the government or in (3) special research laboratories supported by various industries. Some fields of research involving expensive equipment and from which little or no financial return is to be expected have been provided for by private endowment.

Since our higher educational institutions are our chief conservers and disseminators of organized knowledge, it is but natural that they should lead in the development and extension of that knowledge. However, the plant is designed primarily for teaching and is but ill adapted to research. Neither students nor instructors have more than scraps of time to put on research, while effective research requires steady, continuous application. The biggest problem in university research is to remedy these conditions.

Since the university instructor's time is devoted chiefly to teaching fundamental facts and principles and the student's chiefly to acquiring them, the research undertaken by both is naturally adapted to these purposes. This is doubtless as it should be. Our chief ground for criticism is (1) that the instructor is too crowded with teaching to do enough research work to found a real school for specialists and (2) the student either does not take his work seriously enough or give it time enough to get results of any great value as a rule. Under the circumstances, it is rather surprising—a credit to native ability—that so many pieces of really good work are turned out.

Industrial research laboratories have been started in great numbers in recent years in response to insistent demand for more precise knowledge and a clearer understanding of the fundamental principles applicable to specific problems. The public does not realize the desperate plight of a plant that has run into some obscure works trouble, stopping production. As in cases of illness, diagnoses quickly but surely made by experts are indicated and treatment is prescribed, but by physicists, chemists and engineers as physicians. The original industrial laboratories were staffed by scientists retained largely to look after works troubles where they occurred. Then there is raw material to be tested, specifications to be written, product to be tested, new products and processes to be nursed along into the works.

A full-fledged research division of a large industrial concern may properly consist of two wings, one devoted to fundamental research, the other to engineering research covering routine testing and the simple works troubles. The former covers the field between pure science and special works troubles and may be expected to yield a considerable harvest of scientific papers as well as patents and technical reports. With work continued day after day on full time and means always at hand for obtaining needed equipment or assistance, it represents research under its most favorable conditions. Stakes are high so that there is abundant incentive to earnest effort, in fact pressure is likely to run too high for best results.

The chief problems connected with industrial research laboratories are of a minor nature; securing a sufficient number of good physicists and chemists—men thoroughly grounded in fundamentals—having a high degree of originality, together with good judgment, (2) making it easier for research men to come and go, thus putting all research laboratories more on the basis of graduate schools and (3) improving the interrelations between universities and industrial laboratories.

National research has to do with the solution of problems concerning general welfare. Like industrial research, it ranges in character from pure science to statistics and pure engineering—the application of known principles to specific problems. It covers public health, transportation, communication, finance, education, labor, patents, standards, weather and statistics as well as the conservation, utilization and development of natural resources in minerals, agriculture, fisheries and forests. Much of the research is in the nature of special problems and nearly all of it can be most efficiently accomplished by highly trained experts. Since as a rule these experts are not to be had ready trained, the government must select and train its own from among persons of sufficient general academic training.

Government technical work is carried on by the greatest single body of scientifically trained experts in the country and is on the whole well planned and carried out. There is a large percentage loss (20 to 30 per cent. annually) of the best men in some bureaus—practically the same as in institutions of higher education—hence government research bodies constitute in a sense a great graduate technical school. This condition is to the advantage of the country at large, but it would undoubtedly be for the best interests of all if a higher percentage of the best men were retained in the service. Conditions indicate that (1) higher salaries should be paid and a better system of promotion put in force to retain in the services more high-grade men. (2) The work should be more highly organized and centralized to promote team work and cooperation. Possibly a sort of university organization with a few lectures by experts and many seminars and conferences would be advantageous in attracting good men to the service and giving a wide selection from which to draw. Obviously political appointments should be limited to clerical and unskilled labor and should be limited even in those classes.

9. *Incentives to Achievement.*—However great our knowledge or skill, we accomplish nothing unless fired to achievement by powerful incentives. As a rule we produce hardly ten per cent. of the results of which we are capable, due partly to lack of opportunity, but mostly to lack of incentive. We are a nation of slackers. We fail to live up even to our opportunities by at least seventy per cent. Obviously then the problem of incentives is one of the most vital in the problem of the welfare of the nation.

Men of great achievement are invariably those who supply or create their own incentives. They are typified by the hen which, of her own effort, was unable to fly over a fence, but by worrying a dog into chasing her, was able to mount the fence with ease. The incentive of the hen roost was inadequate, but that of self-preservation was ample for the task to be accomplished. Men of achievement are not content merely to earn a living or even to live up to a certain standard, but are constantly spurred to greater endeavors, to attacking ever more difficult problems, to win over ever more powerful rivals. A fatuous content with existing conditions and previous accomplishments is as intolerable as a shirt of fire.

The psychology of achievement presents many complex problems not easily disposed of. Both temperament and education are involved. Incentives to activity are many and varied, some of the most powerful arising in ideas and impulses coming apparently from nowhere. The choice of activities leading to greater or lesser achievement is always with us and that choice frequently depends upon factors almost fortuitous. It is hoped that these problems may receive the most serious consideration of psychologists as an issue in national welfare.

In conclusion then it may be stated that the proper field for the application of organized knowledge is to secure and enhance the national welfare through increasing the strength, the skill and the activities of the nation, the organization and of the individual. The nation requires organized knowledge for administration, for safeguarding the public welfare and for directing the best development, utilization and conservation of national resources—natural, intellectual, manual and financial. Organizations require it for the attainment of the purposes for which they are organized. Individuals require it to assist them in living up to their possibilities. Although the advantages of its application are matters of the simplest common sense, we are but beginning to apply organized knowledge in an organized manner. The results to be anticipated from such a general and systematic application are almost beyond conception.

THE WORK OF MUSEUMS IN WAR TIME—II

By HARLAN I. SMITH

GEOLOGICAL SURVEY, OTTAWA, CANADA

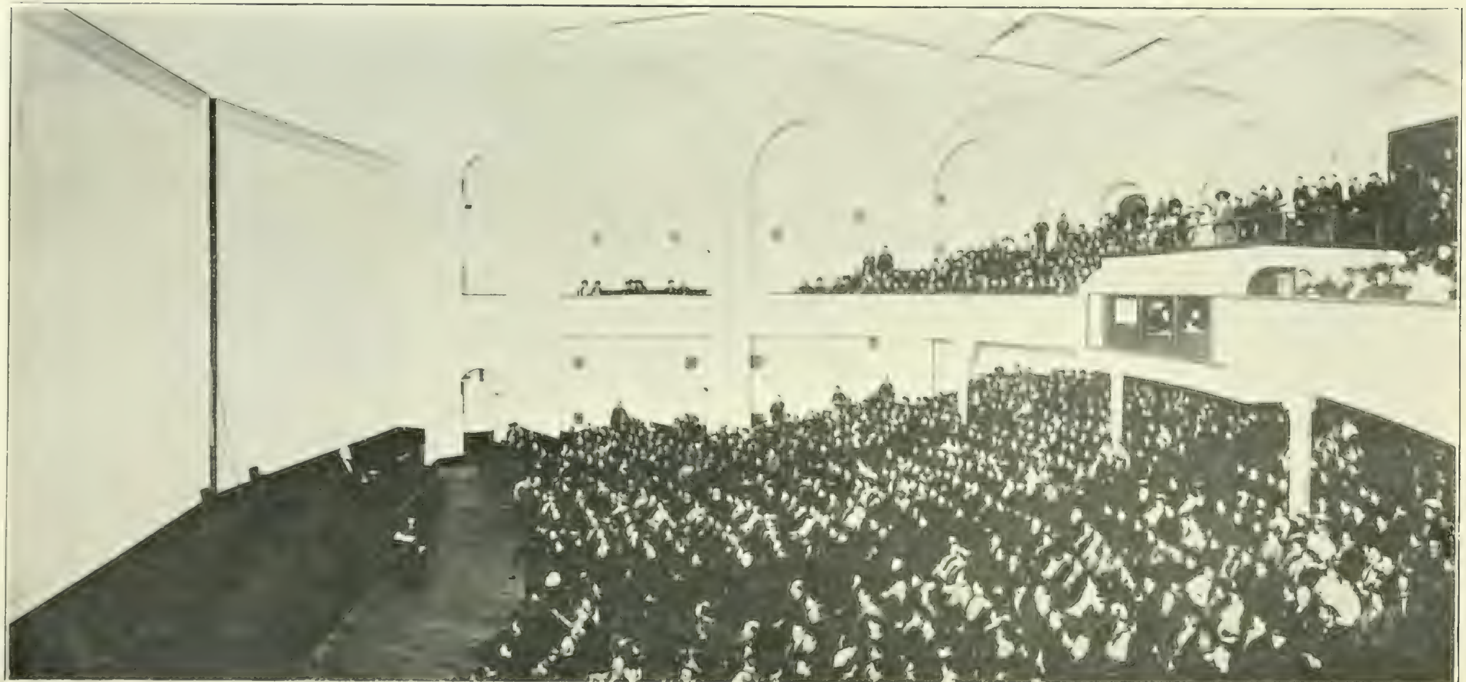
VISITORS

IN peace times most visitors come for recreation. The report to the British Government Committee on the Health of Munition Workers states that observations for a year on the output of workers employed in making fuses showed that a reduction of working hours was associated with an increase of production both relative and absolute. Generally, the cumulative effects of fatigue neutralize and overpower efficiency produced by practise. In the absence of rest and recreation the fatigued worker has no opportunity for complete recuperation

TAKING MOVING PICTURES OF BIRDS ON AN EXPEDITION OF THE GEOLOGICAL SURVEY, CANADA.

and his output, though more uniform, remains permanently at a lower level than that shown by a worker who has had rest and recreation.

Some museums are devoted entirely to recreation, but never-



Museums like Universities have Lecture Halls and Vast Audiences use them. In the American Museum of Natural History. They may be well used in war time.

theless all the exhibits are instructive. Recreation now is especially necessary to relieve as much as possible the unnatural strain on both civilians and soldiers. Properly administered museums not only furnish this healthful distraction but at the same time can also instruct and inspire.

Museum Lectures

Museums like universities have lecture halls and vast audiences use them in ordinary times. In war time these and their illustrative apparatus for projecting lantern pictures and moving pictures may be well used not only for war-time publicity but also for giving recreation or instruction. The instructive lectures may be given to the forces being trained and to convalescent returned soldiers who are unable to carry on their former occupations and who need a new means of livelihood. The recreative lectures may be given to ease convalescent suffering. The moving pictures, of such cheering subjects foreign to war and its frightfulness as birds, photographed on expeditions, would serve well for this purpose. They would reach men who came to realize while lying wounded how sweet life and nature are when compared with the sordid rush for mere money.

Museum Photography

Thousands of negatives, prints, maps and lantern slides are made by the Photographic Division in the Museum of the Geological Survey, Canada. The lantern slides are used in the lecture hall and are loaned throughout Canada. This work is also done in many other museums and is part of the education needed to make a people efficient in the arts of warfare and in those necessary behind the lines as well as always needed in the arts of peace. The museum workers who make and use these materials, often taking photographs under difficult situations resembling some war conditions, are fitted to assist in developing new war-time photographic necessities such as are used by the flying corps in making photographic maps, detecting camouflage, etc., and that are absolutely necessary for the protection of an army as well as the destruction of its adversary. These workers are also better qualified than the average photographers to become teachers of such photographic work to the fighting forces.

Museum Visitors Future Soldiers

Classes of high-school children who in peace times marched to the lecture halls of the great museums grew up during the

THOUSANDS OF NEGATIVES, PRINTS, MAPS AND LANTERN SLIDES ARE MADE BY THE PHOTOGRAPHIC DIVISION OF THE GEOLOGICAL SURVEY MUSEUM, CANADA. The lantern slides are used in the lecture hall and are loaned throughout Canada.

CLASSES OF SCHOOL CHILDREN IN LINE OF MARCH TO THE LECTURE HALL OF THE AMERICAN MUSEUM OF NATURAL HISTORY.

continuation of the world war and contributed many men and officers to all branches of the fighting forces. Over seven thousand school children came to hear one lecture. This shows that the work of teaching school children in the regular subjects which are of use in war time must continue with increased efficiency during war so that suitably trained material may always be available. No one ever knows how long a war may

Over 7,000 Children came to Hear One Lecture in the American Museum of Natural History.

last. Even exhibits of objects connected with the war, such as guns and shells, may be used in a series to attract children to exhibits instructing them in regular studies such as history and physics, which will always be needed by both the citizens and soldiers of a country at war.

Temporary and Loan Exhibits

Museums loan space for horticultural and other temporary exhibits. These are placed sometimes for one or two days around permanent exhibits. In war time some museums loan space for war-time exhibits. For instance, the American Museum has had special war-time exhibits of food and health in war and peace. A popular handbook was issued for this exhibit for sale at the news stands. Both were especially prepared for

EVEN MUSEUM GROUNDS ARE AVAILABLE FOR SOCIAL USE. Folk dances are held by the children on the lawn of the American Museum of Natural History. In war time this ground is used for drilling.

the use of soldiers. All the museums of the country might well loan space for the exhibition of loan exhibits from the Food Controller. In June, 1917, Red Cross Week was held in the Museum at Newark, N. J., and a complete set of Red Cross supplies, conforming in every respect to the latest specifications of the American Red Cross, was exhibited. It included hospital linen and supplies, surgical dressings, operating-room supplies,

MUSEUMS LOAN SPACE FOR HORTICULTURAL AND OTHER TEMPORARY EXHIBITS IN PEACE TIME. These are placed for one or two days around permanent museum exhibits in the American Museum of Natural History. In war time this museum provided space for war-time exhibits.

and linen, patients' clothing and such supplies as the Red Cross furnishes to the army and navy. A similar temporary exhibit including models and pictures was made in the U. S. National Museum.[3]

The windows and the glass of the cases in the Provincial Museum at Halifax were broken by the terrific explosion of the munition ship that blew up in the harbor. A water pipe burst and snow stormed into the museum, so in this emergency museum work was stopped and the cases were covered with boards and used as tables for Red Cross and other relief supplies.

Museums have aided in the food-conservation campaign of the United States National Emergency Food Garden Commis-

[3] Cf. U. S. N. M. Rep. 1916, p. 121.

EXHIBITS ARE PUT IN TRAVELLING CASES TO BE SENT FROM SCHOOL TO SCHOOL IN OTTAWA.

SCHOOL BOYS CARRY THE MUSEUM TRAVELLING EXHIBITS FROM ONE SCHOOL TO THE NEXT IN OTTAWA.

sion by distributing to visitors quantities of manuals attractively illustrated and printed. This material and other literature were placed with the "help yourself" cards where visitors to the museums readily see and take them.

Museum Grounds

Even museum grounds are available for war service as well as social service. Folk dances were held in peace times by

Travelling Exhibits from the Museum of the Geological Survey are used in the Schools of Ottawa.

the children on the lawn of the American Museum of Natural History, but, after the United States entered the war, the grounds were used for drilling. The Brooklyn Museum grounds were planted by the museum workers and considerable food was raised by them.

Travelling Museums

Exhibits are put up in travelling cases to be sent from school to school in Ottawa, St. Louis, Chicago, New York, and other places. School boys carry the museum travelling exhibits from one school to the next in Ottawa, while in St. Louis, New York, and Chicago, this system of museum extension has grown

A COMMERCIAL MUSEUM ON WHEELS. The "Made in Canada Special."

so in recent years that a special auto delivery van is used for the purpose.

The St. Louis Public School Museum makes as many as thirty deliveries of such exhibits in a single day. It delivered 66,810 separately boxed groups of material to the schools during the school year 1916–1917, and has called into service an additional delivery truck. Every public-school teacher of St. Louis is welcomed to select from the new catalogue and order the

COMMERCIAL EXHIBIT IN THE "MADE IN CANADA SPECIAL" RAILWAY TRAIN.

collections she can best use to illustrate the various lessons planned for the week. The delivery trucks serve every school once a week, collecting the material previously delivered and depositing the material ordered for the current week. The entire annual expense to the Board of Education of all this museum work, including overhead expenses, salaries, delivery service, and additions to the collections, averages about 14 cents per pupil served. This method serves the country in

THE CROWD VISITING THE COMMERCIAL MUSEUM IN THE "MADE IN CANADA SPECIAL" RAILWAY TRAIN.

war time as does other educational endeavor, and may be applied to distributing special war-time instruction to schools, the public and the fighting forces.

A commercial museum on wheels, the "Made in Canada Special," carrying commercial exhibits on a railway train across Canada in peaceful years, was visited by crowds. The same means provides opportunity to spread useful war-time knowledge regarding conservation of food and fuel, the speeding up of necessary industries, the making of munitions, political propaganda as in the exhibition of captured guns, and the training of fighters. In the United States a Food Control exhibit has been installed in a railroad car.

MUSEUM EXTENSION

For years minerals have been given to Canadian schools by the Geological Survey, Canada. A covered tray containing an elementary series is sent to the elementary schools, but cabinets containing five drawers to higher schools. Exhibits of things relating to war can be handled in the same way.

For Years Minerals have been given to Canadian Schools by the Geological Survey. A covered tray containing an elementary series is sent to the elementary schools; cabinets, containing five drawers, to higher schools.

Cooperative Labelling

Encyclopedic species labels were prepared as the text of the Handbook of the Rocky Mountains Park Museum by the Dominion Government and have already been used by eighteen different museums, the Rocky Mountains Park Zoo, and for several other educational purposes. Lantern slides have been made to illustrate some of them and these labels can consequently also be used as lecture notes. They need only to be shuffled when it is required to rearrange a lecture. The same method may be employed by the museums in supplying information needed by a nation at war.

Restaurants

In large cities it is sometimes desirable to provide a restaurant in a museum so that students or other visitors may not have to go out. In the American Museum of Natural History, the restaurant is modelled after the ancient Mexican ruin of

Encyclopedic Species Label in the Zoo of the Rocky Mountains Park prepared as the text of the Handbook of the Rocky Mountains Park Museum by the Dominion Government, and already used by seventeen other museums and for several other educational purposes.

Restaurant in the American Museum of Natural History. This is modelled after the ancient Mexican ruin of Mitla.

Mitla and, therefore, is an exhibit as well as a restaurant. In war time such restaurants should be made available to soldiers, sailors, and others engaged in activities of defense.

Conclusion

If the museum fraternity does not rise to the occasion and at least adjust itself to meet war needs and help the general progress of the world other agencies will take over what should be the most important part of museum activities. For instance, the Canadian department of Trade and Commerce opened a museum in January because of the need of such a museum in war time. Those in charge were not recruited from among museum men. The children's museums, which are at present apparently the chief hot beds of new museum ideas, are being made such by persons not formerly connected with museums. It was two boys who were trained in the Children's Museum in Brooklyn who sent and received the first wireless telephone message from Paris to Hawaii.

Now, when the young and active men from the small towns and the country districts of the whole world are passing through the great centers of culture such as London, New York and Paris, or are visiting them on leave of absence, is the very time when museums should be most active in entertaining, instructing, or offsetting the vicious experiences of the war. The cream of New Zealand, Australia, India, Canada, and many allied nations, gathers in London. What better time than now for the museums to offer these men attraction, recreation and instruction, and an inspiration to carry home to the individual corners of the world the seeds of the world's best fruits? Museum work, instead of being curtailed, should certainly be directed towards doing in war time its part both in fighting the war and in making up for the evils and deprivations caused by it.

THE ALSACE-LORRAINE QUESTION

By C. C. ECKHARDT, Ph.D.

ASSISTANT PROFESSOR OF HISTORY IN THE UNIVERSITY OF COLORADO

WHEN by the Treaty of Frankfurt of May 10, 1871, France was forced to cede Alsace and Lorraine to Germany there was created one of the most difficult and most permanent problems of internationtal relations. This question has remained one of the most active sources of international friction. It lies at the basis of the Triple Alliance, and of the counter alliances, the Dual Alliance between France and Russia, and the Triple Entente. It has been the cause of crushing competitive armaments. It was the cause of constant ill-feeling on the part of France toward Germany, and led to frequent friction between the two countries. In spite of Germany's having affirmed all along that the Alsace-Lorraine question was closed by the Treaty of Frankfurt, it has ever been on her mind. This is a question that concerns not only France and Germany, but it is of moment to every civilized nation.

From Cæsar to Bismarck. Alsace-Lorraine before 1871

France and Germany both have historic claims to these provinces; it is well therefore to consider the history of them previous to 1871. The earliest record of these lands dates from the time of Julius Cæsar, when they formed a part of Gaul. When the Germans invaded the Roman Empire in the fourth and fifth centuries they overran and conquered Alsace and Lorraine. Until 870 these lands were controlled by the Merovingian and Carolingian Franks. When the Empire of Charles the Great was finally divided by the Treaty of Mersen in 870, Alsace and Lorraine became a part of the German Kingdom. To this time these two provinces had had a common history; but now they were divided and until 1871 had a separate history. Lorraine became a duchy with an independent existence in Germany, and Alsace became a duchy attached to Suabia. Both regions were German-speaking.

In 1552 France, for the aid she rendered to the German Protestants against Charles V., was given as fiefs of the German Empire the three bishoprics of Metz, Toul and Verdun; and by 1648 at the close of the Thirty Years' War France was given these three bishoprics in full sovereignty; they ceased to be a part of Germany. They were geographically a part of the

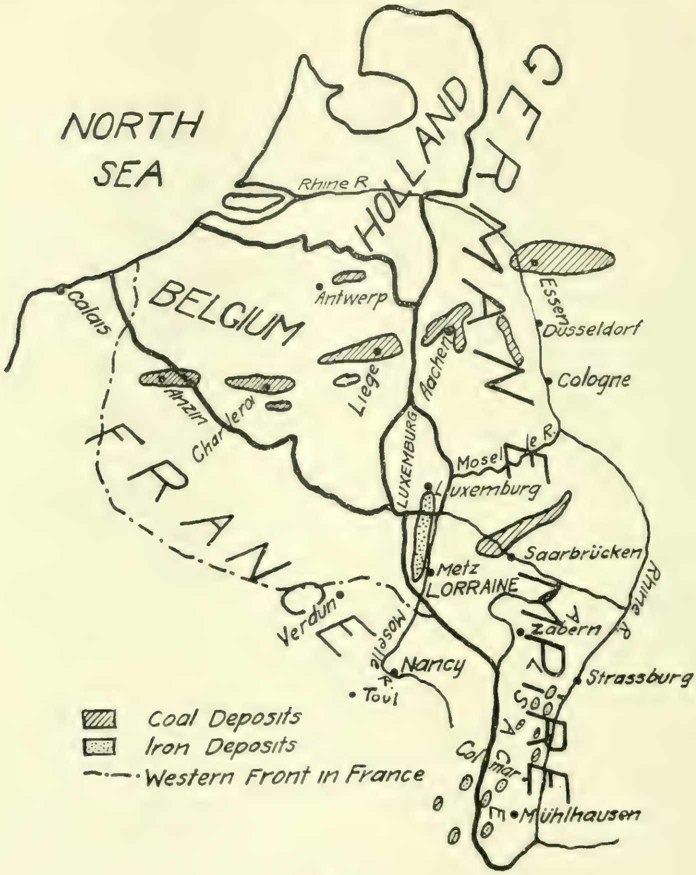


FIG. 1.

Duchy of Lorraine, but were independent of it, and were now a part of France. In 1648 France was also given Alsace as a reward for her services in the Thirty Years' War. Some added territories, Colmar and Strassburg, were secured by the French "courts of reunion," and in 1697 by the Treaty of Ryswick French possession of these was confirmed. Lorraine was in 1737 transferred to Stanislaus Lesczinska when he had lost his kingdom of Poland. He was father-in-law of Louis XV., and in 1766, upon the death of Stanislaus, the Duchy of Lorraine came into the possession of France. So by 1648 and 1766 Alsace and Lorraine, which had been separated from France since the ninth century, once more became a part of France.

Whatever attempts France made to assimilate these German-speaking people previous to the French Revolution were not very successful. It was the French Revolution that aroused in the Alsace-Lorrainers a French sentiment. The democratic and liberal phases of the Revolution appealed to them; the republican principles fascinated them, and many Alsace-Lorrainers fought in the French wars in the armies of the Republic and Napoleon. It is regarded as significant that the "Marseillaise" was first rendered by Rouget de Lisle in 1792 at a dinner given by the French mayor of Strassburg.

Ever since 1815 the Alsace-Lorrainers have been largely French. In 1871 they were handed over to the German Empire much against their will, and when the French National Assembly ceded these provinces to the victorious enemy, the deputies from Alsace-Lorraine protested against this cruel separation from the mother country, and they were expressing the feelings of the greater part of the people of the ceded territories. When, in 1874, the fifteen deputies from Alsace-Lorraine took their seats in the Imperial Reichstag in Berlin, they also protested against the annexation of their lands by Germany. It is also interesting to observe that in 1871 the two great socialist leaders of Germany, Bebel and Liebknecht, father of Carl Liebknecht, protested against the annexation, and were imprisoned for their boldness.

Why Germany annexed Alsace-Lorraine

Germany annexed these lands for three reasons: (1) For linguistic and historic reasons. The Germans claimed that these provinces had been taken from Germany in the seventeenth and eighteenth centuries, and now these brothers were to be brought back into the fold and allowed to become Germans again. In the literature of Germany's political aspirations long before 1871 there were references and allusions to the need of regaining these lost provinces.

(2) For strategic reasons. Von Moltke persuaded Bismarck that these provinces were necessary for Germany's defense against France. The Vosges Mountains would be a far more satisfactory frontier from the military standpoint than the Rhine. Ever since then the Germans have claimed that the Vosges Mountains are the natural boundary between France and Germany.

(3) For economic reasons. Alsace-Lorraine contains much coal, iron and other minerals. But the German desire for these deposits was by no means as great in 1871 as it has become since that time.

Of all the reasons the military reason for annexation was the most potent. Germany needed Alsace-Lorraine for purposes of defense, and the people of the annexed provinces were to be regarded as conquered dependents; they were to be kept in subjection at all costs.

The Émigrés and Immigrants

When Germany signed the Treaty of Frankfurt she agreed to allow all inhabitants of Alsace-Lorraine that wished to emigrate to do so by October 1, 1872. By that date 60,000 had left the country, all going to France or the French colony of Algeria. 100,000 others were not allowed to go because they had not departed by the prescribed date. But emigration has continued all along, from 5,000 to 12,000 leaving annually, and one French authority states that fully half a million people emigrated from the provinces between 1871 and 1910. Many of the people who emigrated did so because they did not wish their sons to enlist in the German army and later kill their relatives and friends in France. The 100,000 that were not allowed to emigrate in 1872 claimed the rights of foreigners, namely freedom from military service. But the German government refused to grant this concession, and this led to much emigration. Ambitious Alsace-Lorrainers wishing to pursue a military career will go to France, for in the German army they would have very little chance of promotion. In 1914 there were only three Alsatian officers in the German army, while there were thirty generals of Alsatian stock in the French army. In 1900–1913 over 22,000 boys fled from Alsace-Lorraine to enlist in the Foreign Legion of the French army.[1]

To take the place of the Alsace-Lorrainers that went to France Germany sent many colonists or immigrants into the conquered provinces. They were people in all the walks of life, and in 1914 out of 1,800,000 inhabitants, 400,000 were immigrants from various parts of Germany. They did the very things that would make them unpopular with the native inhabitants; they boasted of Germany's greatness, emphasized German superiority and tenaciously adhered to all their German characteristics, which increased the difficulty of reconciling the two peoples.

Government of Alsace-Lorraine Since 1871

When Germany had acquired Alsace-Lorraine it was thought best not to annex the provinces to any one of the German states, for then some of the German states would have felt that they

[1] Gibbons, "New Map of Europe," 16.

had fought in the Franco-Prussian War so that Prussia, or Baden or Württemberg could gather in the spoils. Bismarck felt that it would be the wise thing to make Alsace-Lorraine an imperial land—"Reichsland"—directly under the control of the Empire. That would make all the states equally responsible for the annexation and for keeping the spoils of war.

Previous to 1911 Alsace-Lorraine was not a member of the German Federation. For forty years it was a mere dependency, an imperial territory. Administrative affairs were conducted by the Emperor, the Chancellor and the Bundesrath. There was a representative of the Emperor, the governor-general, situated at Strassburg. In 1874 a territorial committee or "Landesausschuss" was created; its members were elected by the city councils of the four largest cities. At first the committee could merely give advice concerning local laws and taxation. By 1877 it could enact laws concerning local affairs; but these laws had to have the sanction of the Bundesrath, in which Alsace-Lorraine had no representation until 1911. Not all laws were made this way. Some were enacted by the Reichstag, the Bundesrath and the Emperor in the same way that all imperial laws were enacted. Moreover, the Emperor and Bundesrath could issue ordinances having the force of law; the governor-general was responsible only to the Emperor; he was virtually a dictator. Alsace-Lorraine was wholly ruled by outsiders. From 1879 to 1887 an effort was made to establish a mild rule for the conquered lands, but then this policy gave way to a rule of harshness, which merely intensified the prevailing dislike for Prussia.

In 1873 Alsace and Lorraine were allowed to send fifteen members to the Reichstag; but here they could exercise little influence, since that body is of little consequence, the real ruler of Germany being the Bundesrath, in which Alsace-Lorraine was not represented. From the beginning there has been a growing party that demanded local autonomy. As a result of the agitation by this party the imperial government in 1911 granted Alsace-Lorraine a constitution. Alsace-Lorriane could now send three delegates to the Bundesrath; but these were to be appointed by the governor-general, an instrument of the Prussian King. This merely meant that the strength of Prussia would be increased by three votes in the Bundesrath, and therefore it was provided that whenever Prussia by means of these three votes has a majority these votes were not to count. Plainly this kind of an arrangement would not satisfy the demands of those that wished Alsace-Lorraine to be represented on an equality with the other states of Germany.

This bill of 1911 also provided for changes in the local government of Alsace-Lorraine. Instead of the "Landesausschuss" there was to be a bicameral legislature of 36 and 60 members. Half of the 36 members of the upper chamber were to be appointed by the Emperor, the remainder were to be office-holders and representatives of chambers of commerce and other professional and business institutions. The lower chamber of 60 was to be elected by manhood suffrage by secret ballot. But this constitution has not satisfied the people. The Emperor can still refuse to sanction the laws of the local legislature, and the Alsace-Lorrainers have no power in selecting the three members of the Bundesrath. The Alsace-Lorrainers before 1914 wished to have local autonomy, their own sovereign or their own republic, and unqualified representation in the Bundesrath of the Empire.

The Language Question

It is difficult to secure adequate information concerning linguistic conditions in Alsace-Lorraine; statistics and opinions differ. The French maintain that the language of the lost provinces is still French. The Germans officially state that the language is preponderantly German, and what French is spoken is largely *patois*. However, one is safe in saying that on the whole Alsace is more German than Lorraine. Even in Alsace the large cities, Mühlhausen, Colmar and Strassburg, are French. The city of Metz in Lorraine is more French than any place in the two provinces, though in a standard German encyclopædia it is stated that only forty per cent. of the population of Metz speak French.[2] In this same work[3] is a map indicating the linguistic dividing line between the French- and German-speaking regions. This represents as French-speaking fully two fifths of Lorraine, and only small indentations on the French border of Alsace are indicated as French. Whatever the official statistics, the facts are that Alsace-Lorraine is not German from the German standpoint. French is still widely spoken; many newspapers are printed with both French and German on the same page; in the shops one is waited on with equal courtesy when speaking French or German. Although the street signs are in German, many of the people always refer to them in French. French plays are presented as often as the law allows, once in two weeks. The German government permits no new French business signs to be put up over the

[2] Meyer, Konversationslexikon, 6th edit., Vol. 5, p. 726.

[3] *Ibid.*, pp. 726–7.

stores. Therefore, old French signs, no matter how old and dilapidated, are still kept over the shops. If the owners tried to repaint the signs that would be equivalent to a new sign and would therefore need to be in German. If you ask an Alsatian whether Alsace is still French, he will answer: "It is not German yet."

The Treatment that hurts

On the whole the Germans have done little to conciliate and placate the people of Alsace-Lorraine. They have regarded these provinces as conquered lands and have treated the people in the very ways that would be designed to intensify the existing spirit of protest and opposition. The regulations are all of the petty and annoying kind. For asking an orchestra to play the "Marseillaise," or whistling it, the people are expelled or punished. When French veterans of 1870–1871 get together and talk over old times their meetings are dispersed and their guns taken from them on the ground that the guns are being carried without the veterans having secured licenses. Those Alsace-Lorrainers that left the country at the time of its cession may visit it only three weeks in the year. If they neglect to secure the required police certificates they must leave at once. Those that come back on business trips may see their clients only at the railway station; they may not enter the town. Parents are not allowed to send their children to foreign schools without governmental sanction, and this is granted sparingly. If the children are sent without governmental sanction the parents are liable to fine and imprisonment. In this way it is hoped to prevent the children from learning French, but this regulation seems to heighten the desire to acquire the language.

Only certain French newspapers are allowed to be brought into the country—those that have agreed to omit all reference to Alsace-Lorraine. But people living on the border of France drive over into France, buy the prohibited papers and the women of the party secrete them in specially contrived pockets in their petticoats. The Germans have levied a high tariff on many French goods entering Alsace-Lorraine. Young men leaving Alsace-Lorraine to avoid German military service may never return until they are forty-five. If detected they must pay a heavy fine. This means that unless the parents of such young men have ample means for travel into France they may not ever see their sons again. Even if able to travel, they must get the consent of the German government before they are allowed to leave. French conscripts from Alsace-Lorraine are sent as far as possible from home. If they get sick or die their relatives can seldom reach them. During the fall maneuvers the people of Alsace-Lorraine must lodge and cook for as many soldiers as the government requires. At various times the manufacturers and merchants of Alsace have been carefully watched by informers to detect any pro-French leanings. When detected they are made to feel the full displeasure of the government. At Grafenstaden, near Strassburg, there is a great locomotive works that had for a long time supplied the railroads of the vicinity with locomotives. One of the directors of the company was a French enthusiast who made no attempt to conceal his sympathies. Suddenly the company was notified that unless it discharged that man it would secure no more orders from the government, and the company had to yield.

All of these circumstances explain why the Prussians are hated. They make it possible to understand the following incident. At Colmar a school teacher was describing vividly the cruelties of Alexander the Great when dealing with the inhabitants of a captured city in Asia Minor. A little girl in the class exclaimed, to the mortification of the teacher: "Surely he was a Prussian!"

One of the most striking outrages of German rule in Alsace-Lorraine was the Zabern or Saverne affair in 1913. At the barrack town of Zabern in Alsace a twenty-year-old lieutenant did various irritating things while in charge of his men. He made uncomplimentary remarks to his men about the Alsatians, he showed open contempt for the civilians. When the populace heard about these things they stoned his house and made annoying remarks to him when on the street. One thing led to another until finally a crowd was dispersed by the young lieutenant and his men, and he himself struck a lame shoemaker with his sword, inflicting an ugly wound on the forehead. Instead of being adequately punished the lieutenant was given the minimum sentence, forty days in jail. The German government did nothing to show that the military had been in the wrong; the protests in the Reichstag were unheeded. The whole affair indicated that the Prussian military government was absolutely dominant, that the civil population in all Germany had no rights as against the military, and it indicated especially that there was not the least inclination on the part of the imperial government to show a conciliating attitude toward the Alsatians. Whatever the German government had succeeded in achieving in the way of placating the conquered provinces was undone in a few weeks by the Zabern affair.

Educational and Industrial Development

However, not all of Germany's acts have been of the brutal, domineering nature. She has done much to promote the material, educational and religious condition of the people. Alsace-Lorraine has become a very important industrial center of the Empire; the iron and coal mines are the richest in the Empire, as will be shown later; the population has increased by 300,000 in spite of the emigration of several hundred thousand. Canals have been constructed; a splendid system of railways has been created; sanitation of the most modern type has been established. A splendid school system has been introduced; when these provinces fell into German hands education was not compulsory and was largely in the control of the Catholic Church. Now the same high type of schools prevails as will be found elsewhere in Germany.[4] Many of these benefits would have accrued to these provinces if they had remained in the possession of France, for in industry, transportation, sanitation, commerce and education France has also made much progress since 1871. But undoubtedly the greatest advantage that Alsace-Lorraine derives from her connection with Germany is of an economic nature, and the economic aspects of the question will be considered below.

The Various Views as to a Settlement. The German View

The Pan-Germanists maintain that Germany conquered these lands and was given them by the Treaty of Frankfurt. France has no rights in these provinces. The people of these territories have only the rights that Germany sees fit to give them. Whatever happens in Alsace-Lorraine is no concern of France. By international law the rights and interests of France ceased in 1871 by the Treaty of Frankfurt. The Germans declare that for years France had tried to suppress the German language and customs in these territories, and it is now the right and duty of the Empire to wean the Alsace-Lorrainers away from French culture and instil German culture once more. Napoleon III. began the Franco-Prussian war in order to gain the Rhine provinces of Germany for France. The Pan-Germanists say that Alsace-Lorraine was taken to prevent a repetition of such an attempt of France. Germany must keep her western boundary as it is. Military necessity demands it.

This is the view that is held by most Germans. To advocate other measures would be about as unpopular as it would

[4] Sir Harry H. Johnston, "Germany and Alsace-Lorraine," *Nineteenth Century and After*, 75: 40–41.

be for Americans to advocate our giving up Porto Rico, the Philippines or the Canal Zone; however, Maximilian Harden, the courageous editor of *Die Zukunft,* and some others, favor the granting of full autonomy, with certain rights in choosing a monarch.

The French View

Officially the French have never given up the hope of reconquering the lost provinces. Every year since 1871 a formal ceremony has occurred in which a wreath is placed on the Strassburg Monument in the Place de la Concorde in Paris, and the statue of Strassburg is constantly kept veiled in black to remind the French of the country's bereavement. However, among the second generation especially, this ceremony has had less meaning than for the older generation. After the Franco-Prussian War Bismarck did his utmost to divert the French from thoughts of revenge. By 1881 he had succeeded in directing France into the field of colonial expansion. France added Tunis and other African lands to her colonial possessions. She took a new interest in strengthening her political and commercial power in her dependencies in India, Indo-China, Madagascar and elsewhere. She became, next to Great Britain, the greatest colonial power in the world. Under these circumstances French ardor for reconquering Alsace-Lorraine was, in a measure, allowed to cool off. But the interference of Germany in Morocco in 1905 in the Tangier affair indicated to the French that Germany had broken the tacit agreement of Bismarck. If Germany were going to interfere in French colonial enterprises, that automatically opened the Alsace-Lorraine question again. The French newspapers have all along done their share toward keeping up an agitation for the recovery of Alsace-Lorraine, and they have done all they could to kindle a feeling for France in the hearts of the Alsace-Lorrainers. But there seems to be no evidence that there was a hearty response. Let me quote some typical statements:

> The writer, who had good opportunities of getting acquainted with the "Imperial Land" and its people in the decade preceding the European war, must share the opinion of those observers who were not able to find much real enthusiasm for France there. That there was much sentimental sympathy for the brilliant nation to the westward, particularly among the wealthier families, cannot be denied. But so far as could be judged, there were not many Alsatians or Lorrainers who would have liked to be French again.
>
> Forty-odd years of separation has not availed to make the inhabitants of the provinces Germans, but they have thoroughly unmade them Frenchmen.[5]

[5] R. H. Fife, "The German Empire between two Wars (1916)," 230–231.

Before the outbreak of the war in 1914 the Alsace-Lorrainers wished autonomy under German rule. After the outbreak of the war many Alsatians have claimed that they have always wished annexation to France. But Mr. Gibbons states:

> This is not true. It would be a lamentable distortion of fact if any such record were to get into a serious history of the period in which we live.[6]

The Alsace-Lorrainers' View

Whatever the attitude of the Alsace-Lorrainers since the outbreak of the war, they hoped for nothing better than autonomy under German rule before 1914. They wished to be as autonomous in directing their local affairs as Bavaria, Baden and Saxony. They are not Germans, neither are they French, they are Alsace-Lorrainers. In a splendid article written before the war, David Starr Jordan summed up the situation thus:

> The present attitude of Alsace is concisely summed up in these three lines of current doggerel:
>
> "Français ne peux,
Prussien ne veux,
Alsacien suis."[7]

The Alsace-Lorrainers value the prosperity that has come to them through being ruled by Germany. If they had been allowed to vote on their remaining with Germany with autonomy or returning as departments to France, they would have voted for the former. But this does not mean that they have any sympathy for imperial aggrandizement as advocated by the Pan-Germanists. They consider themselves as Alsace-Lorrainers, and wish to be left alone. Their slogan is: "Alsace-Lorraine for the Alsace-Lorrainers."

These are the views of the three parties concerned. It has often been suggested by outsiders during the last three years that the settlement of the question should be left to the vote of the Alsace-Lorrainers. It may be that now, instead of voting for autonomy under Germany, they would vote for annexation to France. But this method of solving the question would satisfy neither France nor Germany. France distrusts Germany; she would manipulate the election. Moreover, there would be no provision for the suffrage of those that emigrated, and they are vitally concerned too. If allowed to vote they would turn the election in favor of annexation to France. The Germans

[6] "New Map of Europe" (1914), p. 5.

[7] "Alsace-Lorraine: a Study of Conquest," *Atlantic Monthly,* 113 (1914); 282–287.

would never be willing under the present circumstances to submit the question to a plebiscite. If applied here it would also be applied with justice to Schleswig and Posen. Moreover, the importance of Alsace-Lorraine industrially makes the matter one for settlement by other means. This is a question of national honor to both Germany and France; hence neither would be willing to submit it to a vote of the people.

The Economic Bearings

While Alsace-Lorraine was annexed partially for economic reasons, to-day the Germans desire to keep it for economic reasons of much greater potency than those of 1871. In 1871 it was known that Alsace-Lorraine had coal and iron. But the iron ore was of the kind called *minette*, which contains two per cent. phosphorus; this amount of phosphorus was too large to make it feasible to use the ore. However, in 1878 two Englishmen, Thomas and Gilchrist, invented a modification of the Bessemer process that removed phosphorus from the ore and also produced a slag containing the phosphorus extracted from the ore. This invention benefited Germany greatly. She could now use her hitherto useless iron deposits and use the slag as a fertilizer to enrich the soil at home, and she also exported large quantities of this slag. Germany became a great industrial country. She was particularly well favored by nature. In the Rhine country at Saarbrücken and Essen are rich coal fields, and these are close to the iron mines of Lorraine and Luxemburg. These iron mines are the second largest in the world, those in Minnesota, Wisconsin and Michigan alone being richer. The region between the Moselle and Rhine rivers is the only one in Europe that has both coal and iron close together. In all other cases it is necessary to haul one or the other long distances in order to smelt iron. Owing partly to these circumstances Germany has outdistanced England in the iron industry. In 1914 Germany stood second to the United States in steel output. Before 1871 Germany produced only half a million tons of steel, in 1911 she produced fifteen million tons, and about three fourths of the ore came from Lorraine and Luxemburg. This ore could easily be transported to Saarbrücken and Westphalia, and this fortunate combination of natural resources has produced such new industrial towns as Essen, Elberfeld and Düsseldorf.

In the first weeks of the war Germany took Luxemburg, Belgium and northern France. In Luxemburg she secured the remainder of that rich deposit in northern Lorraine. Belgium and France have rich coal beds. In the Anzin region in northern France nearly three fourths of the French coal supply was produced previous to 1914. So Germany struck a heavy blow at French industry, and greatly strengthened her own resources for carrying on the war. It is plainly evident that if Germany be allowed to retain any of these conquests—Belgium, northern France, Luxemburg—her industrial and military supremacy would be greatly enhanced. She would not only dominate Europe, but also be able to endanger the position of the United States as the foremost steel producer of the world. It is therefore interesting to us Americans to observe that in the allied countries there is an insistence on Germany's giving up not only Belgium, northern France, and Luxemburg, but Alsace-Lorraine as well, in order that she may be so crippled industrially that she may not be able to continue her militaristic policies.

The Alsace-Lorraine question is to-day not merely a question of patriotism and strategic frontier. There is also the economic aspect that seems more important than the other two. Germany could better afford to yield Alsace-Lorraine from the linguistic and strategic standpoints than from the industrial and commercial standpoint.

It is plainly evident that to-day the Alsace-Lorraine problem is still unsolved. Three things stand out clearly: (1) The annexation of 1871 was unjust from the standpoint of the French nation and the Alsace-Lorrainers themselves. (2) If there is any justice in the annexation Germany has failed to convince the Alsace-Lorrainers of it, and has been unable to instil in them a feeling of loyalty and devotion to the Empire. The Alsace-Lorraine question is still a menace to Germany and to the rest of the world. (3) The economic phases of the question have merely complicated it. No matter how the question is settled there will be an injured party, either France or Germany, and probably the people of Alsace-Lorraine too. If Germany loses Alsace-Lorraine her industrial life will be crippled, and she will have a desire for revenge as France has had. This is an exceedingly knotty problem and will be solved only when there is a new spirit actuating nations in their international intercourse. If we can at the close of this war establish a workable system of international government, supported by a new spirit of international friendship and cooperation, the difficulties of the Alsace-Lorraine question will vanish along with many other questions of international friction that promise to disturb the peace of the world for ages to come.

BEEKEEPING AND THE WAR

By Dr. E. F. PHILLIPS

BUREAU OF ENTOMOLOGY

IN former times, beekeeping was a more important branch of agriculture than at present, but the development of trade with the tropics made possible the bringing in of cane sugar and honey production decreased in relative importance. It is far from being a lost art, however, for in normal years the United States produces about 250,000,000 pounds of honey and the amount is increasing steadily. That this much honey is available is a matter of surprise to most people, for many American families never include honey in their menus, and the only honey which many people eat is that which is concealed in cakes for the purpose of keeping them moist for a considerable time. The small amount produced is sufficient to provide a little over two pounds annually for each person, equivalent only to three per cent. of the sugar consumed in years of sugar plenty.

The amount of sugar on every hand in the form of nectar is so great as to stagger the imagination, but some estimate is possible. In a year of prosperity a colony of bees consumes for its own uses a great amount of honey, this amount having been variously calculated as from 200 to 600 pounds. The lower estimates doubtless obtain only for weak colonies, and the average amount may be placed conservatively at 400 pounds. While the bees are gathering this for their own use they are perhaps providing 50 pounds additional which the beekeeper may take, making the estimated total gathering of the colony 450 pounds. An apiary of 100 colonies will frequently, on this estimate, gather 22½ tons of honey in a season. This comes from a territory included within a radius of about two miles. While the beekeeper harvests only a meager 2½ tons, the total of 22½ tons has been produced by the nectar-producing plants in that area. This, it should be remembered, is sugar produced in a region where most persons would not recognize the presence of any sugar production. To assure the sceptical reader, it may be stated that there are often apiaries where the average yield of surplus honey is over 200 pounds, this being the honey which the beekeeper takes for his own use. Yields of 600 pounds to the colony have even been recorded for unusual circumstances.

It is conservative to state that there is every year produced in nectar-producing flowers in the United States more sugar than is consumed by the American people. Obviously, since the bees consume so much, only a small part of this vast wealth can be conserved for human food. The honeybee, so often compelled to serve as an example of industry, does not appear as an efficient collector of human food, when its necessary consumption is recalled. However, any agency for the conservation of this vast sugar supply must be one which is ever on the alert, since the nectar is so soon lost after it is produced. No agency other than the honeybee has as yet been found which will save any of it for man.

Speculation, such as the above, may be subject to criticism, but an unanswerable argument lies in the records of commercial beekeepers. There are thousands of places where commercial apiaries are now established and as the industry expands beekeepers do not experience difficulty in locating additional apiaries all around their home locations. Within the last decade commercial beekeeping has shown a rapid development and yet it would be extremely difficult to find a place where there are so many colonies as materially to reduce the crop. In a few localities beekeeping has been especially developed and if the same progress had been made throughout equally favorable localities, the honey crop would be more than twice what it is to-day. Any one familiar with the conditions surrounding the industry must realize that the crop may be increased ten times without increasing the cost of production per pound.

Why has this sugar supply been so generally wasted? It is not easy to answer this question, but the answer probably lies in the nature of the beekeeping industry. Beekeeping is applied animal behavior. The honeybee is still, after years of human care, in no sense a domestic animal. Its reactions to external stimuli are, so far as known, what they were when cave-men first robbed them of their honey. Man has by selection in breeding changed the color of the abdominal bands in certain strains of Italian bees and he has selected those which are less inclined to sting, but no progress has been made in any fundamental change of bee nature. The successful beekeeper is therefore necessarily a student of bee behavior, so that he may adapt the activities of the bee colony to his ends. He has learned that by providing the proper conditions he may not only increase the gathering power of the bees but he may have a larger part of the honey stored in such shape that he may take it. He has also learned that by attention he may reduce swarming, thus preventing the bees from wasting their energies in making more colonies when he desires honey rather than more bees. But bee behavior is rather a complex subject into which to initiate the average citizen. It is a subject of impelling interest if properly presented but it is so far from the type of study necessary for other branches of agriculture that an insufficient number of people have taken up the work with sufficient thoroughness.

Beekeeping differs from other branches of agriculture in that little land is needed in its pursuit and only in rare cases is it necessary to use land which is useful for other agricultural purposes. The production of honey does not deplete the soil. An important consideration is that the commercial beekeeper is exceedingly busy at just the time when the man engaged in general farming can not find time to give to bees. Beekeeping does not mix well with general farming and must usually be combined either with work other than general farming or with some other specialized branch of agriculture. To a large degree this takes the beekeeper out of the country and it is a fact that most commercial beekeepers live in towns and suburbs. The small amount of land needed, combined with the small necessary expenditure for apparatus makes it safe to say that in proportion to the investiment there is no other branch of agriculture which yields so great a return. However, it must not be assumed that beekeeping is a rapid and easy road to wealth. The returns which the beekeeper receives are directly proportional to the labor and especially to the intelligent care which he invests.

The literature on beekeeping has not been of a type which would induce people to take up the work as a commercial industry. The trouble is not that there are too few beekeepers, for the United States boasts about 800,000, but is rather that relatively few have looked on beekeeping as a possible means of livelihood. A better presentation of the subject might serve to overcome this attitude. No effort need be made to induce more people to keep bees: rather an effort might be made to induce half or more of the present bee owners to sell their bees to good beekeepers in order that the bees might be enabled to produce a crop with the proper care. At present several of the agricultural colleges are maintaining good courses in beekeeping, most of the states have laws providing for the inspection of apiaries to prevent their destruction from infectious diseases and other agencies are assisting in the upbuilding of the industry.

To waste all of this bounteous sugar supply is an economic loss of the first magnitude at any time but never before has this been so forcibly brought home as recently. When the normal sugar supply was reduced people realized as never before the need of a home supply, one not so subject to barbaric ravages on commerce and the perplexities of a restricted production and a more restricted commerce. It is a matter of regret that in 1917 the United States did not save more of the vast store of sugar that is free on every hand. The German nation, with its far-reaching plans for world destruction, had for some years past fostered beekeeping by the giving of bonuses to employees of the national railways if they would engage in beekeeping and similar minor branches of agriculture. We may well pride ourselves that the nation is not dependent on such a means of development but the United States would have been better able to do its share in the war if more attention had been directed to activities such as this.

The entrance of the nation into the war and the shortage of sugar through which part of the country has just passed has wakened an interest in beekeeping, and it is to be hoped that this interest will not lapse when peace is made. Many of the agricultural colleges have begun to urge the better care of bees, the apiary inspectors have assisted in the work, the five journals devoted to beekeeping have rendered valuable service and beekeepers throughout the country have realized more than ever before the need of building up the industry. On the declaration of war the Federal Department of Agriculture began a campaign for increasing the honey crop and the response of beekeepers throughout the country has been most encouraging. It is not the purpose of this article to report what has been done in all lines to bring about this much desired result. An important factor in the increased crop will be the higher price of honey on wholesale markets which has come because of the increased need. It would be difficult to convince beekeepers of this need did not the market prove it to them.

It is desirable, however, to mention one line of activity which from its nature promises the best results. Mention has been made of the fact that beekeeping is applied animal behavior and that the peculiarity of the beekeeper's work has been a retarding factor in the developing of beekeeping as a commercial industry. Literature does not seem to fill the needs of the case for all the necessary details have been printed in a multitude of forms, as government bulletins and as books. It appears that to an unusual degree personal instruction is needed in making better beekeepers, at least until there are more of them available to act as instructors to others in their communities. The Department of Agriculture has therefore incorporated work in beekeeping in the extension activities and while this work is new and tangible results can not be expected so soon, the interest aroused gives assurance of the good which may be expected from this method of instruction. For the author to urge that extension work in beekeeping is more important than in other lines places him liable to a charge of bias but it is pertinent to point out the greater desirability of personal instruction in these branches of agriculture which involve unusual lines of effort and which are somewhat complex in character. The extension work in beekeeping is small in extent. It has been a difficult task to find available beekeepers who have the necessary equipment in a knowledge of bee behavior and also in the practices of the apiary. There are plenty of beekeepers in the United States who have the requisite training, but the improvement of the honey market, due in no small degree to the light thrown on the subject by the recently organized market news service, has made commercial beekeeping so attractive to those who are equipped for it that few of the properly qualified men have been willing to take up this work and those engaged in the work are taking it up as a patriotic labor. The nature of the extension work and the earnestness of the field men who are doing it give promise for most helpful results in saving for the American people more of the vast store of sugar now so largely wasted. It must not be expected that the honey crop of 1918 will be ten times any previous crop, or even twice as large. Much depends on the season, until such time as better beekeeping makes the crop less dependent on seasonal variation. It is safe to say, however, that patriotic beekeepers from one end of the country to the other will make a greater effort than ever before to do their share. They will be encouraged in this by the realization that they are helping. It will also help them to know that others are interested in their success. They will plan to increase their apiaries with the assurance that the beekeeping industry has now the best possible opportunity to prove its usefulness and to establish its rightful place among the multitude of agricultural industries. It would be an untrue and even ridiculous assumption to prophesy that beekeeping will result in a reduction in the sugar consumption of the American people, but its growth will enable us to have a larger supply of a sweet which might with profit replace a considerable amount of the jellies, jams and sirups now so widely used. More honey would serve to reduce the consumption of inferior food products for, as beekeepers so often tell each other, it is " Nature's own sweet."

HOG CHOLERA; ITS ECONOMIC IMPORTANCE AND PREVENTION

By Dr. R. R. BIRCH

CORNELL UNIVERSITY

EVERY "ultimate consumer" knows that there is an insistent demand for more fats and more meat. Every live-stock breeder knows that the grains that formerly have been used to produce these commodities are commanding prices that well-nigh prohibit their use in meat production. Every live-stock statistician knows that our supply of meat-producing animals is diminishing. And every scientist knows that we must have meats and fats. When these facts are forced to our attention with greater emphasis every day, and when we begin to seek a solution of this one of many problems the war has so suddenly thrust on us, we turn instinctively to the hog. And as with Postum, "There's a reason."

The hog is by far the most economical producer of any of our meat animals. Four or five pounds of dry matter fed to hogs in the form of grain will produce a pound of gain; it requires ten or twelve pounds of dry matter to produce a pound of gain in beef cattle. The fat hog yields almost 80 per cent. of his live weight as dressed carcass; the fat steer dresses only about 60 per cent. of his live weight. In addition to the fact that the hog makes the most of every pound of feed given him, he will eat feed that other animals spurn. City garbage, tankage, small potatoes, and the like, he devours with avidity, converting them promptly into palatable and nutritious human food.

The hog reproduces so rapidly that comparison in this respect with other meat-producing animals leaves us wondering how the latter can survive. A good beef cow bred to-day will have to her credit a year from to-day a calf weighing, at best, three hundred pounds. A good brood sow bred to-day will have to her credit a year from to-day three quarters of a ton of finished pork. If she is bred a second time she will also have to her credit at the end of the year from six to ten pigs such as we roast for Thanksgiving. Speaking in mechanical terms we have rapid acceleration applied both to production and reproduction of swine. In fact, we are not much in error in saying that we have arithmetical progression exemplified in reproduction of beef cattle, and geometrical progression exemplified in reproduction of hogs.

Adding to all these advantages the fact that pork may readily be cured so that it will keep weeks and months at room temperature without deterioration, we have in a nutshell the reasons why the hog still finds a place in intensive farming, in spite of the fact that beef cattle are being crowded out.

But with all the outstanding advantages the hog possesses as a producer of meat, he has one vulnerable point. He contracts hog cholera and dies. True, he is subject to many other diseases that are more or less destructive to him, but hog cholera is his Nemesis. When it attacks one hog in a herd, it usually attacks all, and with the exception of a few stragglers, all succumb. In 1914, the disease cost our nation $75,000,000, killing more than 10 per cent. of its swine population.

In this country, hog cholera appeared first in the Ohio valley, in 1833. Its ravages increased as transportation facilities multiplied, and, as early as 1875, when bacteriology as a science was yet in its infancy, the losses caused by it were so extensive that swine breeders regarded it with universal dread, and it was curtailing, in an alarming degree, America's swine industry.

At this time the science of bacteriology was unfolding a new world. The bacteria, or germs, as they were called, that cause some of the infectious diseases, had been discovered and described, and there was an eager and perhaps hurried search in other directions. Hog cholera, because of its tremendous economic importance, became the object of close and prolonged study, and the researches conducted with this disease are among the most interesting that have occurred in the development of the veterinary sciences.

In 1885, Dr. Elmer Salmon and Dr. Theobald Smith announced that they had discovered the cause of hog cholera, and their findings were corroborated and accepted by trained investigators in this country, and in Europe. This organism (*Bacillus choleræ suis*), a member of the colon group, could be isolated in pure culture from the organs of hogs dead of cholera, it could be grown for generations on culture media, and when these cultures were injected back into other hogs they sometimes caused them to sicken and die. Cultures from the organs of these dead hogs revealed the presence of *Bacillus choleræ suis,* and the incriminating evidence was regarded as complete.

Meanwhile the science of preventive medicine was developing rapidly, and vaccines, serums, and bacterins had sprung into existence. Pasteur had produced vaccines that prevented fowl cholera, rabies, and anthrax, and scientists were eagerly seeking to prevent other infectious diseases in a like manner.

Here again, hog cholera received its share of attention, but all the efforts to produce an effective vaccine by using cultures of *Bacillus choleræ suis* ended in disappointment. Outbreaks of hog cholera still occurred in the field with the same deadly results, and hog raisers still continued to buy nostrums of all descriptions in the forlorn hope of checking the ravages. This state of affairs continued until the close of the nineteenth century, at which time there was a growing belief among some scientists that *Bacillus choleræ suis* was not the real cause of the disease.

This belief was supported by certain facts which will be mentioned presently, and consequently a further search was made for the organism responsible for this disastrous disease. The outcome was that in 1903 de Schweinitz and Dorset of the United States Bureau of Animal Industry announced that it was caused by a filterable virus. This announcement was received with considerable skepticism by those who had followed the long and difficult trail of the *Bacillus choleræ suis*, and who had for eighteen years accepted without doubt its etiological connection with hog cholera. Had not the organism been found repeatedly in the organs of hogs dead of cholera? Had it not been isolated in pure culture and grown in the laboratory for generations? Had not the cultures produced disease and death in hogs to which they were given? Was not the organism found in pure culture in the organs of hogs thus killed? In short, had not *Bacillus choleræ suis* conformed to Koch's dicta?

As a matter of fact it had not wholly, because cultures did not produce disease and death with any degree of regularity. Closer study also revealed the fact that hogs to which the cultures were given did not develop lesions precisely similar to those found in hogs dead in field outbreaks, nor did these artificially infected hogs transmit disease to healthy ones in contact with them. Finally, it was found that hogs artificially infected, and recovered, were not immune to outbreaks of natural infection. Thus there were good reasons to doubt whether *Bacillus choleræ suis* caused hog cholera.

On the other hand, the evidence against the filterable virus was piling higher and higher. Repeated experiments showed that blood from cholera-infected hogs when passed through fine filters capable of removing all visible bacteria (*Bacillus choleræ suis* included) still remained constantly infectious. More than that, the few hogs that sickened as a result of doses of the filtered blood, and subsequently recovered, were found to be immune to field outbreaks of hog cholera. The mask was at last removed and the filterable virus, after remaining in disguise eighteen years, was revealed to the scientific world as the true cause of hog cholera. Although it did not conform entirely to Koch's dicta, in that it could not be grown in the laboratory, the evidence against it was so conclusive that it was allotted a conspicuous place in the rogue's gallery.

But the filterable virus of hog cholera is found to be far less amenable to the Bertillon system than is *Bacillus choleræ suis*. The latter organism is easily visible with the compound microscope, it grows readily and somewhat characteristically on common culture media, producing gas and acid with a regularity comparable to that observed in chemical reactions. The filterable virus will do nothing of the kind. So far it has refused to grow in any culture medium except the hog; so far it is distinguished by what military men might term "low visibility," at least it is invisible with the strongest microscope; so far its morphological characteristics remain unknown, so it has been placed, in company with others of its stripe, in the pigeon-hole labeled "filterable viruses." Meredith spoke a great truth when he said, "Mankind is the sport of invisible powers."

But after all, what difference does it make how a certain organism behaves in the laboratory if its ravages in the field can be controlled? After numerous baffling attempts directed toward growing the filterable virus artificially, scientists turned their attention toward the latter problem. One fact gave great promise. There was observed an active life-long immunity in hogs that had recovered from hog cholera. Could this immunity safely be produced artificially?

Because the virus could not be grown in the laboratory, vaccines prepared in the usual manner were out of the question. Serum from immune hogs gave disappointing results, but it remained for Dorset, Niles and McBride, of the United States Bureau of Animal Industry, to demonstrate that immune hogs will tolerate enormous doses of blood drawn from hogs sick with cholera, and that subsequently blood from these immunes, or hyperimmunes, as they are called, will prevent cholera in susceptible swine. This blood became known as anti-hog cholera serum. But the immunity produced proved to be of short duration, unless the hogs treated for protection were exposed to hog cholera near the time at which the serum was administered, so it came to be the practise to produce this exposure by injecting each animal with a small quantity of hog cholera blood at the same time that serum treatment was given. It was found that this produced a lasting immunity, and that it involved but little danger to the animals thus treated.

The product known as anti-hog cholera serum is nothing more than the defibrinated and carbolized blood of hogs that, prior to bleeding, have had their immunity built up by enormous doses of hog cholera blood. Under ordinary circumstances, one cubic centimeter of hog cholera blood will kill a two-hundred-pound susceptible hog, but the immune hog of like size will tolerate a quart of this blood injected into the blood stream.

Anti-hog cholera serum, before being sent into the field for use, is subjected to rigid tests to prove its potency, and when it is carefully prepared it passes these tests with clock-like regularity. It is required to protect hogs given sufficient doses of hog cholera blood to kill them, and exposed, in addition, to natural infection by being placed in a pen with hogs sick with cholera. And it is with a feeling akin to triumph that the serum producer observes his serum-treated hogs surviving the ordeal with no outward signs of disease.

Is hog cholera conquered? Not by any means, but we have in our hands the instrument with which it is possible to conquer it. We can say to any individual breeder with perfect confidence that he does not need to lose his hogs with cholera unless he elects to do so. But our weapon is double-edged, and it is not without flaws in workmanship.

When hogs are treated with serum and virus to produce a permanent immunity, one occasionally sickens, to the extent that he secretes hog cholera virus in his urine. This virus is just as dangerous for other hogs as it would be were the sick hog naturally infected with cholera. In the immediate herd treated this makes no particular difference, because all the hogs are immunized, but new centers of infection may sometimes be produced, from which the virus may find its way to other herds. This danger is greatly augmented when untrained men use serum and virus, and it grew to be so serious that even private serum laboratories, interested in selling as much serum as possible, refuse to sell their products to others than graduate veterinarians, because they realize that if these products are used by untrained men, they will, in the long run, be discredited.

The danger incident to untrained men in the field is no greater than that due to untrained men in the laboratory. The federal government has recognized this fact, and it now places an inspector in every laboratory that manufactures serum for inter-state shipment. The business of the inspector is to see that the laboratory is kept clean, and that the serum offered for sale is carefully handled and tested.

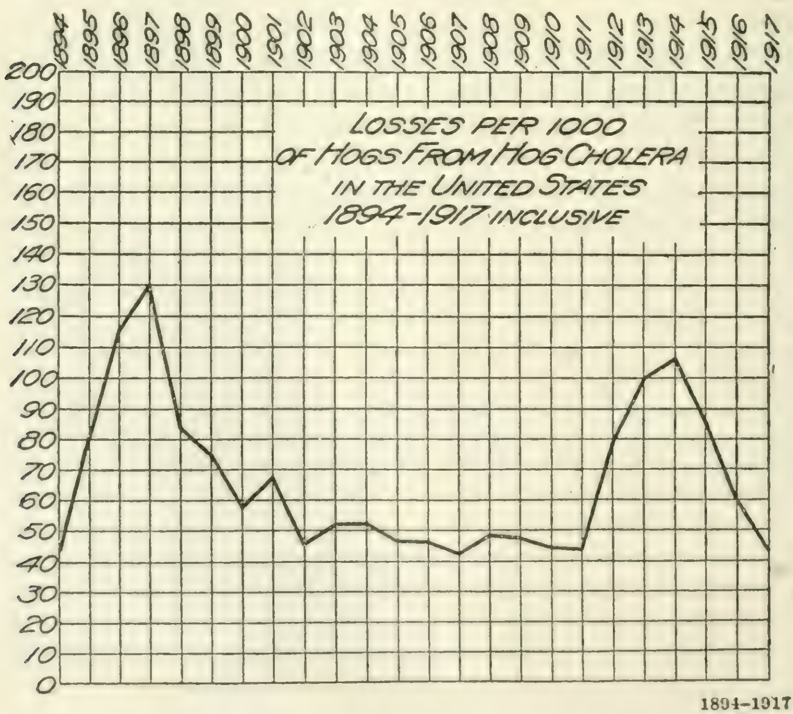
Even when there is a plentiful supply of potent serum, though, there are various obstacles that militate against its most effective use in the field. It is used as a cure instead of as a preventive, it is used to prevent diseases incorrectly pronounced hog cholera, serum alone is used when both serum and virus are required, and *vice versa*. Each time serum is wrongly used and bad results follow, there is created a certain degree of skepticism regarding its effectiveness.

Added to these obstacles we have constantly with us certain well-meaning but half-informed persons who enthusiastically advise all farmers to have their hogs treated with serum. Such advice is almost equally absurd as would be the order of a fire chief who would direct his men to dash down the street with the chemical wagon, squirting soda and acids indiscriminatingly in all directions, because one house happened to be on fire. Obviously the efforts should be directed at the seat of the trouble, and at points where danger appears imminent. It is also true that unconsciously, perhaps, there has been a certain relaxation in the enforcement of quarantine regulations since hog cholera serum came into use, and the serum has too often been regarded as a substitute for sanitary measures, rather than as an adjunct to them.

What is the attitude of hog raisers toward hog cholera serum? This is an important consideration, because it must ultimately determine success or failure, as far as hog cholera control is concerned. Skepticism prevailed when the discovery was first announced, and even to-day, ten years after that announcement was made, this skepticism is not wholly dispelled. But to those of us who are engaged in the manufacture and use of serum, the wonder is that so much, rather than that so little, progress has been made. Scientists are likely to complain that their devious trails are not closely followed by those whom their efforts are supposed to benefit, and from time to time various educators complain, and too often with justice, of the vast store of useful knowledge that has received decent burial in books. But Emerson's law of compensation remains always effective, and there is one great advantage associated with the fact that the layman does not follow the scientist too closely. He may meet the scientist coming back.

In the case of hog cholera serum, though, this skepticism, now fast disappearing, has worked great harm to our swine industry, and it has been fostered, not only by certain swine breeders who have to be shown, but by certain "quacks" in the veterinary profession. The doubting farmer is the one who has for years been trying every form of nostrum advertised to prevent or cure hog cholera. The doubting "quack" is the man who has prepared the nostrums.

Nevertheless, it is true that in the great hog-raising states of the Union, there exists to-day no doubt in the minds of progressive hog raisers as to the effectiveness of hog cholera serum. In fact this confidence is so strong that from time to time there arises a short-sighted but insistent demand that hog cholera serum shall be made and distributed free as a



1894–1917

FIG. 1. Losses from Dog Cholera in the United States for the years ending April 1, 1894–1917.

governmental function. This would entail an immense and unnecessary expenditure of public funds, because thousands of doses of serum would then be used without cause, and the supply to meet the legitimate demand would be insufficient. Worse still, serum would be used universally as a preventive of practically every malady that affects swine, and every failure would help to break down confidence in its effectiveness.

What progress is actually being made toward the suppression of hog cholera? One hesitates to quote statistics because one is always reminded of a certain analogy that might be suspected of existing between a person quoting statistics, and the devil quoting Scripture. But I am venturing to include a curve prepared by Dr. J. R. Mohler, chief of the Bureau of Animal Industry, illustrating in graphic form the annual losses from hog cholera throughout a term of years.

If we remember that hog cholera serum came into use in 1908, and if we examine this curve with that fact in mind, we do not at first see much encouragement in the figures presented. But if we remember that during the years when the curve was ascending the facts regarding the effectiveness of hog cholera serum were not generally known, if we remember that its use was but imperfectly understood, if we remember that during those years the supply of serum was far short of the demand, we gain a new understanding of the situation.

Further, when we are told that as far back as 1887, the annual losses from hog cholera reached a proportion of 120 per thousand, and in 1897, a proportion, as the curve shows, of 130 per thousand, we are inclined to believe that the wave whose crest was reached in 1914 was in reality a wave cut short. The downward tendency of the curve since 1914 gives renewed encouragement, but while we must wait several years before we can be sure that this downward direction is maintained, and that it is due to the use of serum, rather than to a normal fluctuation, we believe it can truly be said that out of the misunderstandings and chaos inevitably wrought by a remarkable discovery of his kind, there is steadily and surely being constructed a beaten trail leading to the goal—the complete control of hog cholera.

DOES CROP ROTATION MAINTAIN THE FERTILITY OF THE SOIL?

By J. E. GREAVES

CHEMIST AND BACTERIOLOGIST, UTAH EXPERIMENT STATION

FROM time immemorial it has been considered a self-evident fact that where crop rotation is practised there is a bigger and better yield. The farmers of ancient Rome understood that crops following beans, peas and vetches were usually better than those following wheat or barley; but it was not until the last quarter of the nineteenth century that it was learned that the legumes with the aid of associated bacteria has the power of feeding on the free nitrogen of the air, while the non-leguminous plant has not this power and requires a supply of combined nitrogen. To-day we find the best farmers practising some system of crop rotation. They have learned from experience that where crop rotation is practised the crops are bigger and better than where the single crop system is followed. This is usually interpreted as indicating that crop rotation has increased the fertility of the soil. We find many farmers planting legumes for a number of years on rundown soil, each year removing the entire crop and feeling confident that their soil is becoming richer in plant food. Let us examine some of the results which have been obtained in carefully planned experiments to see if this conclusion is warranted by the experimental evidence.

Plants are composed of ten elements, each of which is absolutely essential to their growth and formation. Only two —carbon and oxygen—are secured from the air by all plants, only one—hydrogen—from the water; the other seven are secured by all plants from the soil. One class of plants—the legumes—may, under appropriate conditions, obtain their nitrogen from the air. Six elements—phosphorus, potassium, magnesium, calcium, iron and sulfur—are obtained entirely by the growing plant from the soil.

The great majority of agricultural soils contain large quantities of all these essential elements, with the exception of nitrogen, phosphorus and potassium. These are used by the growing plant in larger quantities than are any of the other elements which are obtained direct from the soil, and in the great majority of soils nitrogen, phosphorus, or potassium is the limiting element in crop production. Therefore our problem resolves itself into the question: Can crop rotation maintain these elements in the soil in quantities sufficient for maximum yields? Phosphorus and potassium are obtained by the growing plant only from the soil; it is, therefore, self-evident that no simple system of crop rotation can maintain the phosphorus and potassium, since the quantity within the soil must of necessity be reduced with each crop removed; the extent depending upon the specific crop grown; hence, nitrogen is the only element which we can hope to maintain by crop rotation. This is the element which is found in the soil in smallest quantity and removed by most plants in larger quantities than the phosphorus or potassium. Moreover, large quantities of this element are at times lost from the soil by leaching, while the loss of the others is comparatively small. It is of the greatest importance, therefore, that nitrogen be supplied to the soils in sufficient quantities for maximum crop production and in the cheapest manner possible. The total quantity of these three elements found in an acre-foot section of two Utah agricultural soils, assuming one acre-foot to weigh 3,600,000 pounds, is given in Table I.

TABLE I. POUNDS PER ACRE OF TOTAL NITROGEN, PHOSPHORUS AND POTASSIUM IN AN ACRE-FOOT OF SOIL FROM THE UTAH GREENVILLE AND NEPHI EXPERIMENTAL FARMS

	Greenville Farm, Pounds per Acre	Nephi Farm, Pounds per Acre
Nitrogen	4,904	3,744
Phosphorus	2,700	8,388
Potassium	60,560	87,840

Both soils contain an abundance of potassium, but the supply of phosphorus and nitrogen is much lower. A study of these results reveals the fact that a fifty-bushel crop of wheat each year for forty-nine years would remove the equivalent of the total quantity of nitrogen in the Greenville soil to a depth of one foot, while a similar crop on the Nephi farm would accomplish this in just thirty-seven years. It would, however, require a fifty-bushel crop 170 years to remove the phosphorus from the Greenville soil and 525 years to remove it from the Nephi soils. Of course a crop would never remove all the nitrogen or phosphorus from a soil, but in actual practise the elements are slowly removed; the crop yields being reduced each year until a certain minimum is reached. When crops can no longer be produced economically then the owner abandons his soil, moves on to virgin soils, or if it be in an old district he resorts to the expensive commercial fertilizer. The illustration is, however, sufficiently accurate to make it clear that the limiting factor, in so far as soil fertility is concerned in both of these soils, is the nitrogen. And it is true of the great majority of all soils that an increased nitrogen supply means an increased yield. This principle is one of the fundamentals of soil fertility.

Nitrogen exists in the atmosphere in inexhaustible quantities, every square yard of land has seven tons of nitrogen lying over it or if the quantity covering one acre could be combined into the nitrate it would be worth as a fertilizer $125,000,000. Now it has been demonstrated that the legumes—peas, beans, alfalfa, etc.—when properly infected have the power of feeding on this limitless supply of atmospheric nitrogen, while the non-legumes—barley, wheat, oats, etc.—must depend upon the supply within the soil. The farmer should take advantage of this fact to supply nitrogen for his crops, as the commercial fertilizer can not be used economically for the production of most crops, as is seen from the fact that the nitrogen in a 50-bushel wheat crop would cost $14.40, 20 tons of sugar beets $15.00 or one ton of alfalfa hay $7.50 if bought as a commercial fertilizer. But will the legume draw nitrogen from the atmosphere while there is a supply in the soil, or will it follow the line of least resistance and turn only to the atmosphere when nitrogen is lacking in the soil? If it does, it must first drain the soil of its valuable nitrogen and thus leave it no richer than it was before the legume was grown upon the soil. This is the problem which this paper is to answer.

Crop rotation has been practised for centuries, but the oldest system of which we have accurate information is the one on Agdell Field at the Rothamsted Experiment Station. This system was inaugurated in 1848 and is still being carefully followed. It consists of a four-year rotation as follows:

First year—Swede turnips (rutabagas)
Second year—barley
Third year—clover or beans
Fourth year—wheat

Still another system has been running parallel and similar to this, except that fallow cultivation is practised in the third year instead of growing a legume. The average yields for twenty-year periods are given in Table II. These systems are of especial interest to the farmers of Utah, for when we substitute sugar beets for the turnips, and alfalfa or peas for the clover or beans, we have nearly an ideal rotation for our soils.

TABLE II. AVERAGE 20-YEAR YIELDS FROM AGDELL FIELD, ROTHAMSTED STATION

Crop	Legume			Fallow		
	Yield 1st 20 Years, 1848–68	Yield 2d 20 Years, 1868–88	Yield 3d 20 Years, 1888–1908	Yield 1st 20 Years, 1848–68	Yield 2d 20 Years, 1868–88	Yield 3d 20 Years, 1888–1908
Turnips						
Roots pounds	5,264	1,723	967	5,785	3,067	2,502
Leaves pounds	600	447	242	629	538	458
Barley						
Grain, bus.	38.0	22.5	13.7	37.0	22.8	15.9
Straw pounds	2,373	1,496	1,172	2,244	1,489	1,172
Wheat						
Grain, bus.	29.6	21.1	24.3	34.5	23.2	23.5
Straw pounds	3,169	2,082	2,445	3,761	2,420	2,412

Even where the legume was used in the system there has been a decline in the yield. The yield of the turnips during the first twenty years was 5,264 pounds, the second 1,723, and the third only 967 pounds, thus showing a decrease to about one sixth the original in sixty years. The results with the barley are no better, for we find a drop from the fair yield of 38 bushels per acre during the first period to only 13.7 during the third. The wheat which followed the legume in the rotation, and hence occupied the most-favored place in the system, shows a decrease of 5.3 bushels. Not even a good yield has been maintained for the clover, for from 1850 to 1874 the average yield was 4,165 pounds, while from 1882 to 1906 the yield was only 1,246 pounds. In reality we find no greater decline in the yields where fallow cultivation is practised. But both systems strongly testify to the fact that rotation is not maintaining the productive powers of this soil. And the evidence is strong that the legume gets no more nitrogen from the air than that which is removed with the plant. Otherwise we should expect better results in the legume system than in the fallow system.

That the alfalfa, when grown on fertile soil and the crop removed, does not increase the nitrogen of the soil is seen from experiments conducted by Dr. Hopkins at the University of Illinois. The experiment was made possible by the fact that many of the Illinois soils do not normally contain the symbiotic bacteria thus making it impossible for the alfalfa to obtain nitrogen from the air. This being the case, a field was taken which had not grown alfalfa and hence did not contain the symbiotic nitrogen-gathering bacteria. This was planted to alfalfa, only one half of it being inoculated with the legume organism. To some of the plots were added lime and phosphorus to make sure that these were not the limiting factors. The results thus obtained are given in Table III.

TABLE III. FIXATION OF NITROGEN BY ALFALFA IN FIELD CULTURE, ILLINOIS EXPERIMENTS

Plot No.	Treatment Applied	Pounds in Crop		Pounds Nitrogen Fixed by Bacteria
		Dry Matter	Nitrogen	
1*a*	None	1,180	21.81	
1*b*	Bacteria	2,300	62.04	40.23
2*a*	Lime	1,300	26.20	
2*b*	Lime bacteria	2,570	68.02	41.82
3*a*	Lime phosphorus	1,740	35.40	
3*b*	Lime phosphorus bacteria	3,290	89.05	53.65

It is evident from these results that the alfalfa has obtained from 40 to 53 pounds of nitrogen from the air, depending upon the treatment. There was slightly more than one third as much nitrogen in the alfalfa crop from the uninoculated as in the inoculated. Therefore, it is quite evident that the alfalfa in these plots had obtained one third of its nitrogen from the soil and two thirds from the air. Now, nitrogen is required by the root for its growth as well as for the growth above the ground, and we have every reason for believing that the root also would obtain it in the same proportion from air and soil as did the hay crop.

Now, if we examine dry matter and total nitrogen occurring in the roots and stalks of alfalfa, we should be able to decide whether more nitrogen is being returned to the soil in the roots and residues than is removed by the growing plants.

The results for this comparison have been obtained from Illinois and Delaware experiments and are given in Table IV.

TABLE IV. PROPORTION AND COMPOSITION OF TOPS AND ROOTS OF SOME LEGMUES

Legume	Dry Matter per Acre, Pounds	Nitrogen per Acre, Pounds	Per Cent. of Total Nitrogen in Tops
Sweet Clover			
Tops	9,029	174	76
Roots and residues	3,748	54	
Crimson Clover			
Tops	4,512	103	70
Roots	2,022	41	
Alfalfa			
Tops	2,267	54.8	60
Roots	1,980	40.4	

With the clover three fourths of the total nitrogen is found in the plant above ground and only one fourth in the roots, while the alfalfa shows a greater proportion in the roots—40 per cent. This represents the proportion for the first-year growth for alfalfa and it is not likely that in the older plant this high proportion of the total nitrogen would be maintained in the roots. It is quite certain that if only two thirds of the total nitrogen of the plant is obtained from the air the quantity returned to the soil with the roots and plant residues does not exceed that removed from the soil by the growing plant, which would give no increase in soil nitrogen from the growing of a legume where the entire crop is removed. And this even where the roots are allowed to remain and decay; yet we find some farmers who remove the roots from the soil and even then expect an increase in their soil fertility.

It is therefore quite certain that the legume, where the crop is harvested, does not increase the soil nitrogen of the fertile soil of Illinois and other soil fairly rich in nitrogen. But what will happen on the arid and semi-arid soil where nitrogen in many cases is the limiting element and is present in much smaller quantities than it is in the soils on which the experiments considered have been conducted. Experiments which have been conducted at the Utah Experiment Station during the last twelve years have demonstrated that even on soils poor in nitrogen the legume first feeds upon the combined nitrogen of the soil. It is known that plant residues and other complex nitrogen compounds found in the soil are transformed by bacteria into ammonia and this in turn by another class of bacteria into nitric nitrogen, and it is mainly on this nitrogen that the growing plant feeds. The quantity of this found in the soil at different periods under different plants has been measured at the Utah Experiment Station and the average results for twelve years are given in Table V.

Table V. Nitric Nitrogen found under Various Crops at Different Seasons of the Year, Pounds per Acre to a Depth of Six Feet

Crop	Spring	Midsummer	Fall	Average
Alfalfa	22.3	15.8	32.8	23.6
Oats	35.7	14.1	20.6	23.5
Corn	24.8	18.9	22.0	21.9
Potatoes	81.1	60.8	54.2	65.3
Fallow	81.5	53.6	62.6	65.9

Here we find the legume alfalfa, removing the nitric nitrogen from the soil just as fast as do the non-legumes. Yet this soil was well inoculated with the symbiotic bacteria which undoubtedly assisted the alfalfa in obtaining free nitrogen from the air when needed, but not until the soluble nitrogen had been drained from the soil to its full extent, as is shown by the fact that alfalfa soil never contains more than does oats and corn land and is very poor as compared with potato and fallow soil.

It may be argued that the small quantity of nitric nitrogen in the alfalfa soil is due to a lack of its formation, as it is not needed by the legume, hence not formed; but this conclusion is not warranted by the facts in the case, as may be seen from the results obtained where the speed of formation of nitric nitrogen (nitrification) was measured. These also are the average results extending over a number of years and obtained at the Utah Experiment Station.

TABLE VI. MILLIGRAMS OF NITRIC NITROGEN PRODUCED IN 100 GRAMS OF SOIL IN 21 DAYS

Crop	Spring	Midsummer	Fall	Average
Alfalfa	3.15	7.48	3.08	4.56
Oats	2.40	4.00	3.00	3.13
Corn	2.18	3.50	1.48	2.38
Potatoes	3.00	15.55	5.60	8.04
Fallow	1.30	5.50	2.48	3.09

Here we find the quantity of soluble nitrogen produced in the alfalfa soil greater than that produced in either the oat or alfalfa soil, and there is no doubt but that this is one reason why an increased yield is obtained the year following the plowing up of an alfalfa field; for this increased nitrification is noted for several years after an alfalfa field is planted to some other crop. This is due to the alfalfa plant stimulating bacterial organisms of the soil so they make available faster the nitrogen of the soil, but this only depletes the soil of its nitrogen more readily than does the non-legume, for it is the nitrogen already combined in the soil on which the nitrifying organisms act. Hence, we must conclude that alfalfa not only feeds closer on the soluble nitrates of the soil, but it also makes a greater drain upon the insoluble nitrogen of the soil by increasing the nitrifying powers of the soil, and would therefore deplete the soil, if the entire crop be removed, more readily than would other crops, a conclusion which is borne out by the direct analysis of the soil. For the analysis of a great number of Utah soils which have grown various crops for a number of years—some of them having been into alfalfa or wheat for upward of thirty years—revealed the fact that almost invariably the alfalfa soil contained less total nitrogen than did the wheat soil. The average for a great number of determinations made from alfalfa soils was 7,232 pounds per acre of total nitrogen, while the average for a great number of wheat soils was 7,398 pounds.

These are average results from a great number of determinations made on adjoining alfalfa and wheat soil and they clearly indicate that in ordinary farm practise the alfalfa is making just as heavy a drain upon the soil nitrogen as is the wheat.

Hence, from a consideration of the yields obtained in crop rotation, the relative quantities of nitrogen obtained from the atmosphere and the soil by the alfalfa, the feeding and stimulating effect of the alfalfa upon nitrates, and finally the actual quantity of total nitrogen remaining in the soil after wheat and legumes, we must conclude that the legume does not increase the nitrogen of a common agricultural soil—even in the arid region where the nitrogen is low—when the entire crop is removed.

This conclusion does not, however, mean that crop rotation should not be practised, for there are many reasons why crop rotation commends itself to the careful farmer, but it must not be used and the legume removed with the intention of maintaining soil fertility. This may appear to be an unfortunate conclusion, but it is just the reverse, and if its teachings are heeded it means a fertile soil and an economic gain to the farmer from the system of farming which it requires him to adopt.

There are two practicable methods of maintaining the nitrogen content of the soil. First, planning systems of crop rotations with legumes, the legumes being plowed under and allowed to decay, thus furnishing nitrogen to the succeeding crop. Second, practising a combined system of crop rotation and livestock farming.

Three tons of alfalfa contain 150 pounds of nitrogen, all of which we could assume came from the atmosphere; assuming the quantity found in the roots as coming from the soil. This is the equivalent of the nitrogen found in the grain and straw of seventy-five bushels of wheat. If the alfalfa is plowed under some of the nitrogen would be lost to the growing plant in the processes of decay and leaching, but that the total nitrogen of the soil may actually be increased by the turning under of the legume is certain from field experiments.

The Dominion of Canada Experiment Stations grew mammoth clover for two successive seasons on a soil very low in nitrogen. The two cuttings of mammoth clover with all the residues were turned under each year with the results that the soil gained as an average 177 pounds per acre of total nitrogen which is the quantity of nitrogen found in three forty-bushel crops of wheat, provided the straw was returned to the soil, as two tons of this contains 20 pounds of nitrogen. On the other hand, work on the soil of the Utah Nephi Experiment Farm, with a rotation of wheat and peas where the peas were plowed under, showed a gain in total nitrogen of 240 pounds in four years. That is, in addition to furnishing the small quantity of nitrogen required by the wheat crop, the peas had added to the soil an average of 60 pounds of nitrogen per year.

The second method of maintaining the nitrogen and organic matter of the soil—the combined rotation and livestock method—is the more practical and if systematically practised will not only maintain the nitrogen of the soil but will prove of great economic value to the individual following it. For it consists of a rotation in which the legume plays a prominent part. The legume to be fed and all the manure returned to the soil: This would mean the selling from the farm the hay crop in the form of butter, milk, or beef which carries from the soil only a fraction of the nitrogen stored by legume; moreover, it brings for the producer much greater returns than does the system in which the legume is completely removed from the soil.

It must, however, be remembered that in this system only about three fourths of the total nitrogen of the feed is recovered in the dung and urine. So that in place of three tons of alfalfa adding 150 pounds of nitrogen to the soil from the air, it would add only 120 pounds and this on the condition that all of the liquid and solid excrements are collected and returned to the soil. But where the alfalfa is to be fed and the manure returned to the soil, the legume can occupy a much longer period in the rotation and that with greater economy than where the legume is to be plowed under directly.

Hence, we find that if these principles which have been established for soils even low in nitrogen be systematically applied it will result in greater revenue from an increased livestock industry and will maintain the soil rich in nitrogen and organic matter in place of depleting it of its stored-up nitrogen, as is so often the case with the present methods.

THE INTERRELATIONS OF ANIMALS AND PLANTS AND THEIR INFLUENCE UPON THE FOOD SUPPLY OF MAN

By Professor ROBERT W. HEGNER
THE JOHNS HOPKINS UNIVERSITY

CHARLES DARWIN in the "Origin of Species" gives several interesting examples of the "complex relations of all animals and plants to each other in the struggle for existence."[1] One of these is very frequently cited, namely, that of the influence of cats upon the clover crop, since cats catch field mice, and field mice destroy more than two thirds of the bees which are alone instrumental in pollenizing red clover. What will happen when the equilibrium of nature is disturbed by the introduction or extermination of a certain species of plant or animal, is in any case difficult to predict. We know comparatively little about the biological results of changes in the fauna and flora, but certain of the more direct effects of one sort of organism upon the welfare of another in a widely different sphere of life have been carefully worked out. Some of the relations revealed are indeed startling and, economically considered, effectually transpose many apparently harmless organisms into the highly injurious class. Of particular interest at the present time are those relations between organisms that influence the food supply of man.

We are all most familiar with the animals that may be used directly as food. Among these are the domesticated mammals, such as the cattle, sheep and pigs, and mammals that are still wild but have been hunted extensively in the past for food and some of which are still of value in certain localities. Among these are the opossum, the bear, seals, squirrels, rabbits, muskrats, woodchucks, deer, moose, caribou, elk, mountain sheep and mountain goats.

The domesticated birds are only second to the domesticated mammals in food value. Most important of these are the chickens, geese, ducks, guinea fowls, turkeys and pigeons. As among the mammals, there are many wild birds that might form part of our bill of fare, but unfortunately we have in the

[1] "The Origin of Species," 6th edition, 1872, pp. 55–59.

past so thoughtlessly abused this "inexhaustible" natural resource that now the grouse, bobwhites, pheasants, turkeys, wild ducks, wild geese, plovers, snipes and wild pigeons are all but exterminated and are of practically no value to us.

Among the principal reptiles of food value are the turtles, such as the diamond-back terrapin, soft-shelled turtle and green turtle.

The amphibia are of very little importance, furnishing us only frogs' legs. Efforts have been made to carry on frog "farming," but these have not been very successful in close quarters, because the frogs eat each other, and their food, of small animals, can be obtained for them only with difficulty.

Fish, on the other hand, have been for centuries one of man's most abundant food resources, and both the federal and state governments are now expending large sums to plant new waters or to restock depleted fishing grounds.

Shellfish, likewise, have figured strongly on human bills of fare from the days of primitive man to the present time. Oysters have been particularly favored. Other shellfish that are commonly eaten by human beings are the soft-shell clam, razor-shells, hen clams, mussels and scallops. Certain large snails are considered a delicacy, especially by the French, and squids are eaten by some people, particularly the Chinese and Italians.

The sea serves as a pasture for many species of edible Crustacea. Of these the most important are the lobsters, blue crabs, and shrimps. Freshwater crayfishes are not used as extensively as food, but the growing scarcity of lobsters makes it probable that raising crayfishes for market may soon become a flourishing industry.

It is evident from the above list that man has in the past been indebted for much of his food supply to wild animals, which have come to him with no more effort than that required to capture and distribute them, and this list has been presented simply to remind us of the extent of our indebtedness to them.

Not only are many kinds of animals used directly as food by man, but certain of them manufacture food products that we would greatly miss if we were deprived of them, such as milk, butter, cheese, eggs and honey.

Each of these food animals has its own particular part to play in the struggle for existence, and its value to us makes its enemies our enemies. Among the most conspicuous destructive animals are the predacious mammals. The relations of predacious mammals to other animals and to man are very complex and each species must be examined separately in order to determine its economic status. Space allows us, however, only room for a few general statements. Where uninfluenced by the presence of man, a balance is struck between these flesh-eaters and the herbivorous animals upon which they prey. Often their activities are of real benefit, since vast numbers of rabbits, mice and other harmful species are destroyed by them. The more important predacious mammals are the wolf, coyote, mountain lion, bear, lynx, fox and mink. The wolf is particularly destructive in localities where domesticated animals are reared in large numbers. Lack of their natural food, which formerly consisted of wild game, principally bison, has decreased their numbers almost to the vanishing point, and the relentless war waged upon them by man has all but exterminated them. Wolves and coyotes also have beneficial qualities, since they destroy prairie dogs, ground squirrels and other harmful rodents, but these are far outweighed by their destruction of wild game and domesticated animals. Mountain lions kill deer, young elk and other food animals. The bear and lynx are too rare to be of much importance; the fox and the mink prey upon both wild and domesticated birds, but often pay for their depredations by destroying obnoxious insects, field mice, ground squirrels and rabbits.

Less conspicuous than the predacious mammals, but of greater economic importance, are the parasitic organisms, most of which are very small, but none the less effective. Mention may be made of the threadworms, such as syngamus, which causes the disease known as gapes in poultry and game birds; and the stomach worm of the sheep; of the tapeworms, such as that of the dog, which spends part of its growth period lodged in the brain of certain food mammals—they cause "gid" or "staggers" in sheep; of the liver fluke which likewise attacks sheep; and of several extremely minute species belonging to the lowest group in the animal kingdom—the protozoa. Of the last named, one of the most important is the microscopic organism that causes Texas-fever in cattle. The life history of this organism may well serve as an illustration of the interrelations of animals widely separated in the animal series. The fever organisms or germs live in the blood corpuscles of sick cattle. They are often sucked into the bodies of ticks which infest these cattle, and after multiplying for a time, some of them become lodged in the eggs of the tick. These eggs are laid on the ground and the young germ-infested ticks that emerge from them cling to grass blades or weeds waiting for cattle to brush against them. When this happens they fasten themselves to the animal's body and begin to suck their blood. Some of the fever germs are injected into the blood of the victim during this attack and Texas-fever in due time results. Thus this apparently insignificant organism aided by an apparently harmless tick causes an annual loss of about sixty million dollars to the people living in the fever district and a corresponding decrease of our food supply.

The control of the Texas-fever tick is very simple. The adult ticks die after laying their eggs, and the young die if they do not gain access to cattle within a few months. A pasture may thus be freed from ticks if left vacant for a few months. Ticks may also be removed from cattle by dipping the animals in vats containing substances such as crude petroleum or arsenical mixtures which kill the ticks.

Animals that destroy or lessen the value of food plants and their products are frequently overlooked. Every one who has attempted to raise garden vegetables or fruit knows what constant attention is necessary to prevent potato beetles, squash bugs, San José scales, codlin moths and other insects from preventing a harvest. So numerous and varied are these insects that the general impression arises that all insects are injurious. This however is far from true, since many parasitic species cause the death of countless harmful ones, and in fact, by holding the latter in check, are responsible for preventing the production of such mighty hordes of greedy pests that we are actually saved from starvation by their efforts.

For example, the minute tachina flies really make it possible for us to raise grain in many localities, since they destroy enormous numbers of army worms. The army worm is a black and yellow striped caterpillar about one and one half to two inches long when full-grown. It is the young of an inconspicuous dull-brown moth. Sometimes these caterpillars become so numerous that they are forced to migrate in search of food, like a foraging army. Crops over large areas are eaten by the worms with tremendous loss to the farmer and indirectly to the food-consuming public. Fortunately the tachina flies increase as rapidly as the army worms which they parasitize. Their eggs are laid on the body of the worms and the young that hatch from them burrow into their hosts, finally killing them.

Other insects are, like the bumble bee, responsible for the pollinization of flowers and consequently the production of seed.

The dependence of plants upon pollinization by insects is well illustrated by the Smyrna fig. Prior to the year 1900 this fig could not be grown in the orchards of California, but since then the causes have been found, and the remedy applied with satisfactory results. The figs did not ripen because their flowers were not pollinized. When pollination was found to be accomplished by a minute insect, this insect was introduced into the fig-growing districts of California and a successful new industry established.

Rivaling in interest the establishment of the fig industry in California is that of the salvation of the orange and lemon trees of the same origin. Kellogg gives the facts in this case in the following words:

> In 1868 some young orange trees were brought to Menlo Park (near San Francisco) from Australia. These trees were undoubtedly infested by the fluted scale which is a native of Australia. These scale immigrants throve in the balmy California climate, and particularly well probably because they had left all their native enemies far behind. By 1880 they had spread to the great orange-growing districts of southern California, five hundred miles away, and in the next ten years caused enormous loss to the growers. In 1888 the entomologist Koebele, recommended by the government division of entomology, was sent at the expense of the California fruit growers to Australia to try to find out and send back some effective predacious or parasitic enemy of the pest. As a result of this effort, a few Vedalias were sent to California, where they were zealously fed and cared for, and soon, after a few generations, enough of the little beetles were on hand to warrant trying to colonize them in the attacked orange groves. With astonishing and gratifying success the Vedalia in a very few years had so naturally increased and spread that the ruthless scale was definitely checked in its destruction, and from that time to this has been able to do only occasionally and in limited localities any injury at all.

The relations of birds to insects are known to most every one, but we can not mention too often or emphasize too strongly their influence in maintaining the equilibrium in the insect world. Much of the trouble now encountered by gardeners, horticulturists, and farmers would vanish if we could only bring back the birds that have been killed for food or driven away by various agents controlled by man, such as the domestic cat.

The decision as to what attitude to take toward any particular wild animal is indeed a difficult one. Whether to encourage it by protection or to eliminate it by paying a bounty for its capture is often a puzzling question. Among the birds the great horned owl occupies a doubtful position, sometimes being considered decidedly harmful, at other times neutral, and even beneficial. The owl feeds principally on birds and mammals, and less frequently on insects. The birds are mostly game birds and poultry. There can be, of course, no doubt regarding its injurious character so far as this part of its bill of fare is concerned since all these birds are decidedly beneficial. On the other hand its mammalian food consists largely of rodents, such as mice, ground squirrels and rabbits, and an occasional skunk. Mice, ground squirrels and rabbits are among the most destructive gnawing animals, whereas the skunk may be destructive if it acquires a taste for poultry and the habit of robbing birds' nests, or it may be beneficial, feeding largely on insects and mice. Judgment regarding the great horned owl, therefore, becomes largely a matter of opinion and the conclusion is perhaps justified that in such cases it is best to regulate the number of individuals so that no notable destruction ensues. In the case of the owl, no effort is necessary since almost every hunter and farmer's boy shoots an owl on sight and thus their numbers are kept down to a minimum.

Among the many apparently useless animals that are really indispensable for the proper production of our food supply are the minute swimming animals, the Crustacea, of which the water flea is an example, and the lowly earthworm.

Although the Crustacea used as food by man in the United States are valued at several millions of dollars annually, still their indirect value as food for fish is probably greater. The smaller Crustacea furnish perhaps the principal item in the fish's bill of fare. They are extremely abundant everywhere; at one time there may be more than 250,000 in a single cubic yard of lake water or of sea water. Their effect upon the abundance of mackerel has recently been studied with the following results: The number of fish depends upon the number of Crustacea that are available for food. These Crustacea feed upon minute plants, mostly diatoms, that float about near the surface of the sea, and their abundance must depend upon the abundance of these plants. The plants require sunlight for their growth and multiplication, so that the amount of sunlight controls the number of plants. Actual observations have shown that a season of bright sunshine is followed by good fishing, and a cloudy one always results in a poor catch of mackerel.

Charles Darwin, in his book on the "Formation of Vegetable Mold through the Action of Worms," has shown, by careful observations extending over a period of forty years, how great is the economic importance of earthworms. One acre of ground may contain over fifty thousand earthworms. The feces of these worms are the little heaps of black earth, called "castings," which strew the ground, being especially noticeable early in the morning. Darwin estimated that more than eighteen tons of earthy castings may be carried to the surface in a single year on one acre of ground, and in twenty years a layer three inches thick would be transferred from the subsoil to the surface. By this means objects are covered up in the course of a few years. Darwin speaks of a stony field which was so changed that "after thirty years a horse could gallop over the compact turf from one end of the field to the other, and not strike a single stone with its shoes."

The continuous honeycombing of the soil by earthworms makes the land more porous and insures the better penetration of air and moisture. Furthermore the thorough working over of the surface layers of earth helps to make the soil more fertile.

The need for a more detailed knowledge of such interrelations as above cited has long been recognized by the experts of the United States Department of Agriculture and by others, since there is still much to be learned. One who investigates this subject even superficially soon learns how wasteful we have been of our inexhaustible (?) resources of food animals and also of animals that protect our plants and animals from their natural enemies. May we not hope that among the benefits that we may derive from the conditions in which the world finds itself at present will be a realization of how dependent we are upon wild animals for our food supplies, and how important it is that steps should be taken for their conservation.

TWILIGHT IN THE ADIRONDACKS.

A Habitat Group of Virginia Deer installed in the American Museum of Natural History, by Hobart Nichols, A.N.A., showing the beautiful results now obtained in museum exhibits.

THE PROGRESS OF SCIENCE

THE ARMORED DINOSAUR

Recently there has been placed on exhibition in the United States National Museum, at Washington, the mounted skeleton of an armored dinosaur on which science has bestowed the name *Stegosaurus*. The skeleton as exhibited (see Fig. 7, reproduced here from a photograph of the specimen) measures 14 feet 9 inches long and stands about 8 feet high from the ground to the top of the highest plate. The bones of this specimen were discovered in southeastern Wyoming, a region long famous for the many and well-preserved fossil specimens found there. Although collected more than thirty years ago, it is now exhibited to the public for the first time.

The Stegosaurs were by reason of their large size and ornate bony skin structures the more striking and characteristic of the large reptilia that inhabited the Northern Hemisphere in the long-past ages. It should be stated, however, that this family is not confined exclusively to North America, for specimens have been found in England, France and German East Africa that are but little unlike the American representatives.

At this time the origin of the family is not known, though it is now generally believed that they were descended from a bipedal ancestry and that increasing bulk and development of the dermal armor caused them to lose celerity of movement, thus becoming sluggish, slow-moving creatures of low mentality. By measurement of the brain cavity in the skull of *Stegosaurus* it is found that the brain displaces but 56 cubic centimeters of water, with an estimated weight of about 2½ ounces. This small organ directed the movements of a creature estimated to weigh several tons, whereas the average normal human brain has a capacity of 900 cubic centimeters in a

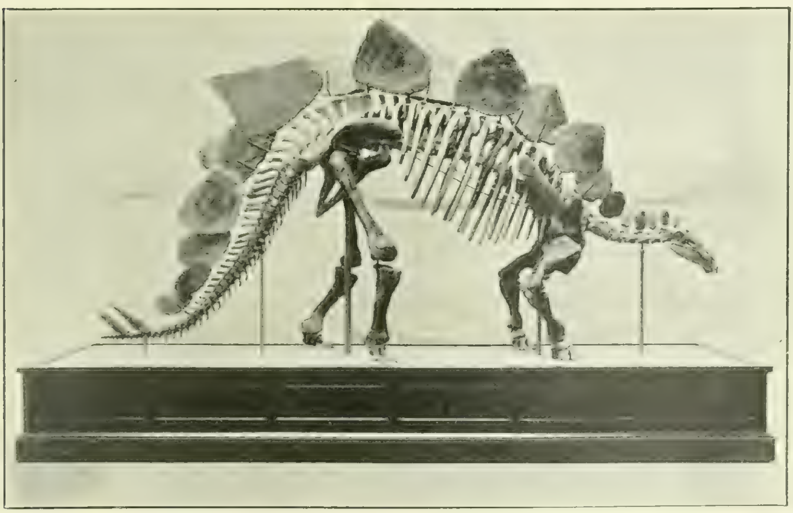


Fig. 1. The mounted Skeleton of *Stegosaurus*.

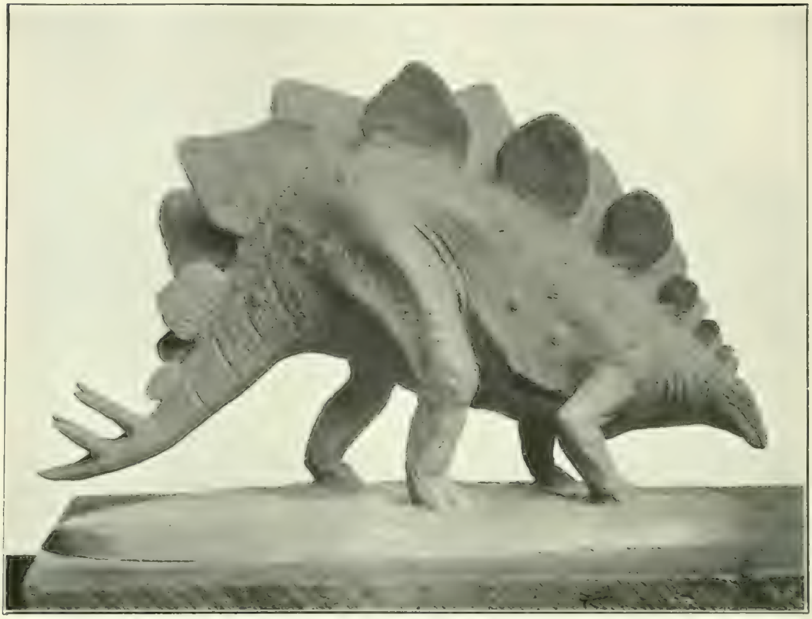


Fig. 2. Restoration of *Stegosaurus*.

creature weighing from 130 to 150 pounds.

The most remarkable feature of the nervous system of this great brute, however, is the enormous enlargement of the spinal cord in the sacral region, which has a mass of more than 20 times that of the puny brain. At best the intelligence of this animal was of the lowest order, hardly more than sufficient to direct the mere mechanical functions of life. Whereas the great horned dinosaurs with skulls from 7 to 9 feet long were the largest-headed land animals the world has ever known, the Stegosaurs are the smallest-headed when the great bulk of the body is taken into consideration. The jaws are provided with a dentition made up of teeth so small and weak as to be always a source of wonder and conjecture as to the real character of their feeding habits. It would at least appear to indicate that their food consisted of the most succulent of terrestrial plants.

The structure of the large, broad feet suggests they were land haunting, doubtless of low, swampy regions rather than the upland, and such an environment would be most suitable for furnishing the soft plant life necessary for their sustenance.

In addition to the small head, the great difference in the proportions of the fore and hind legs, the one most striking external feature of *Stegosaurus* is the unusual development of the skin armor, consisting as it does of two parallel rows of erect alternating bony plates extending from back of the skull on either side of the midline of the back to the end of the tail, the tail being armed near the tip with two pairs of bony spikes or spines. There are also a considerable number of small rounded bony ossicles that in life were held in the skin and probably formed a mail-like protection to the head and neck. The primary purpose of this armor must have been for defense, protective to the extent of giving the animal a most formidable appearance rather than actually useful as defensive instruments.

While the fossil remains of these animals are not uncommon in our museums, they consist for the most part of the scattered and disarticulated bones of the skeleton, the present specimen being the only mounted skeleton of this animal on exhibition at this time.

In Fig. 2 is shown a model restoration of *Stegosaurus* prepared by the writer and which portrays his conception of the life appearance of this animal. In this restoration is incorporated all the latest evidence relating to its external appearance, and it is thought to give a fairly accurate picture of the living animal. The recent discoveries of skin impressions with the fossil remains of other dinosaurian specimens makes it not unreasonable to expect that *Stegosaurus* had a scale-like integumentary covering, instead of the smooth elephant-like skin as here depicted. In the light of these recent discoveries we may yet hope to have still more definite knowledge as to its true nature.

Charles W. Gilmore

THE SULPHUR SITUATION IN THE UNITED STATES

A publication of the U. S. National Museum under the title "Sulphur: An Example of Industrial Independence," by Joseph E. Pogue of the Division of Mineral Technology, presents in a simple and non-technical manner the striking aspects of one of the most interesting mineral industries in our country to-day. A feature of value is a series of half-tone plates, made not only from actual photographs of mining operations, but also from several views of a miniature model-reproduction of a typical sulphur mine, with the underground disposition of the sulphur exposed to sight, so reproduced as to give the appearance of bird's-eye or aeroplane view of both occurrence and mining.

At the outbreak of the war in 1914, the United States was producing each year about 350,000 tons of sulphur, valued at a little over $6,000,000. This quantity was sufficient to supply not only the needs of this country, but contributed about 100,000 tons to European markets. With the development of war activities, however, the production has increased to meet the growing needs of munition makers, while the exports have decreased as a result of disturbed trade conditions and the need for building up reserves of this essential material at home.

It is a singular fact that the chief raw materials of explosive manufacture are localized in a remarkable manner, and sulphur is no exception to this rule. In the United States practically the entire supply comes from a number of deposits in Louisiana and Texas near the Gulf Coast. These deposits are similar in nature and consist of a series of beds and lenses of pure sulphur at a depth of several hundred feet from the surface.

The discovery of the occurrence of sulphur of this type was made as far back as 1865, in connection with a well drilled for oil. All attempts at mining the sulphur failed, however, until some fifteen years ago, when a highly ingenious method was devised for winning this substance without recourse to the ordinary costly underground operations usually prosecuted in mining. This process makes use of the fact that sulphur melts at a relatively low temperature. By drilling a well through the overlying rock until the sulphur bed is tapped and then sinking a series of interpenetrating pipes through which superheated steam is forced, the sulphur is melted and forced to the surface as a hot liquid, where it is piped to large bins, into which it pours and cools. This process, which is known as the Frasch process after its inventor, has been described as one of the triumphs of modern technology, and its successful application to the Gulf Coast deposits has in the past fifteen years transferred the center of the world's sulphur industry from the island of Sicily to the United States, making our nation absolutely independent of the rest of the world in this important particular.

With the development of the world war, the sulphur deposits of the Gulf Regions have, of course, assumed special importance as supplying the sulphur needed in the manufacture of gunpowder and other explosives. But in addition to this, these deposits have quite unexpectedly during the past few months been able to meet and solve a critical resource problem arising out of the submarine campaign. This problem concerned the raw materials of the large and very vital sulphuric-acid industry, and arose from the fact that most of the several million tons of sulphuric acid used in this country was made from a sulphur-bearing mineral called pyrite, brought as ballast in quantity from large deposits in Spain. The restricted shipping conditions resulting from recent events as a matter of course seriously affected this source of supply, and since sulphuric acid is a product nearly as fundamental to industry as iron or coal, the situation bade fair to assume critical proportions. But it so happens that crude sulphur under emergency can also be used in making sulphuric acid, and accordingly the Gulf sulphur deposits have come forward to tide over the dearth of Spanish pyrite until the domestic supplies of pyrite, which are adequate but as yet only in part developed, can be brought up to a suitable measure of productiveness.

There are numerous lean deposits of sulphur in many of the western states, but these as yet have practically no effect upon the output of the country. It is therefore certain that without the Gulf deposits and the ingenious method of making them available, this country would have scarcely been able to meet successfully the war needs of sulphur and sulphuric acid; which goes to show, of course, the pressing necessity for widespread appreciation and understanding of the importance of proper development of the mineral industries of our nation.

WAR WORK OF THE U.S. COAST AND GEODETIC SURVEY

THE steamers *Surveyor, Isis* and *Bache,* of the Coast and Geodetic Survey, their crews and 38 commissioned officers of the survey have been transferred to the Navy Department, and 29 commissioned officers and 10 members of the office force have been transferred to the War Department with military rank corresponding to their grade in the survey.

In conformity with the wishes of the Navy Department, after the beginning of the war all of the topographic, hydrographic and wire-drag work of the survey was directed so as to meet the most urgent military needs of the Navy Department. The work done comprises wire-drag surveys on the New England coast and coast of Florida; hydrographic surveys on the South Atlantic coast and Gulf of Mexico; the beginning of a survey of the Virgin Islands; the investigation of various special problems for the Navy Department; wire-drag surveys, current observations, and special work on the Pacific coast; and surveys in the Philippine Islands.

The work undertaken for the War Department by the field parties of the Coast and Geodetic Survey was intended to furnish points and elevations for the control of topographic surveys for military purposes. To expedite this work an allotment was made from the appropriation for the War Department to cover the expenses of the field parties employed. The chief of the division of geodesy was authorized to confer with officers of the Corps of Engineers, United States Army, and officials of the Department of the Interior in regard to the proper coordination of the various operations.

Extensive surveys were undertaken, including primary triangulation, primary traverse, precise leveling and determination of differences of longitude, and good progress has been made, and the results of previous surveys have been made available by copies or in published form as promptly as possible. From April, 1917, to January, 1918, 80 per cent. of the time of the office force of the geodetic division was devoted to war work.

RECONSTRUCTION OF CRIPPLED SOLDIERS

Surgeon-General Gorgas has issued a recommendation that hereafter no member of the military service disabled in line of duty, even though not expected to return to duty, will be discharged from service until he has attained complete recovery or as complete recovery as it is to be expected that he will attain when the nature of his disability is considered. The inauguration of this continued treatment will result, during the period of the war, in the saving to the service of a large number of efficient officers and soldiers who without it would never become able to perform duty. Physical reconstruction is defined as the completest form of medical and surgical treatment carried to the point where maximum functional restoration, mental and physical, has been secured. To secure this result the use of work, mental and manual, will be required during the convalescent period. This therapeutic measure, in addition to aiding greatly in shortening the convalescent period, retains or arouses mental activities, preventing "hospitalization," and enables the patient to be returned to service or civil life with the full realization that he can work in his handicapped state, and with habits of industry much encouraged if not firmly formed.

At each hospital where reconstruction work is carried on there will be a special "educational" officer, whose functions are to arrange for and supervise, under the direction of the commanding officer of the hospital, the means provided for the use of therapeutic work, such as curative workshops, classes, etc.; to act as technical adviser to the commanding officer on this subject; to recommend the development of necessary means to keep patients employed so far as it is possible to do so; to make the necessary records of work done in his department; and to have immediate charge of any special training of vocational nature which can be given with the means at hand.

These officers are to be obtained from the ranks of teachers, vocational instructors and others especially qualified, and will be selected for their training, experience and peculiar fitness for the work. Where it is possible a man will be obtained who is himself handicapped by some physical disability and who has made a success in life.

As a result of a survey made by the Surgeon-General's Office of men already undergoing reconstruction treatment in this country, it is expected that enlisted men who have completed their treatment and retraining, but who are unfitted for further field service, will be found worthy of commissions and well fitted for the work outlined in the two preceding paragraphs. No increase in the number of enlisted men in the Medical Department is anticipated for this work, the expectation being that patients, or former patients, will be used.

SCIENTIFIC ITEMS

We record with regret the death of Ewald Hering, the eminent physiologist, professor at Leipzig; of G. A. Lebour, professor of geology at the University of Durham, and of C. I. Istrati, professor of chemistry at Bucharest.

Dr. William Wallace Campbell, director of the Lick Observatory, University of California, has been elected a foreign member of the Royal Society.—Professor Russell H. Chittenden, director of the Scientific School of Yale University, Professor Graham Lusk, of the Cornell Medical School and Mr. John L. Simpson, of the United States Food Administration, have been representing the United States at the inter-allied food conference in Paris.

The annual meeting of the National Academy of Sciences was held at the Smithsonian Institution in Washington on April 22, 23 and 24. The program included accounts of war activities in different branches of science and reports of the results of several important scientific researches by members of the academy and others. The Hale lectures were given by Professor John C. Merriam, of the University of California. His subject was "The beginnings of human history from the geologic records."—The American Philosophical Society held its annual general meeting at Philadelphia on April 18, 19 and 20. Dr. William B. Scott, professor of zoology at Princeton University, presided, succeeding Dr. W. W. Keen, who after ten years of distinguished service would not permit himself to be reelected. The general lecture was given by Lieutenant-Colonel R. A. Millikan, whose subject was "Science in relation to the war." On the afternoon of April 20, there was a symposium on "Food-problems in relation to the war."

THE SCIENTIFIC MONTHLY

JUNE, 1918

A GLANCE AT SOME FUNDAMENTAL ASPECTS OF MATHEMATICS

By Professor C. J. KEYSER
COLUMBIA UNIVERSITY

IN a recent book Sir Oliver Lodge has said that "the mathematical ignorance of the average educated person has always been complete and shameless." To those who know how vast a body of human achievements the term mathematics has come to denote, to those who are aware of the immense development of the subject in modern times, and especially to such as understand and value its spiritual significance as manifest in its bearings upon the higher concerns of man, this indictment can not fail to seem a pretty terrible charge.

The charge is a double one: complete ignorance and shamelessness. The two counts, however, are not independent and this fact is a mitigating consideration. If the first count be correct, the second must be so too. For complete ignorance is complete innocence and innocence is never ashamed. Is the first count correct? The answer depends. For what does Sir Oliver mean by an "educated person"? He has not told us. He might, of course, have so defined the term that his statement would be true by definition. He might, for example, have said that by "educated" he meant what the world means by it. In that case the indictment would be just. For the world has never deemed incompleteness of mathematical ignorance to be essential to education. If, however, Mr. Lodge wishes us to understand that by "educated" he means *liberally* educated, then the indictment is unjust, provided one conceives liberal education as the late Lord Kelvin conceived it; for this great man used to tell his students that among the "essentials of a liberal education is a mastery of Newton's 'Principia' and Herschel's 'Astronomy.'" But are there not educators who would deny Kelvin's contention? Undoubtedly there are and have been many of them. Such educators, for example, as Matthew Arnold, John Henry Newman and Thomas Huxley, widely divergent as are their outlooks upon the world, would yet unite in denying the contention impetuously or even with scorn.

It is evident that Mr. Lodge's deliverance is debatable. Certainly it is worthy of consideration. But who will consider it? May we expect its consideration by those whom it inculpates? If so, what should we expect the culprit to say? Well, he might speak as follows: I am an ordinary representative of the large class of average educated persons. You, Mr. Lodge, presumably represent the class of average mathematicians. You have said of me and my kind that our mathematical ignorance has always been complete and shameless. I in my turn desire to say of you and your kind that your average mathematician has always been completely and shamelessly indifferent in the matter of disclosing to his fellow men and women the cultural value of his science. Regarding our mathematical ignorance, which I regret to say is profound, though it is not quite complete nor entirely unashamed, I desire to say that it is not wholly due to the lack in us of mathematical faculty, but is due in large measure to the failure of mathematicians to show us that their science, over and above the appeal it makes to a class of specialists and technicians, is qualified to minister in any precious or important way to the spiritual needs which we have in common with all mankind.

Some such retort the average educated person may, I think, be conceived as making, not without justice, to Sir Oliver's allegation. In saying this I am far from intending to say that mathematicians have been wanting in devotion or patience or skill in presenting their science to multitudes of boys and girls and young men and women in its *technical* aspects. Nor do I mean to intimate that mathematicians may be rightly blamed for not making genuine mathematicians out of more than a very few of those they thus instruct, for every one knows that the genuine mathematician must be born before he can be bred. What I do mean is this: Among the countless host and endless variety of ideas that enter as components into the structure of mathematics there are a few concepts of so great generality and so great organizing power that they are superior to all the others in dignity and importance, serving as bases of the stately edifice or as its general framework or as central supporting pillars, like a tree-trunk to the tree or like a spinal column in the case of a vertebrate animal, giving the whole ideal architecture its substance, its character, its coherency, and its everlasting stability. Now, for the full unfolding of the implicit content of these supreme ideas it is indeed necessary to employ all the curious symbolism and all the other intricate machinery that more than twenty centuries of mathematical ingenuity have been able to invent, for these supreme ideas are just the things of which mathematics is the science. But—and herein lies the justice of the foregoing supposed retort—the great ideas themselves are all of them near at hand, and it is possible to present them, as mathematicians never have presented them, in their more obvious aspects and ruder outlines intelligibly to their fellow men and women; it is possible so to present them that the layman may understand better than he has ever understood what are the things that make up the subject-matter of the mathematician's silent meditations; it is possible so to present them that the science which Plato called "divine," which Goethe called "an organ of the inner higher sense," which Novalis called "the life of the gods," and which Sylvester called "the Music of Reason," shall not seem to laymen to be remote from their interests nor detached from reality, but that it shall appear to them to deal as it does deal with the very essence of reality, penetrating life in all its dimensions.

What are those great concepts?

There is room here merely to glance at a few of them, to call their names and to indicate some of their more obvious aspects somewhat as a traveler in the foothills may note the peaks of a great mountain range above and beyond.

Among the major mathematical ideas there can be little doubt, I think, that the concept to which Mr. Bertrand Russell has given the name of propositional function is supreme. Every one is more or less familiar with the notion of the lawful dependence of one or more variable things upon other variable things, as the area of a rectangle upon the lengths of its sides, as the distance traveled upon the rate of going, as the volume of a gas upon temperature and pressure, as the prosperity of a throat specialist upon the moisture of the climate, as the attraction of material particles upon their distance asunder, as the rate of chemical change upon the amount or the mass of the substance involved, and so on and on without end. This notion of mutual dependence and reciprocal determination which is thus exemplified in every turn and feature of life and the world and whose scientific name of function was first pronounced, it is said, by Leibnitz, is indeed a very powerful concept; it has played a dominant rôle in modern mathematical analysis, giving at once name and character to certain great branches, as the theory of functions of the real variable and the theory of functions of the complex variable. Yet this Leibnitzian concept, powerful as it is, is far inferior to that denoted by the term propositional function, which embraces the former merely as an exceedingly important special case. What, then, are we to understand by this more comprehensive term?

The answer is that a propositional function is any statement containing one or more real variables, where by a real variable is meant a name or a symbol whose meaning, or value as we say, is not determined by the statement, but to which we can at will assign in any order we please one or more values or meanings, now one and now another. I fear that what I have just said is too general and too abstract to be quite intelligible. The idea can be made clear, however, by some simple examples, provided the reader will understand that the examples are related to the general concept in question as a burning match to a world-conflagration or as a few water drops to a boundless ocean. Let us denote real variables by such italicized symbols as x, y, z, w, etc. Then for concrete and familiar examples of what is meant by propositional function we may cite the following quite at random: x is a man; x is a lover of y; x is the specific gravity of y; x, y and z are the coordinates of a point on the sphere whose center has x', y', z' for coordinates and whose radius is w; and so on *ad infinitum*. How many variables may enter a propositional function? As many as we please. How many such functions are there? It is evident that their name is legion—the host of them is literally infinite in multitude. Even so, you may wish to say, the examples are not impressive. And you may naturally doubt whether the concept they serve to exemplify can be so gigantic and majestic after all. I repeat, however, that the idea is sovereign. In the great and growing system of mathematical ideas, the concept of propositional function is indeed "like Jupiter among the Roman gods, first without a second." Its majesty, its power, its subtlety, the immeasurable range and depth of its significance can not be perceived and felt at once, but only more and more with days and months and years of reflection.

Let us reflect a little upon it. Every one knows that nothing can be more important than propositions. Why are propositions so important? Because truth and falsehood are so important, and propositions are just those living things in which truth and falsehood reside or to which they attach—a proposition is whatever is true or is false. Well, we are going to see presently that propositional functions are related to propositions as matrices are related to the things they mould. Again, no one can fail to recognize the importance of the idea of a class. Without this idea life would no doubt be possible but human life would not, not even for a day. So important is it that in all philosophic ages the concept of class has been held, not quite justly, to be supreme, and for more than two thousand years logic, the science of thought as thought, has been the doctrine of classes. What of it? As in the case of propositions, so here too: We shall see that it is from propositional functions that what we call classes derive their definitions and the determination of their content. And what shall we say of relations? Who does not know that our universe presents itself under scrutiny as an infinite plexus of relations? Who does not know that what we call things—whether they be objects of sense like the moon or objects of pure thought like the orbit of the moon—are but nodes or ganglia where relations meet and pass like a mesh of invisible wires uniting the many into one? "Being," says Lotze, "consists in relations." And it is not things themselves, says Henri Poincaré, that science can reach, as the naïve dogmatists think, but only the relations of things. "Outside of these relations there is no knowable reality." What, then, shall we think of propositional functions if these turn out, as in fact they do turn out, to be the forms in which all relations, whether of things or of ideas, are moulded and defined?

To see the connection of propositional functions with propositions it will suffice to consider some familiar propositional function, the simpler the better. Consider the homely function; x is a man. Observe that this function, though it has the form of a proposition, is not a proposition; for a proposition is true or is false, but the statement—x is a man—can be neither true nor false so long as x has not received an admissible meaning or value (such as Socrates, say), but when such a value has been assigned we no longer have a function, but have a proposition; namely, Socrates is a man. Thus we see how propositions, which are constant and which may be called values of the function, are derivable from the function, which in its turn is not a constant, but is a variable owing its variability to the presence in it of one or more unassigned terms or variables such as x, y, etc. Is this so easy as to be uninteresting and unimpressive? If so, that is no reason for being disheartened, for there are difficulties enough near at hand. Let us notice one of them. I have spoken of "admissible" values of x.

What is such a value? It is one that, when put for x in the function, yields a significant statement, a statement, that is, that makes sense, as we say. In other words, an admissible value of x is one that converts the function into a proposition, into something that is true or else false and not into mere nonsense. But our universe contains an infinitude of constant terms. Are all of these admissible values of x? No; the term John Smith is admissible, and so is the name Fido (the designation of my dog) for the statement—Fido is a man—is significant, it is a proposition, although it is false. Indeed, if it were not a proposition it could not be false, for, as already pointed out, propositions are the only things that can be false or true. Now men constitute a *class*. Is this class an admissible value of x? Evidently it is not, for the class is logically subsequent to the individuals composing it, and so it can not, without logical contradiction or nonsense, be said to be one of its own members. Accordingly, the statement—the class of men is a man—is neither true nor false; it is, rightly understood, just sheer nonsense. It is easy thus to see that our simple and homely propositional function, x is a man, cleaves the universe of terms or values into two infinite parts; one part being composed of inadmissibles and the other of admissibles. Is the line of cleavage always sharply defined? No; it may be doubtful whether a given term is or is not admissible, for we may ask, for example, whether the sweetness of sugar or the glory of renown is, in case of the function under consideration, an admissible value of x. There is here an open and inviting field for scientific research, the problem being to determine the best possible criteria for deciding, in case of any given propositional function, what terms or values are admissible and what ones are not. The situation may be likened to that of physical organisms, for there are plants and there are animals, but in the case of some living organisms there is at present no means of deciding to which division of the kingdom they belong. It is plain, too, that just as a propositional function containing a single variable parts the universe of terms into two infinite divisions of terms, so a function of *two* variables sunders the universe of *couples* of terms into two infinite divisions of couples; and so on and on for the case of three or of four or of n variables.

Again confining our attention to some concrete propositional function of a single variable, let us, for the sake of convenience, denote it by the symbol $F(x)$. Then, if a and b denote admissible values of x, $F(a)$ will be a proposition and so will $F(b)$.

It may happen that one of these will be true and the other one false. Such will be the case if, for example, $F(x)$ means "x was a great Italian poet" and if a denote Dante and b denote Shakespeare. Thus it appears not only that every propositional function of a single variable divides the universe of terms, as we have seen, into two grand divisions, but also—and this is exceedingly important—that the grand division composed of admissible values is at the same time separated by the function into two classes: namely, the class of values that yield true propositions and the class of those that yield false ones. Now the former of these classes, because of its relation to truth, enjoys the distinction of being regarded as *the* class determined by the given function. Is there a function that in this sense determines the other class? Yes; the other class is determined by the negative of the given function. Now a value of the variable that converts a function into a true proposition is said to *satisfy* the function. Accordingly a class consists of all and only the terms or values that satisfy some propositional function. To each function there thus corresponds a determinate class, one and but one. Is the converse true? A class being given, is it true that there is one and but one function that determines the class? Far from it. Given a class, there are, in general, many different functions, each of which suffices to determine it. Thus "x is a prime number" and "x is not divisible by any number except 1 and x" are two functions determining the same class, having, as we say, the same extension, the difference of the functions being what is called intensional difference. And this brings us to the weighty notion of *equivalence* among functions, two propositional functions being said to be equivalent when and only when they determine the same class. It is a very important and often a very difficult problem, when a function is given, to determine whether certain other functions are or are not equivalent to it. Is there a universal class? There is. Such a class may be defined by the function: x is identical with itself, or with x. But it must not be inferred that a universal class includes all things, for such an inference would lead quickly to logical contradiction, or nonsense. A class that included all things would have to include itself and such inclusion is logically impossible, it is nonsensical. There are classes of individuals, classes of classes, classes of classes of classes, and so on upward forever; so that classes and their corresponding functions constitute a summitless hierarchy of types or ranks—a subtle matter that can not be further pursued here, but which has to be faced and which has been faced bravely and with much profit to philosophy and science by Messrs. Whitehead and Russell in their magnificent "Principia Mathematica." Suffice it to say here that the notion of identity and that of universal class must be defined independently for each rank in the hierarchy or else extended from rank to rank by means of some more or less plausible assumption. To the universal class of any given rank there corresponds its negative: namely, the class determined by a function not satisfied by any value of the variable. Despite the fact of its containing no members, this so-called empty or null class is said to exist for the reason that there exists a propositional function determining it. And this strange class is very important because it lies at the basis of that curious integer which is known as *zero* and which is so indispensable to science and to the conduct of civilized life.

I fancy that the non-mathematical reader may wish to say: "What has all this to do with mathematics? I have always supposed that mathematics is the science that deals with number and space, and I quite fail to see any very obvious or close or significant connection between propositional functions on the one hand and the various kinds of number and of space configurations on the other." Very well, let us pause here a moment to exhibit such a connection. You doubtless think nothing can be more familiar than the numbers 1, 2, 3, etc., with which we count. What is it that we humans mean by the number 3 or the number 5, for example? There are probably not more than 2,000 people in the world who can answer that question. In answering it, I shall be relating a piece of the very latest scientific news. Consider the propositional functions: x is a finger of my right hand; y is a finger of my left hand. Each of these functions determines a class. The two classes, c and c', are said to be *equivalent* because we can pair the things of the one class with those of the other in a thing-to-thing way. By such a pairing we are said to *transform* each class into the other, and so we note in passing that the important mathematical term transformation does not mean what it means in general literature, for in general literature it involves the idea of transmutation; but classes that are mathematically transformed are merely associated and are not changed or transmuted into something else. Mathematical transformation is purely psychical, it is merely a lawful way of transferring our attention from a given thing to a definitely associated thing. To return from this digression: are there any other classes that are each equivalent to c and hence to c'? Obviously there are many of them, as the class c'' of letters in the word *write*, the class c''' of toes of a normal human foot, and so on and on. It is now essential to note carefully that there is a class C composed of all those equivalent classes. Observe that the members of C are not fingers, toes, letters, etc., but are classes c, c', etc. Do you know what C is called? In English it is called *Five* and is everywhere denoted by the symbol 5. Thus the number five is simply a certain class of certain equivalent classes, and the name five and the symbol 5 are simply the name and the symbol of that class. Exactly the like is true of all other integers. Does the fact seem strange? Well, science can not agree to discover nothing but what is familiar. Have we answered the question: what is an integer? No, we have merely indicated how to tell precisely what is meant by the number of any *given* class. To tell what is meant by the general phrase, an integer, we must go higher, we must form a more tenuous concept, we must say that the phrase stands for the class Σ of all the classes formable, like C, of classes of things. Here we gain an insight into the reason why the doctrine of number makes such severe demands upon intellection. For observe that a finger is indeed a sensible thing, but that the class c of fingers is not sensible, but is a pure concept. The class C is then a concept of concepts, and the class Σ is a concept of concepts of concepts; and accordingly the meaning of the phrase, an integer, is thrice removed from the domain of sense.

I have now shown how propositional functions are connected with the most familiar of mathematical things; namely, the integers, or count numbers of the shopkeeper. But there are many other sorts of number, as the rational fractions; as the real numbers including such as e, π, $\sqrt{2}$, etc.; as the complex numbers, which involve an even root of some negative real number; and so on. And you may wish to ask: Are all these and are all the configurations studied in geometry connected with propositional functions? They are. To show it, however, it is necessary to show, as I have promised to show, that the notion of propositional function is the source of the great concept of relations.

And that is not hard to do. Let $F(x, y)$ denote any one whatever of the propositional functions that contain two variables x and y. To fix our ideas, as French writers say, let us take the function: x is the lover of y. Any such function determines a class of *couples*, namely, the ensemble of ordered pairs of values of x and y that convert the function into a true proposition. If a loves b, then a and b, taken in the order named, are together one of the couples. Such a couple may be called an *element* of the *relation determined by the function.* Now just what, you may wish to ask, is the relation so determined? The answer is: the relation is the ensemble of all such elements or couples. Thence it appears that in mathematics a relation is regarded as consisting of its *extension* as distinguished from its *intension.* Thus the two functions, "x is greater than y," and "u is neither equal to nor less than v," though they differ in respect to intension, are said to determine the same relation because the two classes of couples determined by them are identical. Every propositional function of two or more variables determines a relation, and the relation is called dyadic or triadic or n-cornered, according as it is determined by a function of 2 or of 3 or of n variables. It is at once evident how infinitely rich and complicate the world of relations is. Let us for the present speak only of dyadic relations. If R denote such a relation, we may say that x has the relation to y by writing xRy. At once we see that dyadic relations have direction or sense, for if aRb, it is generally, though not always, false to say bRa. The things that can stand before a given relation constitute its *domain;* those that can stand after it, its *co-domain;* the domain and co-domain, which may or may not have things in common, together constitute the relation's *field.* Obviously relations present themselves under certain striking types. Thus there are *symmetric* relations, equality for example or diversity, such that if aRb, then also bRa; there are *asymmetric* relations, father or greater, for example, such that, if aRb, then never bRa; there are *non-symmetric* relations, friend, for example, or brother, such that, if aRb, then sometimes but not always bRa; there are *transitive* relations, less for example or identity, such that, if aRb, and bRc, then aRc; and there are intransitive relations, non-transitive relations, one-to-many relations, many-to-one relations, one-to-one relations, like that of husband or that of wife in well-regulated communities, many-to-many relations, and numerous other distinctions.

And now a word regarding applications to familiar mathematical things. A rational fraction is simply a kind of dyadic relation among integers. Thus, the fraction *two thirds* is the relation—that is, the class of couples (a, b)—determined by the propositional function, $3x = 2y$. Of real numbers as distinguished from rational numbers I shall speak presently in connection with the concept of *Limit.* As to geometry, any one a little acquainted with the analytical method discovered by Descartes and Fermat can readily see that any space configuration whatever is a relation. For, to pass abruptly to 3-cornered relations, if x, y, and z be the coordinates of a point—that is, if they be its distances from three chosen planes of reference—then any propositional function, such as $2x^2 + 4y = 9z + 3$, determines a relation among points and this relation is called a surface.

In support of my statement that the notion of propositional function is sovereign among mathematical ideas, I have said enough in this sketch to show that this omnipresent notion embraces the great concepts of proposition, class, and relation like an infinite envelope inwrapping them completely and touching them, so to speak, at every point. I must now hasten on to other pillar-ideas without, however, passing beyond the range of "Jupiter," for that can not be done.

A masterful idea that owes its precision and its great fame to mathematics but which, as we shall see, has everywhere penetrated, under a thinner or thicker disguise, the history of thought and aspiration, is the notion of limit. May I remind you by an example what the notion means? Suppose we are operating in the field of the *rational* numbers. Consider the series or sequence of all the rationals such that the *square* of each is less than, say, the sacred number 7. Then we say that the sequence has a *limit*, which we call the square root of 7 and denote by $\sqrt{7}$. But this thing, this limit, is not a rational number; it is something outside the field of rationals; it is merely indicated and approached by the rational sequence. In relation to our field of operation, this limit is then not an actual thing, but is purely ideal and the process of approaching it along the sequence is, as you see, a process of idealization. It is thus evident that the notion of limit and the process of limits, which lie at the basis of the Newtonian and Leibnitzian calculus and which are indispensable to mathematical computation and generalization (as leading, for example, to the concept of such irrational numbers as $\sqrt{7}$), it is evident, I say, that this concept and this process are but mathematicized forms of those ideals and that process of idealization which in other fields of interest have given man his dreams of perfection, whether in ethics or in religion, or in art, or in governance, or in knowledge. Every manner of perfection, every genuine ideal, every source of supernal light upon our human pathways, is indeed some great unmathematicized limit, unattainable indeed, yet indicated and pursued by familiar sequences of experience in our common life.

In our hasting excursion among the great mathematical ideas, we must not fail to glance at the concept called a system of postulates. It is a system composed of a few so-called axioms or assumptions or propositions called primitive because they are taken for granted, it being impossible to prove everything. The purpose or office of such a system is to serve as a foundation for a doctrine all of whose propositions, except the postulates themselves, are to be logically demonstrated. If a postulate system is to be an ideal one it must be such that the postulates are compatible—that is, not mutually contradictory—and they must be independent in the sense that none of them can be logically derived from the rest. In the course of more than two thousand years, and especially in our own day, numerous such systems, or mathematical branch-foundations, have been discovered. A famous one of these is found in the late Professor Hilbert's "Foundations of Geometry." In every postulate system the postulates are statements about certain terms, or elements as they are often called. These terms are *not defined* beyond the requirement that they must satisfy the postulates or, in other words, that they must be things about which the postulates make true statements. In Hilbert's system, for example, the undefined terms are point, line, and plane. Since the terms are undefined we may as well replace them in the postulates by the variables x, y and z and then it appears on the very face of the postulates, since they now talk about the variables, x, y, and z, that they are not propositions, but are propositional functions. And hence it appears that the so-called doctrine erected upon them is really not a doctrine, for a doctrine must be true or false, consisting of propositions, but is really a *doctrinal function* depending upon the propositional functions at its base. By giving these variables admissible meanings, or values, we get doctrines from the doctrinal function just as propositions are obtained from propositional functions. One of the impressive facts recently discovered in this field is that from a given doctrinal function we can thus derive an infinitude of doctrines, some of them true, some of them false. Inasmuch as these have the same foundation, they are all of them of the same form; they are *isomorphic*, as we say; they are logically *one*, but psychologically they are *infinitely many*. Who can tell the disadvantages that would attach to living in a world, if there were such a world, where every doctrine required a foundation of its own?

Before quitting the subject of postulate systems I desire to mention two considerations, one of them touching the humanity of mathematics, the other indicating one of its fundamental bearings on philosophy. The first consideration is that in seeking a postulate system to serve as the support of a mathematical branch, the mathematician is engaged in the very human work of searching for principles, for beginnings that will guide, and his activity, though it is distinguished by its precision and ideality, is, in point of *kind*, not different from that common quest of man in all ages for fundamental truths which has eventuated, not merely in such scientific things as the principles of Newtonian mechanics, for example, but in decalogues, in creeds, in political constitutions, and in principles of jurisprudence. The other consideration is that by their postulational research, mathematicians have conclusively demonstrated that the now age-long attempt of philosophy to derive the universe from a principle or from a consistent set of principles can never be successful, not because man is lacking in wisdom but because the problem admits of no solution. How is this shown? It is shown by this: Geometricians have discovered three geometries, one of them called Euclidean because, like Euclid, it postulates that in a plane there is through a given point one and but one line parallel to a given line; one of them called Lobachevskian because, like Lobachevsky, it postulates more than one such parallel; and one of them called Riemannian because Riemann postulated that there should be no such parallels at all. Now each of these three classic geometries is internally consistent and is, therefore, indestructible. But the geometries contradict one another. Accordingly we have in our universe these three eternal but mutually incompatible doctrines. If a consistent theory of the universe could be constructed on the basis of a single set of compatible postulates, then the geometries in question, being a part of the universe, would have to be derived with all the rest of it as harmonious affairs; but this can not happen, since neither men nor gods can render concordant two things that contradict each other categorically. To think otherwise would be to abolish the very notion of logical harmony. Herewith, then, is established by mathematics an eternal limit to the possible advancement of philosophical speculation.

Space fails me to deal suitably with such momentous concepts as those of infinity, group, hyperspace, and invariant. As to the first of these I may perhaps be permitted to refer an interested reader to my book, "The New Infinite and the Old Theology," where I have presented, in the language current among educated people, the mathematical concept of infinity together with its bearings upon some problems of rational theology. The concept of group, which entered mathematics about a century ago and which, besides giving rise to an extensive doctrine of its own, has come to serve more and more for the characterization and classification of other mathematical branches, would require a separate essay to present it adequately to laymen along with its bearings upon general thought, ancient and modern. The same must be said of hyperspace.

As to the notion of invariance, it has played so great a rôle, not only in mathematics, but in every cardinal field of human interest, that I can not close without giving at least a little sketch of its nature and significance. What is an invariant? Broadly speaking, it is anything, simple or complex, that remains unaltered when other things connected with it suffer change. The mathematical theory of invariance is about as old as our American independence. Its beginning was like a mustard seed. The seed was an observation by Lagrange that the discriminant, $b^2 - ac$, of the quadratic equation, $ax^2 + 2bxy + cy^2 = 0$, is the same for all the countless equations that can be obtained from the given one by replacing the x in it by $x + \lambda y$, λ being allowed to take any and all numerical values. The mentioned replacement is a very simple example of what is known in mathematics as a transformation, of which I spoke briefly above. Thus what Lagrange noticed was the fact that the above-mentioned discriminant remains invariant under an endless number of transformations. If the reader will take the trouble to reflect for a moment upon the fact that an equation may contain any given number whatever of variables and upon the further fact that, the number of variables being assigned, the equation involving them can have any degree whatever, and if he will then reflect that the number of coefficients increases very rapidly with the number of variables in the equation and with its degree, he can not fail to glimpse the magnitude of the problem which consists in searching out *all* those combinations of the coefficients or of the coefficients and the variables together that remain unchanged when the equations are transformed by replacing in them, not merely one of the variables, as in the example of Lagrange, but each of them by an expression containing them all. That is the magnificent enterprise to which, as a result of Lagrange's tiny observation, mathematicians engaged for some generations, first Gauss, then George Boole, then Arthur Cayley and James Joseph Sylvester and then a small army of master-workmen both British and Continental. The event is a stately doctrine variously styled the theory of invariants and covariants, the theory of quantics, as Cayley was wont to name it, and the calculus of forms, as it was more poetically conceived by Sylvester. The notion of invariant has been extended far beyond the range of algebra in which it originated, into all branches not only of mathematics, but of natural science. A little reflection will suffice to show that nothing can be closer to the heart of man than this seemingly cold and arid mathematical concernment with the doctrine of invariant forms. For it is obviously only the mathematical aspect of man's quest, in all times and places of our fluctuant world, for abiding reality and which in art has given us the doctrine of eternal archetypes of beauty, in jurisprudence the ancient conception of *lex naturæ,* in science the idea of indestructible atoms and of invariant natural order or law, and in religion and theology such dreams as an immutable God and an immortality for human souls.

Finally a word respecting the bearings of mathematics upon ethics. No one can contemplate the ideal cosmos disclosed in mathematics, no one can realize how indissolubly ideas there are interlocked, no one can perceive that there consequences follow from chosen beginnings with a fatality against which not even God, said Plato, can contend, no one, I say, can face such aspects of our world without having his ethical sense touched by a sobering awe.

THE PSYCHOLOGY OF SOCIAL RECONSTRUCTION

By Professor GEORGE T. W. PATRICK

STATE UNIVERSITY OF IOWA

I

FOR the past three years there has issued from the English and American press a flood of books and articles on the subject of social reconstruction after the war. The writers differ widely as to the form that our social and political institutions will take, but there is almost complete agreement as to the goal to be attained. In these new writings one hears little about our once boasted "modern civilization," which, based as it was upon our peace societies and our arbitration treaties and our low percentage of illiteracy and our "freedom" of the slaves and our scientific discoveries and our mechanical inventions, is tacitly admitted to have been more or less of a failure. Instead, we hear now of a new social order, a new social mind, of socialism, of internationalism, of world peace and social justice. Nor is this new social order at all hazy in the minds of these writers. On the contrary, it is quite clear and definite. It involves certain definite social and political changes, such as *the future prevention of war, the more complete democratization of governments, the more complete socialization of the world, the harmonization of capital and labor, the greater equalization of wealth and opportunity, the complete emancipation of woman both politically and industrially, the suppression of alcohol, the greater control of disease and the lessening of crime.* This is the program, the goal towards which, in the thought of the day, society must move. And it is not merely the paper program of idealists: it is the actual working platform of a great number of social movements of intense vitality and life, of nationalists and internationalists, of social democrats and syndicalists and of a dozen different types of socialists. And even this does not indicate the strength of the movement. It is in the air. It is in the spirit of the age. It is in the unquestioned drift of events. So unbounded is our faith in the supreme value of this program, that to attain it we believe that the price even of this awful war is not too great to pay. Even in the untoward event of the victory of the Central Powers, this social program will, as many believe, soon be attained because of the powerful social forces working beneath the surface in Germany and Austria and even in Turkey.

Neither is this program to be criticized on the ground that it is utopian. Too many Utopias have been realized in this rapidly moving age to borrow any trouble on that account.

But it would be interesting to ask how this social program strikes the psychologist. Probably every thinking man is enough of a psychologist to have observed that it is to be realized not by making over the human mind, but by making over our political and social institutions and by the passing of new laws. But, it will probably be added, no one could possibly object to finding himself in happier circumstances and human nature will quickly adjust itself to a social situation which is clearly so much better than our present one. Let us, however, examine this psychological aspect of the question a little more in detail.

II

We observe, first, that the method by which this picture of the new social state has been gained is the simplest in the world. It consists merely in enumerating the "evils" in our present social system and then outlining a plan in which these evils will be absent, a method much in vogue among all the utopianists from Plato to Mr. H. G. Wells. Poverty, for instance, is an evil. Since, now, there is plenty of wealth for all, let it be more equally distributed. Clashes between labor and capital are evil; they are to be prevented. Alcohol is an evil; let its use be prohibited. Disease is an evil; science will show us how to avoid it. Inequality is an evil; let women be given an equal place with men and let all men and all women be afforded an equal opportunity to gain their several ends. War is an evil; let there be some international machinery for the enforcement of peace. Autocracy is an evil; let the people rule everywhere. Waste is an evil; let there be conservation of all natural resources.

To abolish those evils is considered a kind of ultimate goal; like the marriage of the hero and heroine in the story, and "they lived happily ever after" is the invariable assumption in both cases. But when we awake from our castle-building, we realize that the hero and heroine do not always live happily ever after; and it is equally certain that the people of the world may not live happily and contentedly in a social state characterized merely by the absence of evils.

The gist of the matter is simply this: We are living in an economic and social age and our minds are obsessed by economic, social and political ideas. When we turn to the subject of social reconstruction, we take into account only economic, social and political relations and, in spite of many warnings to the contrary, we fail to study the character of the units of which society is composed. In other words we disregard the vital and all-important psychological factor. Our theoretical social structures may, therefore, be just air-castles, in which actual human beings could not live. Our social reconstruction schemes may be of little value until they have been revised in the light of the teachings of psychology, history and anthropology. This is so obvious that it is hard to understand how the psychological and historical factors could be so neglected in these studies.

It is much too readily assumed that human beings will adapt themselves to the new social order because this order is ideally better. It may be better only for ideal beings, not for actual human beings. If this new order is actually better, and it certainly seems so, perhaps man can adapt himself to it in time. But there is no ground for the belief that the human mind is going to change much in the next thousand years, as it has not changed much in the past thousand.

Just here lies the whole difficulty. We happen to be living in a time of very rapid social and economic changes, while the physical and mental constitution of man has changed but little. The picture of the man of the Old Stone Age, as presented, for instance, by Professor Osborn in his recent book, reveals a tall, straight and fine-looking being, with a brow like that of a modern Englishman, and a cranial capacity somewhat in excess of the average European of to-day. Animal and human species are mutable, but this does not happen to be an age in which such mutations are rapid, while it does happen to be an age of dizzy and bewildering changes in our economic, social and industrial environment. Since the days of Aristides and Themistocles, the economic and social order has been completely transformed, while the human unit has changed but little, in respect either to his mental ability or to his fundamental instincts and interests. The changes that have actually taken place in man's nature are superficial, relating for the most part to his inventive powers and his altruistic emotions.

The surface of the earth happened to be underlaid with iron, coal and petroleum, and man happened to discover them, and devise ways of using them, and they have suddenly made for him a totally new environment. Not only have they changed his environment, but they have produced disharmonies in his nature by compelling him to live under new conditions, for which evolution had not adapted him. For instance, the use of gasoline, steam and electricity has solved the problem of transportation without the healthful exercise of walking and carrying burdens. Electricity has enabled man to work and play at night, when formerly he had been sleeping. The construction of airtight, steam-heated dwellings has lulled him into comfort, while inducing new diseases. Coincidently, the discovery of alcohol has provided an artificial, but damaging quietus for the disharmonies caused by his new manner of life and his new efforts at thought. Finally, certain discoveries in hygiene have lengthened life and decreased infant mortality so considerably that, despite the decreasing birth rate and despite the extensive emigration to the newly discovered Americas, the population of Europe has increased from 110,000,000 in 1780 to 325,000,000 in 1911, a situation which from the standpoint of sustenance is beginning to create grave difficulties.

The other change in human nature is the sudden enlargement of the altruistic sentiments. These, originally developed because of their survival value in collective life, have for religious and incidental reasons been so magnified as to effect a change in society quite out of proportion to the actual changes in the human mind, adding a superficial grace, refinement and culture for which the human unit is not prepared.

III

The result of all these circumstances is that man in modern society finds himself in a position somewhat like that of the proverbial bull in the china shop. For a few minutes he seems to contemplate these objects of art with quite an esthetic interest, until he begins to move, when the destruction begins. The economic and social world in which man lived before the war, with its accumulated wealth, its culture, its refinement and its dangerous ease, was a china shop in which for a time he lived quite placidly, his real nature concealed under a veneer of civilization, till suddenly a very slight movement took place, the murder of an archduke somewhere, when instantly confusion reigned and the awful destruction began. It was man's original nature asserting itself, his primitive instincts finding expression, and since we may be certain that they will continue to find expression for hundreds of years, it will be well to build our house of civilization to fit the man who is to live in it.

Certainly this does not mean that we are to make no efforts to eliminate war from human society. It means only that it is idle to construct artificial social schemes which are thought to be so planned that war cannot take place. It serves only as an illustration of the fact that our current ideas of social reconstruction present views of society so far removed from the actual instincts and interests of men that there is not the remotest chance that they can be realized. They do not provide for man's instinctive needs; they provide only for the elimination of evils. It is not even sure that they offer higher social values, since they center so persistently about the ideas of wealth, equality, peace, comfort and ease. Whether peace is better than war depends upon what the peaceful people are thinking and doing. If they are thinking nothing and doing wrong, war might be better.

To the social reconstructionist, the problem is delightfully simple. To the psychologist, it is frightfully complex. To the former, all we need to do is to eliminate war, poverty, intemperance, inequality, conflicts between labor and capital and other such evils, and the social problem will be solved. To the psychologist and student of history such a plan seems fraught with perplexing difficulties. When the frightful waste of war is stopped and the waste of labor strife, and the waste of intemperance, and the waste of disease, and the waste of child labor, and the waste of bad agriculture and bad forestry and badly managed industries, and when science and the mechanic arts have still further advanced man's dominion over nature, wealth will go on increasing faster even than before the war; and, if history and psychology teach anything, it is that mankind will not prosper under such a régime of wealth, even if it is equitably distributed. It has been said that the present war was due to the phenomenal increase of national wealth without a corresponding increase of morality. It is possible that a still further increase of wealth with its associated greed, its dangerous ease and its neglected discipline, might be a more fatal evil than any we are trying to escape.

It is true that man longs for wealth and comforts and luxuries. He even longs for peace and quiet and regular work, and in his quest for these things he will undergo any hardship or deprivation. Hence, it is naïvely assumed that a society which shall provide him with these things will be an ideal society, forgetting that a good society will be one in which men can *live,* and that *life* consists not in the enjoyment of peace and wealth and comforts and luxuries, but in the longing for them and the struggle, pursuit and capture of them. The good things of the world must be won afresh every day.

But even this conception of life is narrow and academic. The real man, revealed to us by the study of psychology and of history, is wholly different from the man for whom the social Utopias are constructed, who is to live presumably in the enjoyment of regular work, plentiful food and clothing, a comfortable home, and social stability and peace. The real man acts from impulse rather than from reason and his primal impulse is to dominate. It is gain and glory that he wants more than bread and clothing. It is a career that he desires more than peace and safety. It is adventure that he craves more than work.

It is instructive to look back upon the history of the development of man in society. He is not by nature a worker, but an exploiter. Sustenance he must have, but it has always been easier to gain it by plunder than by work, and so, as far back as we may go in history, as at the present day, social group has fought against social group, one bent on robbery, the other on self-defense, and within the group, when unrestrained by the stern hand of the law, individual has preyed upon individual, master upon slave, and class upon class. When the life and safety of the group as a whole have been threatened by some rival group, then so much of law and order has prevailed within the group as was necessary for social integration, because only by social solidarity within the group could the group itself be saved.

It is not quite accurate to say that men love to fight. In time of war they long passionately for peace. But they love to dominate, and fighting is incidental. The military impulses lie very near the surface and their roots extend deep. If human progress is to be illustrated by a figure, it is not the figure of a man climbing a ladder, but of one elbowing his way up in a crowd. Men aspire always to something different and better. They love to gamble, to take a chance, to risk something and gain or lose. It is contrary to deep-seated human racial habits to work steadily and monotonously.

The conquest of a great and new country like America will keep a people busy and contented for a century. When it is conquered, it is assumed that they will rest and enjoy it; but really that is when unrest begins. In the last years the world has grown rich and prosperous; but unrest has increased—unrest in America, unrest in England, unrest in Russia, unrest in Germany. In the past two years in America work has been plentiful and the times prosperous; but murders and bank robberies show no signs of abating. The American frontier, so long as it existed, was the best peacemaker for our nation. It has now been reached and conquered; and unrest will increase. The world's frontier has also been reached. Africa and the Pacific islands have been occupied and the world is getting restless.

How different the reality may be from the vision of the social idealists. In rich and fertile America we look forward to a land teeming with happy and contented citizens, free from war, free from foreign oppression, free from autocracy within, free from grinding poverty, free from class oppression, free from decimating disease, free from vice and intemperance. The nearest approach to this elysium which history has seen was in Germany before the war. Here was a land of beautiful cities, well governed and orderly; a great people, well fed, well clothed, well housed, well educated, well behaved with a fruitful agriculture, busy shops, successful industries and a vast and profitable commerce—yet this same Germany broke bounds and went out to conquer. It is not peace and plenty that man wants, but dominion. And yet in our complacent theories of society, we take no account of this instinctive and inherent lust for power, and we innocently assume that a people will be happy and contented if poverty is abolished, the labor problem solved, opportunity secured, and science and inventive genius given a free hand to increase wealth and material comforts.

Human beings are not so constituted that they will work contentedly in a standardized world, under scientific management and the rule of efficiency. By the inheritance of a half million years they are adapted to a different life, and while in the end their instincts may perhaps be changed, this can not be done in half a century.

IV

"Two things," says Nietzsche, "are wanted by the true man—danger and play." There is just enough truth in this to set us thinking. The standardized world as planned for our future will offer us safety and work. In all the ages of man's slow development, he has never known safety. He has lived under the insecurity of war, of robbers, of plunderers, of tyrants, of flood and storm and famine. A safe world seems to him very attractive but it would be a foreign world.

And then, as regards work, it is assumed that, since unemployment is one of the evils of our present system, the problem will be solved provided we can devise some social plan by which regular work may be found for all. Surely it is a naïve inference that if work be provided for all, all will be happy. Man in all his past history has never been a regular worker. In our new social order, work is not only to be regular, but it is certain to be monotonous, for apparently the conditions of our industrial age are such as to make the work of the laboring man more and more of the monotonous and uninteresting type. We are already becoming aware of the discouraging and dehumanizing effect of monotonous labor in our highly specialized industries. Such regular and monotonous work is foreign to man's nature. Under it he frets and the "unrest" which everywhere we hear about breaks out in some form of social agitation, or in strikes, or in revolutions or more often in mere social delinquency.

There is, to be sure, one kind of work which from ages of habit is instinctive to man and under which he does not fret nor manifest unrest. It is typified in the planning and making of anything that he needs, such, for instance, as a canoe, a wagon, an automobile, a dwelling, a new tool, or in the planning and fashioning of a work of art. He experiences first the need of it, he plans it, he makes it, he uses or enjoys it. In such work he will put forth every power of mind and body, deriving therefrom the keenest pleasure and making no demands for higher wages or shorter hours. When we see children working unprompted and with might and main at some self-planned enterprise and gaining at the same time new strength and new courage and new vigor, but, on the other hand, quickly wilting under some lesser task enforced by parents, we speak of the perversity of childish nature. But there is no perversity about it, and there is no perversity either in the case of the unrest which follows upon enforced regular and uninteresting industrial labor. Nor is either case to be explained by referring it to "human nature." The key to the situation is found quite simply in racial history and racial habit.

We have here an instructive illustration of the failure in our plans for social reorganization to take account of psychological as well as economic forces. The society which we are planning for the future lacks the element of zest. Some shadow of romance it must have, if it is to abide; and this element of romance or zest can not be gained by providing eight hours a day for recreation and self-development. It is *life* that the people want, not recreation and self-development. What do the reformers of our social order usually have in mind for these eight hours of the day not spent in labor or in sleep. Libraries, no doubt, and art galleries and theaters and Chautauqua classes and moving pictures and gymnasiums and athletic games. But even a little knowledge of psychology should show us that these things do not satisfy human needs. All men and all women long for some kind of dominion, long to display their personal power, their personal charms, their personal genius. What they want is a career, a sphere of influence, a sphere of action; and in striving for these things they are restrained by no fear, not even fear of overturning the social order.

We hear a great deal in current discussions of social questions about social unrest, and the implication always seems to be that it is an evil and that contentment would be a good. But the reverse might be maintained with more reason. Unrest is the condition of progress. It betokens vitality. It is the symptom of a persisting urge that expresses itself in the will to live, in the will to power, in the will to freedom. Animal species, it seems, may remain fixed and static, but the human species must go forward or backward. When social unrest ceases, social stagnation may be expected to follow.

The society of the future, planned so largely from the economic point of view, makes little provision for the utilization of the two most powerful forces in the human mind, loyalty and devotion. Scientific management, conservation and efficiency are to take their place. The mind of man is so constituted by the conditions of his long history that he wants to be, and needs to be, loyal to some one or something, and devoted to some one or something, and only in this way is the best that is in him drawn out. He must have some *cause* to live for or to die for—some religion, some state, some flag, some woman, some lodge or labor union, or even some gang or band of outlaws. He wants to be, he must be, drawn out and away from himself to something which stands for an idea. This is *life*.

The social Utopias provide for existence, but not for life. It is the precipitous element that is left out of the reckoning.

A stable society in which there is a dreary routine of work and amusement will present problems as serious as those of the old system. A society in which there is no God to worship, no women to adore and protect, no state to defend, no wine to drink, no parties to fight for, no king to be loyal to, no classes to exploit, and no new lands to discover and conquer, might have some kind of happy beings for its citizens, but not *human* beings. They have a different history.

But, it will be asked, what *will* happen in such a society, for the march of events is surely and steadily in this direction. There *are* no more new lands to discover and conquer; kings and autocrats are out of date; alcohol has been condemned, and rightfully; women have demanded, and with perfect justice, the life of industrial activity and political equality, the God idea no longer enters deeply into the daily life of the people, wars between nations will, after this terrible war, no longer be endured; and internationalism is steadily supplanting nationalism. Well, surely no one knows what will happen, but it is conceivable that things may happen which will be worse than the evils we escape from. For instance, social unrest may increase until civil war takes the place of wars between states, as was near to happening in England before the present war. What would happen in such a society could at the best be predicted only if one knew whether vitality remained or did not remain among the people. Complete stagnation might ensue. Physical degeneracy might follow upon the increase of bodily comforts and there might be an increase of morbid sexuality, surrender to sensuous enjoyment, dancing crazes and moving-picture crazes, epidemics of crime and vagaries in religion and literature.

We are told that if war be abolished some substitute for war will have to be found. Yes, some substitute for war, and some substitute for alcohol, and some substitute for the state, and some substitute for the king, and some substitute for God, and some substitute for woman—and these substitutes will have to be provided still thousands of years, until the mind of man, five hundred thousands of years in the making, is made over.

Literature, poetry, the fine arts, will apparently have little place in the new social order, as it is planned. It is always assumed that they will be present and are to be *enjoyed*. But who will create these works of art. Art and literature spring spontaneously from *life* in all its tragic incompleteness, not from an economically prosperous existence. They depend upon sacrifice, upon loyalty and devotion, upon courage and victory, upon sorrow and suffering, upon pain and renunciation, upon ministry and service to the sick and wounded. The question whether a world without so much sorrow and suffering would not be better, even if it should be a world without literature and art, is not the question we are here discussing, but only the question of adapting our new social order to the beings who are to live in it.

A certain wise teacher said that a man's life consisteth not in the abundance of the things which he possesseth. It consists partly in self-sacrifice. In our facile plans for the future of society, no place is found for sacrifice, yet in all the long history of mankind sacrifice has had a conspicuous part.

> Man has sacrificed himself for the state, woman has sacrificed herself for man.

No doubt the answer will be that it is precisely this unnecessary sacrifice to which we wish to put a stop. But here much depends upon the meaning of the word "unnecessary." It may be economically unnecessary, but it may be spiritually, morally, even socially or racially, altogether necessary. It is possible to gain many worthy economic values and lose many still greater spiritual values, to gain the whole world and lose our own souls. There is at least some truth in the saying that he who loseth his life shall find it.

But the loss of the spiritual life and the vulgarization of humanity might be merely incidental features in the new society. The question which we are really interested in here is whether man, as he is mentally and physically constituted, will be able to live at all in such a social state as is planned. Apparently he is usually pictured in his self-owned home, surrounded by his healthy, happy family, working six or eight hours a day, and otherwise cultivating his garden or wending his peaceful way to the public library or art gallery, or "improving his mind" by attending evening classes. And if the disquieting question does arise whether he will behave in this manner, one class of romancers says that he will do so provided that it is physically impossible for him to obtain access to intoxicating drink. Another that he will do so provided that his mother, wife and daughter have an equal voice in public affairs. Another that he will do so provided that the state takes over many functions now belonging to individuals. Another that he will do so provided that he can have the reins of government entirely in his own hands, free from every kind of oppressive autocracy. As a matter of fact, it will depend very largely upon the structure of his brain and the balance of his whole personality. National prohibition, votes for women, socialism, the world for democracy, will have little to do with it. No doubt these are all good and all important. At any rate, they are all impending. But they are not the determining factors.

V

What conclusion then are we to draw from this consideration of psychological forces, as against the economic, social and political forces which rule the thinking of our time? Is the old society good enough with its political rivalries and its incessant wars, with its priests and its sisters of mercy, with its drunkenness and crime, with its women as ornaments and dolls. Some of these things, at any rate, are outgrown. War is now racially, as well as economically, too expensive. Alcohol is a narcotic and poison, not a stimulant, as was once believed. Woman has outgrown the doll stage. We shall not go back to these things. But, nevertheless, it is a misconception of life that places the emphasis of the future upon peace and plenty, upon economic expansion, upon equality, upon comforts, and luxuries, and wealth, no matter how equitably the wealth is distributed.

This mistaken emphasis in almost all our plans for social reconstruction goes back to Francis Bacon. As Lord Macaulay said,

> It was not Bacon's purpose to make men perfect, but to make imperfect men comfortable.

Bacon's ideal has been realized. Men have gained comfort, but they have gained no physical, mental or moral perfection. We are planning in the twentieth century to make them still more comfortable, while giving little thought to making them perfect. And comfort is a dangerous legacy for man.

It would seem, therefore, to be well to think along other lines for the future. How may we make men better? Civilization does not depend upon the increase of wealth, or its equal distribution. It depends upon the proportion of dominant and effective men and women, upon the production of leaders possessing initiative, daring, creative and constructive power, and it depends upon discipline, poise, loyalty, devotion and mental and moral health. With the increase of wealth, on the one hand, and the increase among the people as a whole of the proportion of defectives, or even of ineffectives, and with the startling increase of social diseases, our glittering civilization may be near the fate of other civilizations of the recent past. And if our present civilization does go down, there are apparently no reserves of vital power in the outlying districts of the earth, as there were in the days of Rome, to replenish the impoverished blood of the people, for the effectives of all races are now drawn to the great industrial and commercial centers and their vigor exploited for the glory of the present day, not for racial conservation.

It would seem, therefore, that our endeavor must be in the direction of eugenics and education, and that in our efforts at social reconstruction we must think along these lines rather than so exclusively upon economic, political and social questions. The world will be made safe for democracy only when the people of the world are made fit to live in a democracy.

GALL INSECTS AND THEIR RELATIONS TO PLANTS

By E. P. FELT

STATE ENTOMOLOGIST OF NEW YORK

ABUNDANT food, protection from adverse natural agents and minimum exertion are ideals cherished by many. The first two appeal strongly to the infant, the second to the growing child, while the third may become increasingly dominant with the progress of adult years. Solomon advised the sluggard to go to the ant, probably because he had no sympathy with physical or mental inertia; otherwise he might have said: "Consider the gall insect; it does not sow, yet it reaps; it does not build, yet it is sheltered; it gives nothing and receives abundantly."

Easy living is attractive and it is not surprising to learn that representatives of a number of large groups of insects have developed in this direction. In other words, the term "gall insects" does not represent a systematic entity; it is an assemblage of diverse forms grouped because of similar habits. Before proceeding farther, let us agree as to just what is meant by the term "gall." Insect galls may be defined as vegetable excrescences resulting from insect activities and usually sheltering the immature stages of the producers, though a wide acquaintance with these growths demonstrates the existence of innumerable gradations between the apparently normal and the decidedly abnormal, and as a consequence it is difficult to establish a satisfactory distinction between insect galls and deformations not worthy of classification in this category. Some would include the mere curling of leaves and while to a certain extent this is justified, in most cases, unless the curling is pronounced, the deformation has not been considered as an insect gall. Galls caused by insects and their allies are known as Zoöcecidia; those produced by plants are termed Phytocecidia.

The origin and development of these growths are not less interesting than the deformities themselves. The gall-making habit among insects has undoubtedly developed independently in several widely separated groups and must have originated in a mutual reaction between the insects and their host plants, which has reached its climax in many apparently inexplicable deformities of the present day. All stages of the process may be observed among the gall midges, some of which live among succulent fungus growths and either feed a little upon the fungi or obtain nourishment by absorption from the humid surfaces of the host. There are certain predaceous maggots in this group which have the mouth parts greatly prolonged and apparently especially adapted to withdraw by suction the body fluids of their hosts. It may be one or the other or possibly a combination of the two methods which obtains among the fungus-inhabiting forms. It is only a step from this to absorption with apparently no mechanical injury, as in the leaf spot gall of the soft maple or the pod leaf galls of ash and spiraea. The habit once started, it is possible to understand how the process might continue with indefinite variations among a host of species, which is just what has taken place. The adaptations have continued along a number of lines to such an extent that many gall insects live at the expense of their hosts and in some instances, at least in the case of certain plant lice, the mere satisfying of the primitive pangs of hunger seems to be all that is necessary to compel or cajole, as it were, a host plant to grow or throw around its enemy a defensive barrier or gall within which the aphid may live in the presence of abundance, be comparatively safe and obtain like conditions for its numerous progeny. This sheltered, luxurious type of existence appears to be essential to many species and the tendencies along these lines have developed to such an extent that twenty-nine species of gall-making aphids, Phylloxera, are known to live at the expense of our hickories and in a similar manner a number of species of jumping plant lice, Pachypsylla, subsist on hackberry.

Before going further, let us glance for a moment at the different types of insects possessing this gall-making habit.

The Hymenoptera, best known because of the industrious honeybee, has two important families, the Cynipidæ and the Tenthredinidæ, members of which live in this questionable manner. The first named are minute, four-winged gall flies with legless white maggots. They are moderately numerous in species and remarkable for an alternation of generations; the structural variations between the adults in different generations being so marked, that before the relationship was suspected, they were referred to separate genera. Certain

Cynipids or gall wasps are believed to reproduce only by parthenogenesis. These little insects display a marked partiality for oaks and roses and produce striking types of galls, such as the cortical swellings of the gouty oak gall,[1] a species occasionally becoming so abundant that five hundred thousand individuals may be reared from one tree and its conspicuous galls form giant, bead-like swellings on almost all the smaller branches of a large oak. Occasionally the peculiar bud-like swellings of *Andricus gemmarius* Ashm. are very abundant on pin oaks and the sweet exudation issuing therefrom attracts hosts of bees, flies and similar insects. Another oak gall occasionally numerous is the oak leaf stalk gall.[2] The gall of the wool sower[3] is another striking type and results from the female depositing eggs in a ring of buds around white oak stems, and from the series of wounds inflicted, there develops a seemingly delicate, globose, white, pink-spotted mass which on examination is found to consist of numerous cells, each supported and guarded by a thick fungoid, hairy growth. A more ordinary type may be seen in the familiar banded bullet gall,[4] a representative of a considerable series generally known as "bullet galls."

The gall wasps or Cynipidæ attack plants referable to only six botanical families and but eleven plant genera. There is, however, the most striking limitation in food habits, since a very large proportion of the 445 gall-makers subsist at the expense of the oaks, 38 species have been reared from members of the rose family, 28 of these being species of the genus *Rhodites* and found only upon the rose. The other species of gall wasps are scattered in their food habits, the most evident concentration, and this far from marked, being the 12 species reared from various compositae, the genera *Silphium* and *Lactuca* supporting four and three, respectively.

The gall-making sawflies or Tenthredinidæ produce a great variety of swellings on the willow, mostly upon the leaves. The galls made by these insects exhibit a great proliferation of tissues without distinct layers, according to Dr. Cosens, and are easily recognized by the caterpillar-like inhabitants. The latter are readily distinguished from true caterpillars or Lepidopterous larvæ by the greater number of prolegs. Certain galls, at least, produced by members of this group develop

[1] *Andricus punctatus* Bass.
[2] *Andricus petiolicola* Bass.
[3] *Andricus seminator* Harris.
[4] *Disholcaspis fasciata* Bass.

to a considerable extent before the eggs hatch—a hypertrophy resulting probably from chemical stimuli produced by fluids in or deposited with the eggs and transmitted by osmosis.

The beetles or Coleoptera are so respectable that relatively few species of three families, namely, the Buprestidæ or metallic wood borers, the Cerambycidæ or long-horned wood borers and the Curculionidæ or weevils, live in galls. The deformities are largely the result of mechanical obstructions or stimuli and present little of special interest. The representatives of several families of moths or Lepidoptera, the Sesiidæ, the Gelechiidæ and the Tineidæ produce galls of the mechanical type and as in the beetles, the habit is by no means general.

Two families of the Diptera or two-winged flies are noted for their gall producers, namely, the gall midges or Itonididæ and close relatives of the fruit flies or Trypetidæ. The first named is the banner group among gall insects and are ancient and of presumably honorable lineage, since remains of a number of genera and species have been found in the Baltic amber, two species have been discovered in the tertiary Oligocene beds of the White River, while a Pleistocene swamp deposit of Maryland contains swellings upon the leaves of the bald cypress which, in the opinion of Dr. Howard, were produced by a gall midge. This large family of small flies contains some nine hundred known American species, this being probably only a third or a fifth of the fauna. These delicate midges range in length from $\frac{1}{4}$ to $\frac{1}{50}$ of an inch and present marked diversities in habits and structures. There are striking differences in food habits between this large group of gall-making midges and the gall-making wasps referred to above.

In the first place the 679 galls produced by midges occur on plants belonging to 69 botanical families and 202 plant genera. The larvæ of 66 species live at the expense of the Salicaceæ (52 occurring on willow); 29 species subsist upon the Juglandaceæ, all but one infesting hickory; 42 attack members of the oak family (35 of these being upon oaks); 56 produce galls on the Rosaceæ; 24 on the Legumes, 22 upon the grape and close allies and 150 on the composites. The most obvious concentration of species, aside from those mentioned above, is the 44 midges reared from golden rod and the 22 found upon aster. These approximate figures indicate that the group has been able to maintain itself upon a great many different plants through a considerable physiological adaptability and that the distinctness of the species has been established by relatively small modifications in structure.

Different Types of Galls: *A.* Linden mite gall, sometimes very abundant on basswood leaves, note the varied forms. The interior is inhabited by microscopic plant mites. *B.* Maple spot gall, a yellowish-red margined gall, very common on soft maple; at the center there is an almost transparent maggot. *C.* Bud gall on the western rayless goldenrod, note the protecting brush of plant hairs shown in the enlarged section. *D.* Goldenrod ball gall, very common, each inhabited by a large stout yellowish-white maggot. *E.* Cypress flower gall, a peculiar whitish flower-shaped growth sometimes very abundant on the twigs. *F.* Cockscomb elm gall, a deformity produced by a plant louse and occasionally very abundant on small trees, the slit-like entrance on the under surface of the leaf is shown in the upper right-hand figure. *G.* Downy flower gall, sometimes very abundant on goldenrod. *H.* Witch hazel cone gall, a greenish or reddish gall, sometimes very abundant and produced by a plant louse.

A few galls of the Trypetidæ are well known, particularly the common globular stem swelling on golden-rod known as the golden-rod bullet gall.[5] This deformation is simply a stem swelling about an inch long containing near its center a yellowish-white legless maggot.

The Agromyzidæ, another Dipterous family comprising small and usually overlooked flies, has several rather common though generally ignored gall makers. Oval subcortical swellings upon willow and poplar twigs are frequently abundant. Those on the willow may be produced by a sawfly larva, though we have yet to obtain from the poplar twig gall any other maker except *Agromyza schineri* Giraud.

Most galls produced by Diptera are closed and are easily recognized by the legless maggots inhabiting them. The larvæ of the gall midges are peculiar in the possession of a so-called "breast bone" or "anchor" process, though this structure is not evident in all gall midge maggots, especially the very young stages.

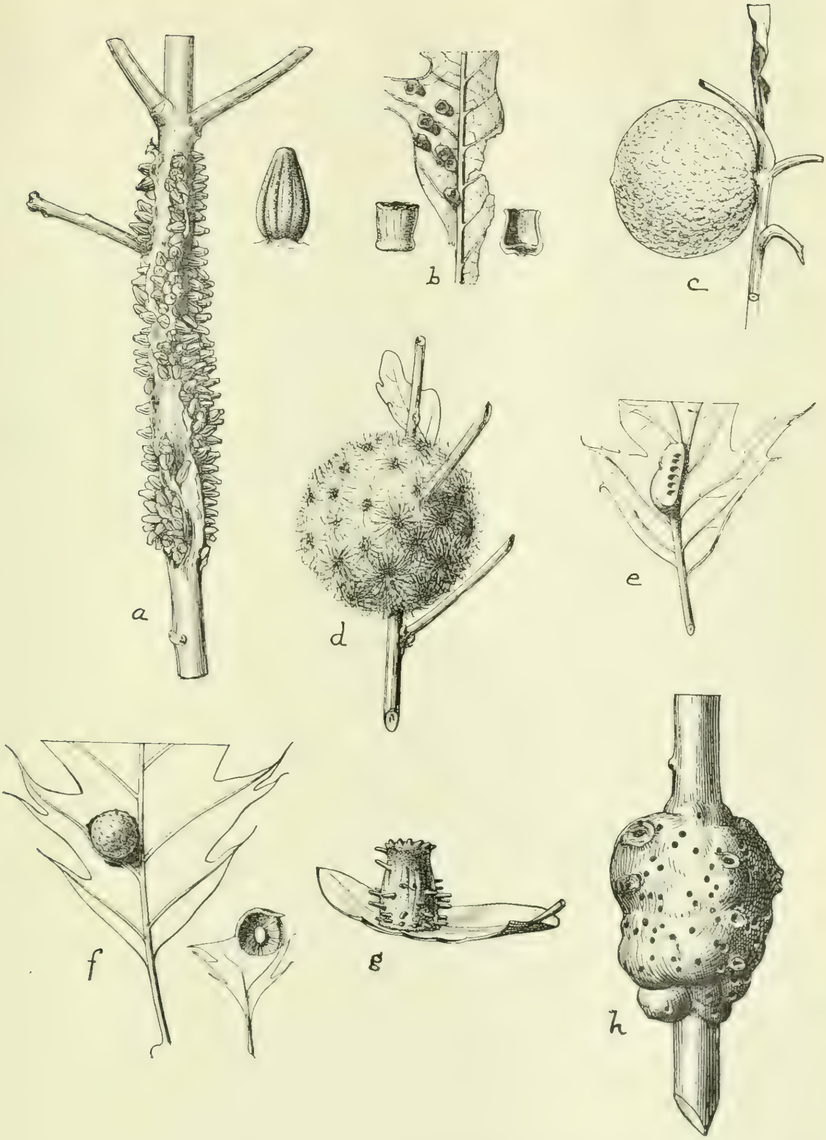
The true bugs or Hemiptera have well-known gall-makers in two families, the plant lice or Aphididæ and the jumping plant lice or Psyllidæ. The former is a large group with occasional species producing galls upon a great variety of plants. Species of jumping plant lice, *Pachypsylla*, inhabit a variety of leaf and stem galls on the hackberry, being strictly limited to this host.

Hemipterous galls are characterized by an opening due to the fact that in some cases, at least, the tissues grow up over and nearly enclose the founder of the gall and eventually form a hollow mass of living tissues with the inner walls nearly covered by plant lice, a condition strongly suggesting the geode of the mineralogist. Certain species of *Phylloxera, Pemphigus* and *Chermes* inhabit characteristic and rather common galls. Some of these species produce a considerable series of generations each year and certain of them may inhabit very diverse galls upon entirely different food plants. One of the most interesting of these is the maker of the spiny witch-hazel gall[6] with its summer generations developing upon and corrugating the leaves of birch. The complicated life history of this insect has been carefully worked out by the late Theodore Pergande, a painstaking student of various plant lice.

The plant mites or Eriophyidæ comprise an important division of the *Acarina* and are best known because of the sack-

[5] *Eurosta solidaginis* Loew.

[6] *Hamamelistes spinosus* Shimer.



CHARACTERISTIC OAK GALLS: *A.* Bud-like galls on oak twigs, sometimes very abundant and since they produce a sweetish fluid, hosts of bees, flies and other insects may be attracted in early summer. *B.* Oak spangles, produced by a gall midge, note the cup-like shape and the little oval cavity at the base, shown in the illustration of a sectioned gall. *C.* Large oak apple, one of the more common and striking galls produced by gall wasps. *D.* Gall of the wool sower, a delicate appearing white, pink-marked wooly growth containing seed-like cells, each inhabited by a white maggot. *E.* Mid-rib tumor gall sectioned to show the series of cells inhabited by the white maggots. *F.* Small oak apple, the one in section shows the characteristic central cell inhabited by a maggot and supported by numerous radiating fibers. *G.* A peculiar cylindrical-spined, rosy red, yellow-banded gall on a western oak. *H.* Gouty oak gall, a large swelling frequently forming bead-like enlargements on most of the smaller branches of various oaks, large trees sometimes being badly infested.

like or hairy galls so common on the leaves of certain trees. The microscopic size of the mites renders their study difficult, and this has been a serious hindrance to investigators. There are now listed 161 deformations produced by these minute forms and much remains to be learned concerning American species.

It is evident from the preceding that the gall-making habit has arisen independently among structurally widely separated groups. The underlying causes are the plasticity of vegetable tissues and the adaptability of animals. The insects have simply followed the lines of least resistance. The abundance of individuals and the multiplication of species are closely related to the food supply and insect adaptability. The greater the latter and the wider the range of food habits, the better are the chances for an abundant life so frequently observed in nature. This phase of the subject has interested the speaker for several years and he would review briefly the conditions found among the gall midges.

They comprise an enormous family of small forms, mostly gall-makers. The more generalized present close affinities with the fungous gnats and like them live on fungi or in decaying vegetable matter. *Miastor* and *Oligarces*, two ancient types of gall midges, live in the decaying bark of various trees and in their larvæ we find that form of parthenogenesis known as pedogenesis; that is, maggots produce maggots directly, the egg, pupal and adult stages being eliminated for an indefinite number of generations. Incidentally this biological short cut is an advantage to the species, since it permits multiplication in the remote, narrow crevices of decaying wood, places inaccessible alike to adult midges and to many parasites and predaceous enemies.

By far the largest number of the gall midges are gall-makers, and these are easily distinguished from the lower forms by the greatly reduced first tarsal segment and the presence of circumfili. These latter are also known as "arched filaments" and "bow whorls" because of the remarkable series of loops they form on the male antennal segments in the most specialized tribe. A few of the more generalized tribe, the Epidosariæ, live in dead, occasionally rather dry woody tissues, some being associated with true gall-makers.

The importance of the bud gall in the biology of gall insects is well shown by a tabulation made a few years ago listing 46 as inhabitants of fruit galls, 145 in bud galls, 150 in leaf galls and 96 in stem galls out of a total of about 437. Fruit galls are potentially bud galls, so that in reality 191 of these were bud galls. *Rhabdophaga* is a genus with a marked preference for willow, and in this we have 12 species inhabiting bud galls, 12 in stem galls and 3 in leaf galls. Though apparently not conclusive, the evidence in this case is really in favor of the bud gall, when we realize that most species of *Rhabdophaga* live on willow; and after making allowance for the softness of the shoot and the rapidity of the growth, it is perhaps surprising that no more primarily bud inhabiting species find themselves left in the race with the plant, as it were, and issue from a deformity which would ordinarily be classed as a stem gall.

The subject is of such interest as to justify further examination. There are two peculiar fusiform galls on narrow-leaved golden-rod, the golden-rod ribbed gall[7] and the golden-rod stemmed gall,[8] both of which may be found among the florets, on the young leaves and the younger portions of the stem, indicating that the parent midges oviposit in the bud and that here, as in the willow, it is not the fault of the insect if the progeny do not issue from bud galls. Another case is that of the nun midge,[9] a species normally breeding in buds and also issuing from deformed flower heads of both golden-rod and aster, and most interesting of all, from small oval cells between two adherent leaves of golden-rod. These latter start while the leaves are in the bud, and as the growth of the plant is hardly affected, it is easy to find in the field these leaves united at the point of injury, with the petioles in all stages of separation; in other words, the upper portion of the stem develops and separates bases of leaves which in the bud are nearly contiguous.

The question of bud infestation does not end here. Some ten species of Cincticornia have been reared from various leaf galls on oaks, the deformities being scattered irregularly over the surface. Some of these galls never develop beyond the blister stage and others form conspicuous, more or less globular, reddish swellings. The primary infestation, we are convinced, occurs while the plastic leaf tissues are in the bud and the same appears to be true of the 18 different leaf galls of *Caryomyia* on *Carya*. These two genera alone give 28 potential bud galls and turn the balance most strongly in favor of the plant bud as the primary source of such deformities. It

[7] *Rhopalomyia fusiformis* Felt.

[8] *Rhopalomyia pedicellata* Felt.

[9] *Asphondylia monacha* O. S.

may be well to add here that the needle-tipped ovipositor of *Asphondylia*, preeminently a bud-inhabiting genus, appears particularly fitted to probe or pierce tender bud tissues.

It happens that over half of the stem galls produced by reared American gall midges result from the activities of the Lasiopterariæ, a highly specialized assemblage producing 52 stem, 12 leaf, 2 bud and but 1 fruit gall. This fact suggests that a high degree of specialization among gall midges is prerequisite to the successful invasion of the harder tissues of the stem.

The fruit gall, botanically speaking, is nothing more than a restriction of attack to flower and fruit, rather than to leaf buds, with such a slow or late development of the insect that the deformity appears in the fruit rather than as a blasting of the blossom. There are a number of seed-inhabiting gall midges. The pear and the fruit of our wild cherry are also subject to attack by members of this group.

Leaf galls include a large number of deformations. The simplest type is a leaf roll, such as the marginal fold gall[10] on oak. Leaf rolls may be rather loose or comparatively tight. Vein folds are common, one of the most abundant being the ash midrib gall,[11] which is simply a large tumid thickening of the midrib on ash leaves. Enlargements of leaf veins may be limited to a rather definite situation, as in the case of the purple vein midge,[12] or they may fuse with irregular enlargements of adjacent tissues and produce a swelling like the grape tomato gall,[13] rather common on leaves and tendrils of grape.

The leaf tissues between the veins may be invaded, one of the simplest types being a small pustule on the oak produced by *Cincticornia simpla* Felt. This may be extended to form a mine as in the purple leaf blotch[14] on *Cratægus* or as a result of the proliferation of tissues develop into a globose, conical or even cylindric swelling.

Stem galls may be classed as medullary and subcortical, the former occurring mostly in herbaceous vegetation and in the smaller limbs or shoots of shrubs and trees. They may be inhabited by one or more larvæ, which usually occur in a more or less definite channel along the pith, as in the case of the aster stem gall.[15] The subcortical type of gall is common in

[10] *Itonida foliora* Rssl. and Hkr.

[11] *Contarinia canadensis* Felt.

[12] *Sackenomyia viburnifolia* Felt.

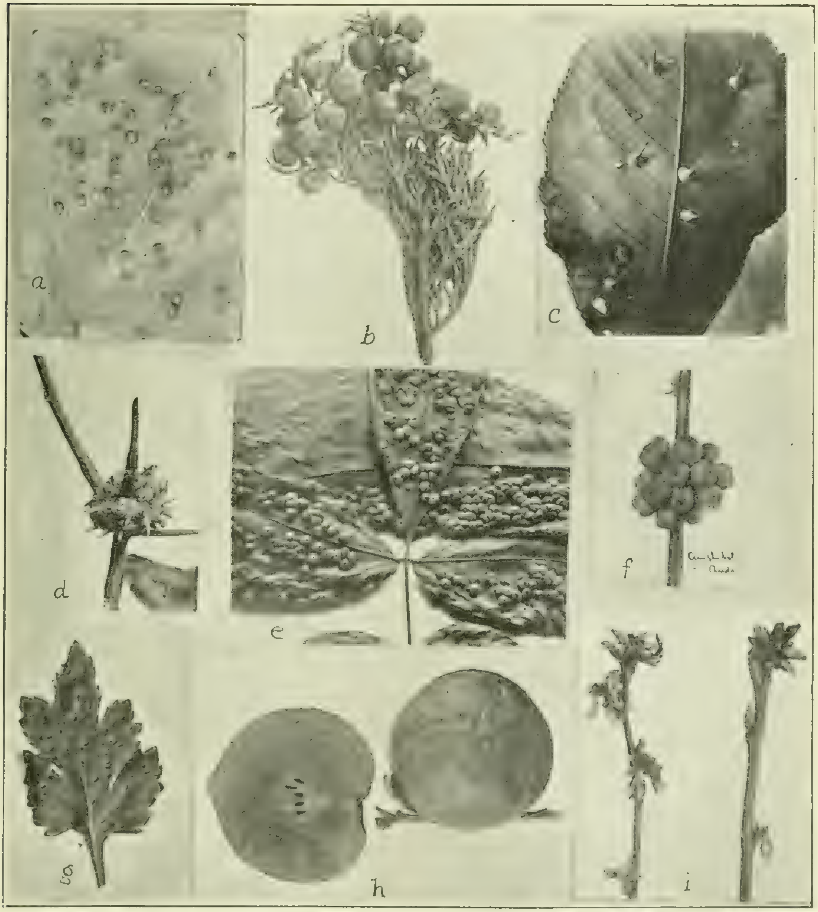
[13] *Lasioptera vitis* O. S.

[14] *Lasioptera excavata* Felt.

[15] *Neolasioptera ramuscula* Beutm.

herbaceous plants and is the predominant type of stem gall in woody plants. It is generally polythalamous, frequently eccentric and, as stated earlier, is usually produced by a rather highly specialized gall midge.

Only a few species are known to produce root galls, probably because of the greater difficulty in finding them. There seems to be no marked difference between root and stem swellings aside from their location.



DIFFERENT TYPES OF GALLS: *A.* Globular greenish or reddish galls on grape. *B.* Swollen fruit of the western juniper, the interior of which was literally alive with microscopic plant mites. *C.* Hickory seed galls, showing a type with very slender tips. *D.* Horned oak gall, a peculiar growth on oak twigs, with harder horn-like projections within which the whitish gall wasp maggots live. *E.* Typical hickory-leaf midge galls showing extreme abundance. *F.* A peculiar clustered bud gall on oak. *G.* Galls of the chrysanthemum gall midge, a recently introduced and very destructive European species. *H.* Apple-like oak gall, a western giant with a diameter an inch to an inch and a half. *I.* Elm bud galls, many midges and gall wasps live in buds and prevent their development.

Malformations produced by gall-midge larvæ appear to result largely, if not entirely, from mechanical or chemical stimuli produced by the larvæ. The size of the gall is, generally speaking, proportional to the number or size of the larvæ and with the death of the active agent, development of abnormal tissues soon ceases. This is particularly well marked in the beaked willow gall,[16] the aborted ones producing only parasites. There is a close relation between the midge and its gall and, generally speaking, a series of flies reared from the gall are the true producers, though inquilines and predaceous gall midges are by no means unknown. For example, the grape tomato gall may produce five species of midges referable to as many genera and the same is true of the swollen wild cherries inhabited by midge larvæ.

Certain genera of gall midges are predaceous, this being well marked in the genus *Lestodiplosis*, an enemy of other gall midges; *Aphidoletes*, an enemy of aphids; *Mycodiplosis*, some species of which prey upon scale insects, and *Arthrocnodax*, with a marked preference for plant mites.

The larvæ of gall midges are mostly legless, usually yellowish or yellowish orange, sometimes nearly transparent and generally with a well-developed "breast bone" or "anchor" process. This structure and the supernumerary segment just behind the head are characteristic. These maggots also have the power of throwing themselves some distance; the two extremities are approximated and then extended with a snap that projects the larva into the air. Midge larvæ living exposed upon leaves usually develop some protective device such as a series of tubercles, as in the case of the larva of the gouty pine midge,[17] after it leaves the gall. The transparent maker of the maple spot gall[18] is another striking example of protective modifications.

The minute size of gall midges, the difficulty of rearing them and their marked fragility have resulted in more attention being paid to the galls than to the insects. The producer in most cases is more interesting than the product and we wish for just a moment to call attention to some of the more striking features of the 900 species belonging to over 70 genera.

The antennæ are unusually interesting structures, the normal number of segments is probably 16, though a very large proportion of the gall midges have but 14 antennal segments.

[16] *Phytophaga rigidæ* O. S.

[17] *Itonida inopis* O. S.

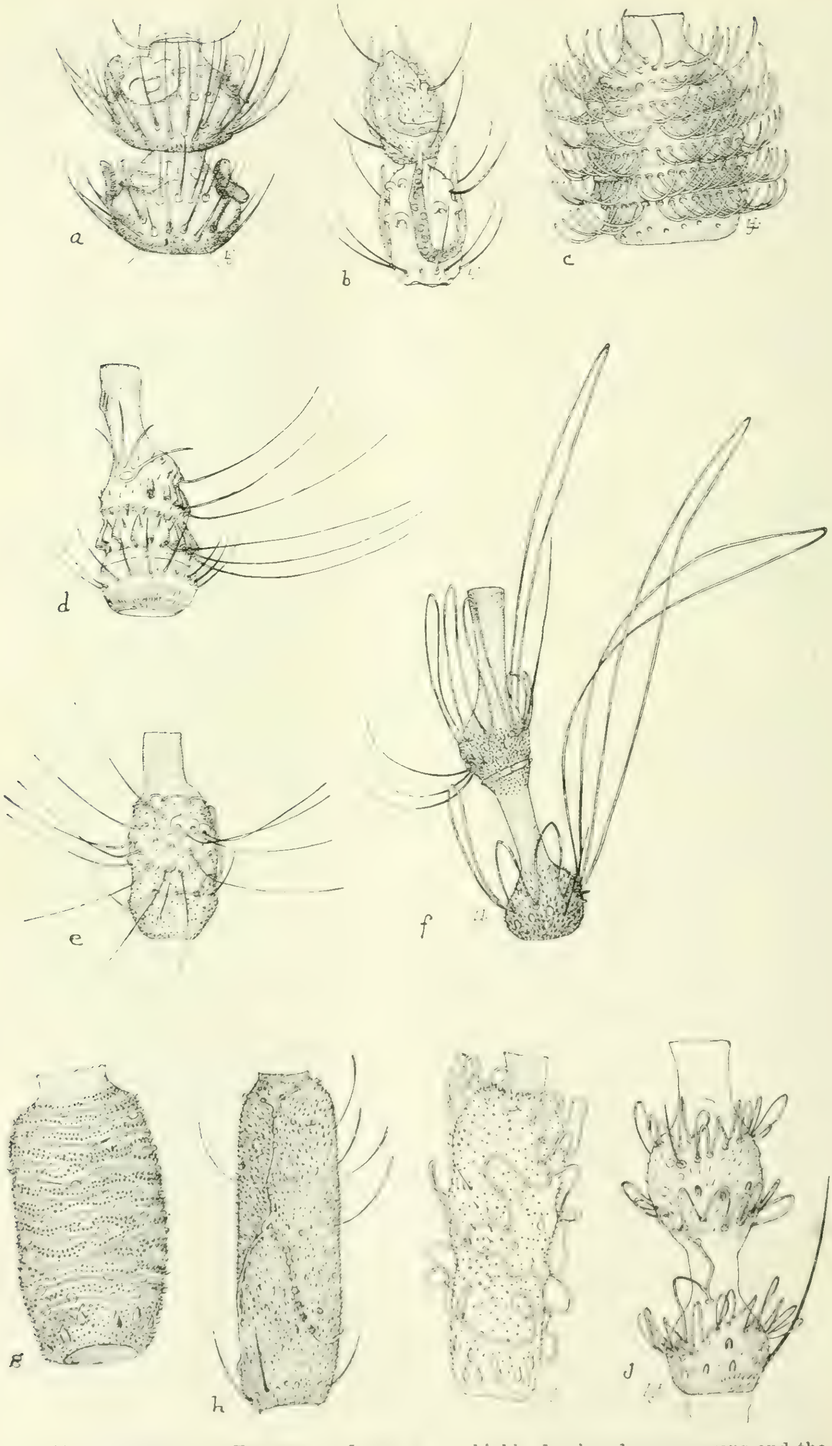
[18] *Cecidomyia ocellaris* O. S.

The extremes range from but eight in *Tritozyga* and *Microcerata* to thirty-three in *Lasioptera querciperda* Felt. These segments vary from relatively simple cylindric units with no particularly efficient sense organs to dumbbell-shaped structures with highly specialized "bow whorls," "arched filaments" or, as we prefer to call them, circumfili.

The more generalized midges are inhabitants of decaying organic matter and bear on their antennæ a variety of olfactory organs. The most interesting of these are the stemmed discs of *Monardia*, though in the same tribe we have the subapical flaring collars and in certain Lestremiinæ striking digitate processes; crenulate whorls are peculiar to the Campylomyzariæ, a simple type being seen in *Corinthomyia*, while the more common and probably the more highly specialized form is to be seen in *Prionellus*.

The "bow whorls," "arched filaments," or circumfili are exceedingly peculiar. In the first place, these homogenous structures have markedly different optical properties from the usual sensory hairs or setæ and are invariably connected in series of low or high loops, the union between the component elements being so perfect that there is no sign of division, no perceptible enlargement and no indication of weakness. They reach their maximum development in the male Diplosid and are characteristic of the most specialized subfamily (Itonididinæ) of the gall midges. The primary type is a low subbasal and subapical circumfilum united on one face of the segment by a nearly longitudinal filum. One of the most peculiar is the horseshoe-like modification, nails and all being simulated, on opposite faces of the antennal segments in *Winnertzia* of the Epidosariæ, a tribe with a marked tendency to hyperdevelopment of these structures. The males of *Asphondylia*, *Schizomyia* and *Cincticornia* also show peculiar modifications.

Males of the most specialized tribe (Itonididinariæ) exhibit the extreme development of these sturctures. They may have two or three whorls of long loops, the former we have designated as the bifili, the latter as the trifili, believing this subtribal division worthy of recognition. In each of these subtribes we may find among the males genera with relatively low loops as in *Thecodiplosis* and *Hormomyia* and many with extremely long loops, such as *Contarinia* and *Bremia*, the latter remarkable because of the great prolongation of two loops and especially on account of the thread-like middle circumfilum characteristic of the female.



THE ANTENNÆ, OR FEELERS OF INSECTS, are highly developed sense organs and the

We may also note that the palpi of the gall midges vary from well-developed four-segmented organs, nearly as efficient as the greatly reduced antennæ of some genera, to minute rudimentary lobes, and in one or more species these organs seem to have disappeared. This tendency toward reduction has arisen independently in several widely separated genera.

There is likewise great modification in the number of tarsal segments, they ranging from one to five; the entire subfamily Itonididinæ having the first tarsal segment greatly reduced. There are certain American genera where there is a reduction in tarsal segments from five to four, to three and in one to two tarsal segments.

The wings, organs which might be expected to respond to environmental agencies slowly, show variations from a structure with five or six veins to one with but one or two veins and in a few extreme cases there are none. The female of one European species has lost the organs of flight.

The association of characters in gall midges is so marked that the presence of one structure means the existence of others and indicates a probable similarity of habits. The *Campylomyza* wing postulates, the long first tarsal segment and larvæ feeding for the most part in dead organic matter, the well-developed crossvein, the short first tarsal segment and the tendency toward the bizarre in the circumfili indicate the Epidosariæ, a group confining itself largely to dead organic matter. The generalized wing of *Rhabdophaga* with the comparatively simple antennæ, quadriarticulate palpi and toothed claws defines a dominant willow group, while the similar *Rhopalomyia* with its reduced palpi and simple claws insistently murmurs solidago buds. *Asphondylia* with its peculiar antennæ, reduced palpi and aciculate ovipositor is satisfied with practically nothing except buds, while the related *Cincticornia* with its

above illustrations give some idea of the wonderful variety of structure to be found in the gall midges. Gall-midge antennæ may be composed of from eight or nine to thirty-four jointed elements or segments. The simple cylindrical segment is indicated in Figs. *G*, *H* and *I*. The same with a stem-like projection is shown at *D* and *E*, while the greatly modified dumbbell type is seen at *F* and *J*. These organs bear peculiar sensory structures, such as stemmed disks, shown at *A* and finger-like or digitate processes near the tip at *D*. There may be few or numerous short or long hairs and in the case of *C* these hairs may be modified into series of stout curved growths running around the segment. Among the most peculiar structures found on the antennæ are the "arched filaments" or "bow whorls" or circumfili. These may be low and few in number as at *E* and *H*, numerous as in *G*, somewhat higher as in *I*, still longer as in *J*, or enormously produced as shown in *F*. One of the most peculiar modifications of the bow whorls is the horseshoe-like structures, nails and all, represented on the two segments illustrated at *B*. These bow whorls under a microscope are very different from the ordinary hairs. The illustrations are all made at approximately the same enlargement and with the exception of *A* and *B*, each figure represents one segment.

quadriarticulate palpi must have oak leaves in the bud and the peculiar *Caryomyia* insists upon hickory.

There are three important groups of gall-makers, the gall midges responsible for 679 deformities, the gall wasps remarkable for their high specialization and the peculiar and extremely interesting alternation of generations inhabit some 445 galls, while plant mites have been listed from 161 galls. The host preferences of these numerous forms are very marked, as evidenced by the following tabulation:

Principal Host Preferences of American Gall Insects

Hosts	Gall Midges	Gall Wasps	Gall Mites
Pines and cedars	35		
Grasses	33		
Willows	66		23
Oaks and chestnut	43	353	17
Rose family	56	38	27
Legume family	24		
Maples	13		34
Grape and Virginia creeper	22		7
Composites	150	12	3
Total for all plants	679	445	161

It is obvious from the above that a close correlation must exist between plants and gall-making insects which live upon them. Generally speaking, groups of plants presenting numerous widely disseminated, closely related forms are acceptable hosts to many gall insects and frequently the members of one order, of a tribe, or even a genus may be closely limited to such plants and in some instances to species or closely related species. For example, gall wasps attacking red oak and its allies are not found on the white-oak series, and vice versa. This great diversity in structure and habits of gall insects is evidently a response to environment and is made necessary by the physical unfitness of adults or larvæ to withstand other conditions. These insects are small in size, fragile, local in habit, mostly slow of flight and generally far from being unusually prolific. Nevertheless, hundreds of species are able to maintain themselves, frequently in large numbers, in spite of apparently unfavorable conditions.

It must not be concluded from the above, lengthy though this may be, that there is nothing yet to learn about gall insects and the deformities they inhabit. New species and new genera are awaiting discovery, the biology of many gall insects and especially of gall wasps is still unraveled. The great variety of galls upon the oaks, many of them attractive in color, delicate in texture and comparatively unknown, challenge our admiration and incite to further study. The same is true of the many and varied deformities inhabited by the fragile gall midges, species which have learned to subsist upon various parts of a large variety of plants. The gall mites, microscopic though they are, invite the attention of the student.

Insect galls are to be found in all parts of the country and they and their makers present a charming and delightful field of study which may be entered with profit by the child at school as well as by the student of more mature years.

The poet must have dreamed of some such condition when he wrote:

> And Nature, the old nurse, took
> The child upon her knee,
> Saying, "Here is a story book
> Thy Father has written for thee."
>
> "Come, wander with me," she said,
> "Into regions yet untrod;
> And read what is still unread
> In the manuscripts of God."—LONGFELLOW.

THE BROOK STICKLEBACK

By Dr. E. EUGENE BARKER

NEW YORK STATE COLLEGE OF AGRICULTURE

IN some of our shallow, weed-choked pools and ditches there lives a most interesting little fish—the brook or five-spined stickleback (Eucalia inconstans), Kirtland. He is so well accustomed to living in stagnant water that he can easily be transferred to an aquarium where he thrives well and is sure to prove an interesting pet. He is diminutive in size—the largest adults measuring barely over one and one half inch in length. The males are bright in color, having a veiling of black over an olive-green ground color which lightens to yellow on the belly. The females are somewhat lighter in color. They are extremely pugnacious little fishes, and show resentment when another fish approaches, even one of their own kind. The spines on the back bristle up like hiars on a dog's back, and with a vicious lunge, the tiny bit of fury rushes, open-mouthed, at the innocent intruder. Often the fish's emotion is registered by a dark flush that sweeps over his body for the time being. It is interesting to note that, when these fishes are transferred to a light or a dark bottom, the color changes in accord with the background. They are voracious feeders and thrive on bits of angleworms, or of fresh meat if it is cut into fine enough pieces.

Like other members of the stickleback family, the brook stickleback is most interesting, perhaps, in his family habits. A true nest is built by the male in which the female deposits her eggs, and the male remains on guard to protect it until after the young have hatched. Some species nest readily in the aquarium, but the brook stickleback has not been observed to do so, at least as far as the writer's experience and knowledge go. On one occasion, however, a male fish was seen guarding his nest in a pond. He was captured and brought home and placed in an aquarium, together with his nest and its contents. As soon as all was settled he assumed again his proprietary air and stood guard over the little home and its precious contents. At one side of the nest there is almost always a small hole through which the eggs can be seen inside it. This fish often approached the opening, and if any of the eggs protruded from it he took them into his mouth, and, backing away a short distance, blew them back again securely into the nest. He swam constantly around the nest, from time to time coming close to it and beating his pectoral fins rapidly like the wings of a hummingbird as it poises before a flower; he would thus draw a current of water through the nest and

THE BROOK STICKLEBACK

aerate the eggs. If any other fish were put into the aquarium, even a female of his own species, he would bristle, flush dark and dart viciously at the stranger and chase it away from the vicinity of his nest.

In the wild state, nesting is begun while the water is still at a low temperature, between 40 and 50 degrees Fahrenheit, although in the shallow surface water, at the margin of a pool where the nest is always built, the water may be as warm as 70 degrees. In central New York State nesting may begin before the middle of April. It continues until late in May. The nest itself is a very dainty structure. It is always built of the materials at hand, which, of course, renders it inconspicuous, indeed, almost invisible amidst its surroundings.

The first nests are built before vegetation has begun to grow in the pools. The only suitable materials that the builder finds at hand are fine fibers, blades of dead grass and the like. These are loosely woven together and held in place by means of a thread which is produced by the male (as in other species of stickleback) from a secretion of the kidneys. It coagulates and hardens upon contact with the water, thus forming a thread suitable for binding together the materials of the nest. As the season advances and vegetation begins to appear in the pools, the nests are made mostly of green algæ, sometimes with sprouting seeds upon them. They are delicate little structures, spherical in shape, about three quarters of an inch in diameter, and with a small round hole on one side through which the eggs are placed within the nest. This little round ball of a home is tethered to a rootlet, submerged blade of grass or some similar attachment, and appears so much like a bit of the general mass of debris around it, or the masses of green algæ, that it can be discovered only with the greatest diligence.

The eggs are about 1 millimeter in diameter, transparent and light yellowish in color. They hatch in about eight or nine days when the water is as warm as 65 degrees. The young fishes are about 5 mm. long when they hatch. At first they still have a very large yolk-sac attached to them which contains enough nourishment to keep them for several days. It soon is all absorbed, however, and the tiny fishling grows fast. For the first few days he attaches himself to some still object by the tip end of his head—possibly by means of a viscid spot. The mouth is almost vertical, but soon becomes terminal. In two weeks time many sharp teeth make their appearance on the lower jaw. All this while the young fry is so transparent that all his inside affairs and private workings can be as easily observed as one can see a gardener at work inside his greenhouse. The primitive backbone with its developing rays, later to become ribs and spines, the heart pulsating at the rate of 108 beats to the minute, even the corpuscles of the blood flowing along the channels of the arteries, can be plainly seen. The eyes are the biggest and most conspicuous organs because of their dark color and take up about one third the size of the whole head. They are moved rapidly in the sockets together like the wheels of an automobile. Before the fishes hatch, there are a few black, star-shaped or moss-shaped chromatophores, or color spots on the embryo. Later, small, orange-colored ones appear, and then yellow ones, so that by the time the fish is a week old he is almost golden in color and quite a pretty little fellow. From this time on, as soon as the yolk is all absorbed and the mouth parts are well developed, the little fellows swim about freely amongst the vegetation and find their own food in the minute forms of life with which all water vegetation and debris teems and we may assume that their voracity and their rapacity also grow apace.

Shallow pools that have clear water all the year through, even though they may be choked with vegetation and covered with floating plants during the summer, are likely to shelter these interesting little fishes. At least, such places are worth a careful search for the five-spined stickleback, and if one fails to find them one will be rewarded with a host of other interesting forms of life which abide here in a teeming world all their own.

EARLIEST ALCHEMY

"Let Art learn so much alchemy that it tinctures all metals in gold."
—"Roman de la Rose," Jean de Meung (1277).

By Professor ARTHUR JOHN HOPKINS

INTRODUCTION

(*a*) *The Popular Idea of Alchemy*

OUR conception of the alchemist is pictured for us in English literature by such writings as Chaucer's "Yeoman's Tale" and Ben Johnson's "The Alchemist," in which there is portrayed a man of doubtful character working in mysterious surroundings, so characteristic of the Middle Ages, claiming to have received from some wonder-worker of a still darker age a small portion of that impregnating powder known as the philosopher's stone, by which crude metals could be transmuted into silver or even into gold. He delighted to emerge from his dark cellar, from among his furnaces and alembics, to make dupes of princes or fathers in holy orders. We have here a perhaps slightly exaggerated but essentially true picture of the conditions which obtained in the dark ages of "pseudo-alchemy," from the thirteenth to the seventeenth century.

But the story of real alchemy has never yet been told. The picture given above, if told in present days, would be called a somewhat journalistic exploitation of a period which may be named the decline and fall of the ancient art of alchemy. Even in the Middle Ages, alchemy was very old. Its beginning was far back in the first century of our era. Its birthplace was in the Greek city of Alexandria in Egypt. Its derivation was still more ancient, for its sources are to be found in the philosophy of ancient Greece and in the mystic rites of Chaldea and Assyria.

The present paper has to do with ancient alchemy, or alchemy proper, and attempts to apply the modern research of Berthelot (1885–1891)[1] to the formulation of an entirely new conception of the activities of these earliest chemists.[2]

[1] "Les Origines de l'Alchimie," 1885. Collection des anciens Alchimistes Grecs (3 vols.), 1888.

"Introduction à l'étude de la chimie des Anciens et du Moyen Age," 1889.

"La Chimie au Moyen Age" (3 vols.), 1893.

[2] This theory was foreshadowed in 1902 by a critical study of the recipes of "The Leyden Papyrus," v. Hopkins, Ch. N. 83, p. 49, "Bronzing Methods in The Alchemistic Leyden Papyri."

(*b*) *The Thesis*

The object of this paper is to prove:

(1) That the fundamental art—the art which led up to alchemy—was the dyeing of fabrics, especially with Tyrian purple.

(2) That by this fundamental art was absorbed the art of what we would call bronzing, but what the Egyptian artisans called the tincturing or baptizing of metals.

(3) That there was a close connection between these two decorative color-processes.

(4) That metals were identified by their original colors, but more surely by their bronzes.

(5) That this last conception was upheld by Greek philosophy which was invoked in support of the newer engrafted alchemistic philosophy.

(6) That the transmutation claimed and attained by the Egyptians was essentially a color-transmutation, an artistic interpretation of laboratory experiments. To this transmutation was allied the transmigration of souls of the the Egyptian religion.

(7) That the conception of the philosopher's stone is in accord with this interpretation.

1. The Sources

The earliest known alchemistic document is the Leyden papyrus—a small portion of papyrus V and the whole of papyrus X. Somewhat posterior to this come the Greek writings of "Democritus," Zosimos and Synesios of the period from the second to the fourth century A.D.

The material found in the papyri consists of workshop recipes,[3] mostly for the production of colors on metals, though there are a few for the preparation of the purple dye from seashells and for the use of this dye in producing colored goods. Alchemy fell by order of the Roman emperor, Diocletian, in the year 290,[4] so that we find a gradual change in the character of the commentaries following the recipes of the Leyden papyrus. The pseudo-Democritus presents recipes enclosed in philosophical discussion while Zosimos and Synesios enshroud their guarded statements with double meanings more difficult to understand.

[3] v. "Collection des Anciens Alchimistes Grecs," Vol. I., p. 28.

[4] "Les Origines," p. 72, note 3. "In order that they might not become rich by that art and to take from them the source of riches which permitted them to revolt against the Romans."

2. The Conditions

There is internal evidence that the dyeing of fabrics was carried on in the temple-workshops of Egypt by the priests, the methods and recipes of this art being kept a trade-secret from the common people.[5] It is well known that the art of dyeing had reached a perfection in Egypt nearly equal to that of modern times; also, that two colors were held in great esteem—the purple of royalty, and black, which was the national color, sacred to the god Anubis.[6]

That the art of bronzing was practised in the same temple-shop is attested by the juxtaposition of the recipes for dyeing and the recipes for bronzing in the Leyden papyrus; also by the fact that the mordants used in dyeing were the first reagents employed upon the metals; again, by the fact that the terms used in the art of dyeing were transferred with a similar but different meaning to the bench of the bronzer.[7]

3. Recorded Processes

In the dyeing of cloth, the first process is cleansing and bleaching. The white fabric is then either dyed with a direct color or more often dipped into a mordant bath and then into the dye. These two processes—the direct and the mordant—produce different colors or shades, the second of which the dyer ascribes to the influence of the mordant. The latter, as the necessary intermediary for the production of some valued color, became important to the Egyptian dyer—to a higher degree than to the modern workman, as is explained below.

The colors available for use in decoration of the robes and temples, the trappings of the dead, the mummy cases and ceremonial insignia were limited to a few organic dyes and to the brighter metals, silver and gold. Gold thread was intermeshed with purple fabric in particularly costly robes. Substitution of gold-colored or silver-colored alloys was also practised. It was then found, probably by accident, that certain base metals, when dipped like the white cloth into the mordant-bath,

[5] "Les Origines," pp. 22–25, 185, 250.

[6] Pliny, "Hist. Nat.," XXXIII, 466 (Bohn translation); Collection, Vol. I., p. 69.

[7] Zosimos: Collection, Vol. III., III., 16, 12 (p. 164): "Add some sulphur-water and digest as one does for purple. One must proceed in this transformation, as one does with the product of the sea when this is changed into true purple."

Pelagius: Collection, Vol. III., IV., 1, 9 (p. 259): "You should notice besides that gold or silver simply spread like a superficial paint does not overcome iron or copper. These metals must first be treated with mordants."

acquired thereby, on standing or heating, a new color or shade, sometimes suggesting silver or gold. A white alloy, like the white cloth, thus obtained its color from the mordant.

It is perfectly natural, therefore, that the production of color on cloth and the production of color on metals, in both of which processes the same reagents were used, should have been carried on in the same workshops and that the recipes for producing these respective color-effects should be found in the same papyrus, side by side.[8]

It was shown by the author many years ago[9] that it was possible, by placing in parallel some of the most ancient recipes with recipes taken from a modern book on the coloring of metals, to judge what colors would be obtained, provided the metal to be bronzed were also known. Fortunately the modern reagents are nearly identical with those indicated in the ancient recipes and in these recipes are also described fairly well the composition of the metal or alloy to be bronzed.

What colors then are actually produced under these circumstances in the Egyptian process and also in the modern shop? The answer to this question gives us what seems to be unquestionably the key to alchemistic theory. The bronze most frequently obtained upon silver was black, the national color; and upon gold and gold alloys was that same purple color which was prized so highly for the dyeing of fabrics.

4. The Interpretation

It is difficult, with our modern ideas, to place ourselves in the same mental attitude as the ancient alchemist in order to get his interpretation of these results. We are compelled to remember that his object was to produce color-effects; that he was an artist interested primarily in color. To him the material was of little account.[10] He was in the same position as the modern artist, mixing his colors on his palette, knowing little of the composition of his "reds" and "browns" except the trade name. It would therefore be natural for the ancient Egyptian, interested only in the color-result, to identify silver as the metal upon which a black bronze could be produced; and gold as the material, *par excellence,* upon which it was possible to produce a purple bronze. Moreover, any metal or

[8] Collection, Vol. I., p. 22; "Chimie au Moyen Age," Vol. I., p. 24. Alchemy was known up to the seventh century as "the sacred art" (*Θεία και 'ιερὰ*) because it had been practised by the priests, in the Greek temples of Egypt, where other color-processes originated.

[9] In 1902, Hopkins, loc. cit.

[10] v. "Les Origines," p. 281.

alloy upon which a black bronze could be produced would be looked upon as silver-like or simply "silver"; and any metal upon which a purple bronze could be produced was "gold." Those were the days when single metals were uncommon and were not accorded the virtue of an identity. Alloys were most common. Asem or electrum[11] was an alloy, well known, consisting usually of silver and gold. Upon it could be produced either of the favorite colors. By adding an excess of silver or gold to asem, the alloy could be made to acquire more of the properties of either metal, including the property of acquiring a distinctive color by treatment with definite salts. An alloy of copper and tin, like our "bell metal," was white, like silver,[12] and the black bronze could be produced upon it. It was "silver." If to it a little gold were added, the purple bronze could be produced upon its surface. It was "gold." The production of these beautiful and decorative colors became a new industry, probably highly remunerative.

But as time went on, it became clear that the base metals, like copper and tin, could be "improved"—could be transmuted into silver and gold as far as color-production was concerned. The capacity for taking the purple bronze (Ἴωσισ) was the measure of gold.[13]

It was common alchemistic practise to add to such alloys a minute portion of gold. Upon such alloys there was probably produced a higher color—a purple, to be sure, but iridescent. The gold in such alloys was looked upon as a ferment,[14] changing and improving the quality of the whole mass. In the elements of Empedocles, the sequence was from the lowest to the highest: earth, water, air, fire. Following this order, the alchemists had the base metals, earthy; the fusible metals (like tin and mercury) having the property of liquidity; the bright or "noble" metals (gold and silver) remaining clear like air; and the bronzes of a higher spiritual nature, playing like fire on the surfaces of the metals. Between the base metals, such as lead and copper, and the noble metals came tin, and later mercury, considered stages of transmutation.[15] But a little pure gold added to a base alloy, no matter how much, improved its quality and raised it in the rank of metals, just as we some-

[11] Hopkins, *loc. cit.;* Collection, Vol. I., p. 62; also, p. 28, note 3, and p. 31, note 1; "Les Origines," p. 90.

[12] v. Recipe 14 of Leyden Papyrus (Collection, Vol. I., p. 31).

[13] Hopkins, *loc. cit.;* "Les Origines," p. 242; Collection, Vol. I., p. 13; Vol. III., p. 214 (3); p. 219 (5).

[14] Hopkins, *loc. cit.;* "Les Origines," p. 53; Collection, Vol. III., p. 248.

[15] v. "Les Origines," p. 230–231.

times speak of a drop of "infinite goodness" purifying a mass of evil so that its sin shall count for naught.

5. The Philosopher's Stone

Just as a little gold could act as a ferment, so the purple bronze, higher than gold, the spirit of gold, free from "base" or earthy entanglements, could be conceived as having infinite power. Certain references and recipes seem to agree in pointing to a bronze, higher than even the purple bronze in purity, not the spirit of gold, but the "spirit of metallicity," possibly to be identified with the fleeting iridescent purple, as the infinitely powerful tincturing and transmuting agent—"the stone which is not a stone,"[16] etc., the ἰός, or virus, the sperm, the element creative for metals.

Roger Bacon (thirteenth century) does not hesitate to say that the philosopher's stone was able to transform a million times its own weight of base metal into gold.[17]

After their expulsion from Egypt, the alchemists claimed that their predecessors had always been disciples of Plato and Aristotle and that it was from Egypt that these philosophers had obtained the elements of their philosophy. From this the alchemists claimed the right to be called philosophers, "The New Commentators of Aristotle and Plato."[18] This accounts for the first term in the expression the philosopher's stone.

Of the second term, Philalethes says:

It is called a stone not because it is like a stone but only because by virtue of its fixed nature it resists the action of fire as successfully as any stone. In species, it is gold, more pure than the purest . . . but its appearance is that of a fine powder . . . in potency a most penetrative spirit . . . easily capable of penetrating a plate of metal.

Raymund Lully exclaims:

If the sea were of mercury, I would transmute it to gold (Mare tingerem, si mercurius esset).

6. Pseudo-alchemy

Escaping from Egypt, the alchemists fled, some across northern Africa, finally reaching Spain during the Moorish invasion in the eighth century; some going to the East, through Syria, Mesopotamia, Arabia and Persia, joining hands with

[16] v. "Les Origines," pp. 181–182.

[17] "History of Chemistry," E. von Meyer (Trans. McGowan, 1891), p. 43.

[18] "Les Origines," p. 4.

medicine, which came from India, and finally entering Europe through Constantinople. These refugees brought with them mostly a body of traditions and some manuscripts. After spreading to western Europe, the downtrodden alchemy finally burst into prominence in the thirteenth century.

Unfortunately, the world had advanced. Metals had already claimed for themselves identity and certain unchanging properties such as are familiar to the modern analyst. Alchemists of the thirteenth century like "Albertus Magnus," "Geber," Roger Bacon, "Raymundus Lullus" and Arnaldus Villanovanus, reading the old manuscripts, believed them, without sensing the Egyptian interpretation. They believed that silver could be changed into gold—into real gold in the modern sense. They believed in and ascribed marvellous properties to the philosopher's stone or "Ancient Stone of the Wise Men." Many claimed to be adepts and to be possessed of a small portion of this stone.

It is strange, but fortunate for us, that many of their writings confirm the argument of this paper. For, though they had no conception of the rôle of color in the original alchemistic theory, they quote the ancient alchemistic writings, extolling the wonders of the color-changes just as did Zosimos, Synesios and Olympiodor—the black, white, red, yellow and purple.

Many of their terms are taken directly from the Egyptian workshops. The metal is dipped, baptized (Βαπτίζω) in the bath. It became tinted (tingere) with the color. The word tincture has come down to us in the present-day medicine, as well as the expression "spirit of wine" and the temper of metals. To temper a metal in Egypt meant to bronze it. (This accounts for the recrudescence of the discussion as to whether the ancient practise of tempering copper is not a lost art.) The expressions base and noble metals, hermetic seal, etc., all attest the fact that the pseudo-alchemist of the thirteenth to the seventeenth centuries had in his possession manuscripts of the ancient alchemists—probably some which can not now be found—from which he quoted freely to his astonished audience, the meaning of which he failed completely to understand.

7. The History of Alchemy

It is seen, therefore, that alchemy began in the Greek city of Alexandria in Egypt among a color-loving people, as a simple art of coloring metals, founded upon the discovery that the same reagents that had been used in dyeing would produce surface-colors on the metals. Greek theories of matter and the Egyptian religious views conspired to uphold the theory that the essential thing was color—not the changing material or body of the metal[19]—so that a change of color was transmutation. Greek theory and the teachings of all kinds of theology supported the idea that each metal had a body, a soul and a spirit; that the spirit was the essential thing, overlying and overcoming the crudeness of the body. Metals were graded in order of perfection. There were base metals and noble metals. The noble metals partook more of the spiritual and could, therefore, be used to perfect the base metals. Moreover, the color was the real spirit, difficult of attainment and hard to keep. As gold improved the lower metals, so the spirit of gold, the ἰός, was identified with the spirit of metallicity—the penetrative tincture—which could tint all metals into gold—the philosopher's stone.

Centuries rolled by. The artistic yearning for color was nearly gone and the methods of recognizing pure metals were much advanced, when in the thirteenth century a false alchemy arose, which claimed on the authority of the ancient writings to be able, by the philosopher's stone, to change lead and copper into silver and gold.

The simple art of the Egyptians had been harmless. Its mission was to feed the color-hungry people of Egypt and it had been eminently successful. Pseudo-alchemy was the teaching of men glorifying in a rapture of self-deceit; later of charlatans who deceived others knowingly. Pseudo-alchemy never succeeded in its pretensions. It succeeded only in holding back scientific progress for some centuries and in bringing into disfavor the fair name of science. This alchemy, so-called, lingered on under the teachings of iatro-chemistry and the impetus of the phlogiston theory until its pretensions were finally crushed by the impressive experiments of Lavoisier, in the latter part of the eighteenth century.

Conclusion

This paper presents a new theory of the origin of alchemy. The theory is supported (1) by internal evidence, drawn from the original alchemistic recipes and the earliest Egyptian manuscripts of about the third century A.D.; (2) by the teachings of the alchemists themselves and (3) by the language and experiments of the pseudo-alchemists of the Middle Ages.

[19] v. "Les Origines," p. 75, p. 281; Collection, Vol. III., 6–10, p. 127.

THE ENGINEERING PROFESSION FIFTY YEARS HENCE[1]

By J. A. L. WADDELL, D.Sc., D.E., LL.D.
NEW YORK CITY

Prelude

ENGINEERING, in one sense the youngest and in another the oldest of all the learned professions, has attained its importance and high standing mainly during the last half-century. It is universally acknowledged to be the profession of progress; and all thinking people concede that without it the advancement of the world would come immediately to a standstill, and even the maintenance of modern civilization would be impracticable. Just imagine what civilization would be without the steam-engine, railroads, steamboats, bridges, the telegraph, the telephone, water-works, sewerage, the typewriter, electrical machinery, the gas-engine, the automobile, mining, metallurgy, applied chemistry, water-power, steel buildings, reinforced-concrete constructions, agricultural machinery and irrigation! All these activities and many others too numerous to mention come within the province of the engineer, and their development has been his task. The importance of the engineer in the community was emphasized in polished language as follows in an editorial of the *Canadian Engineer* for October 18, 1917:

[1] Before starting to prepare this article, the author wrote to a number of his good friends in the various branches of engineering, and propounded to them the following questions:

"*A*. What deficiencies, shortcomings, or defects do you note in our profession in general, and how would you suggest correcting them?

"*B*. In regard to your own specialty, what improvements would you desire, and how do you think they may be effected?

"*C*. In your special line of work, have there been any fundamental novelties or drastic innovations suggested which are either practically feasible or even possible of future adoption? If so, please give a brief description of them; or, if they have been already described in print, tell me where I can find the information."

A few of the responses received to these questions furnished data of considerable value to the speaker in preparing this manuscript; and he takes this opportunity heartily to thank, individually and collectively, the gentlemen who so generously responded to his appeal for aid. It is deemed inadvisable to enumerate their names, especially in view of the fact that their contributions have been utilized mainly as suggestions for development rather than for direct quotation. This arrangement was understood at the outset by all concerned.

Every industry depends directly upon the engineer. There are few points of life where his work has not effected big alterations. Tolerant he must be to human weakness; efficient he must be, for in few other fields of effort is the elimination of the unfit more rigorously practised. His training is applied science, and his practise demands large common-sense.

The engineer is one of the pivots of modern civilization; therefore he should be more in evidence as a public man. He is well fitted to carry forward the lessons of practical experience in the realm of national affairs.

In war as well as in peace the engineer stands preeminent, as is evidenced in the present struggle, by such prominent military men as Joffre, Kitchener, Cadorna and von Ludendorf.

The world could manage to dispense with lawyers and clergymen, and, possibly, even with physicians, but it would be impracticable to get along without engineers. Very few people, however, have looked at the matter in this light; and the engineer, in consequence, has not yet received from the public the consideration which is his due, nor the pecuniary compensation which his services merit.

The fundamental reason for this undesirable state of affairs is, undoubtedly, the newness of engineering as a learned profession, but it must be confessed that much of the blame therefor lies with the engineers themselves. They have been so intent on their own individual activities that they have not fully organized for their protection as a class; and although the engineering societies, both large and small, have done great work and have accomplished much towards the betterment of conditions, their effectiveness is far from being ideal. The larger societies are too cumbersome to accomplish desired reforms in any reasonable length of time, and the smaller societies generally have not in their ranks enough men of prominence.

Recognizing this, some years ago a few engineers in independent practise founded the American Institute of Consulting Engineers. It is proving, in certain lines, to be a most excellent organization; but its field of usefulness is too limited. Its objects are in a certain sense selfish; and its constitution excludes all engineers who are engaged in contracting and most of those who are in the employ of manufacturing or contracting companies.

Some eight years ago a few engineers came to the conclusion that the profession needs at its head a comparatively small and select body of engineers chosen from the leaders in every branch of activity and from all parts of the country, in order to undertake those duties which the existing societies neglect. They, consequently, endeavored to organize an "American Academy of Engineers" on the broadest and most altruistic lines; but they encountered many obstacles which delayed for a long time the accomplishment of their purpose. The principal stumbling block was the difficulty in organizing without subjecting the charter members to the accusation of being self-appointed. It was claimed, and very properly, that the making of such an accusation would militate seriously at first against the effectiveness of the academy, and might even be the means of ultimately preventing its successful establishment.

Great undertakings are apt to move slowly; and such was the case in this endeavor, for it was not until the end of 1916 that a truly impersonal means was evolved for the selection of the nucleus of the Academy. The *modus operandi* finally adopted was as follows:

The Honorable William C. Redfield, secretary of commerce, who for several years had taken a deep interest in the undertaking, and who had been requested in writing by many prominent engineers from all parts of the United States to take the initial step towards the formation of the academy, appointed Major-General George W. Goethals as the first member, and instructed him to select nine others from among the most prominent engineers in all branches of the profession, limiting his choice by the inclusion of at least one past-president from each of five national engineering societies which he named. General Goethals in complying with his instructions went a step farther by selecting one past-president from each of eight national engineering societies, thus covering practically all lines of the profession, and two at large, dropping out himself on the plea that he objected to accepting a government appointment to such an organization. The ten engineers thus chosen met at once in order to select the other forty engineers so as to form the nucleus of the academy and then apply to Congress for a national charter, all in accordance with the program of Secretary Redfield, as indicated in his letter of instructions to General Goethals.

At the first meeting, which was held in New York City, it was unanimously decided that General Goethals should be the first one chosen, and that he should be requested to aid in the selection of the remaining thirty-nine, to which arrangement he subsequently agreed. The method employed was to let each of the eleven members nominate as many suitable candidates as he might desire, and from these, by a process of elimination, to choose the number required. Over one hundred names were proposed, and approximate percentage-limitations for the various groups of engineers were agreed upon. A number of meetings, extending over several weeks, were found necessary.

Each candidate's fitness was thoroughly discussed, and his proposer was required to state in writing the said candidate's professional record and the reasons why he was believed to be specially eligible. A consideration of geographical location was deemed requisite; and for that and other good reasons it was found necessary to exclude temporarily a number of engineers who are in every way eligible. Not one of the fifty gentlemen thus chosen as charter members failed to accept his election.

By direction of Secretary Redfield, the solicitors of the Department of Commerce prepared the draft of a bill for the incorporation of the academy; and this bill was introduced in both the Senate and the House of Representatives. It was passed by the Senate during the late special session of the Congress; but the judiciary committee of the House postponed its consideration until the next regular session. Arrangements are being made for the said judiciary committee to take up the consideration of the bill in the immediate future.

Some opposition has been raised by a few engineers to the granting of a national charter to the academy, the cause apparently being an absolutely unfounded fear that the new organization will usurp some of the functions of the existing national technical societies, but mainly because the true intent of the academy is not generally known or understood.

The fundamental reason why it will eventually succeed in accomplishing many important desiderata for the profession where the large national technical societies have failed is that there are in each group or line of engineers a few individuals who have a deep love for the profession, and who are ever ready to subordinate to its welfare their own personal interests—men who generously spend time, effort and money in giving to others by their writings the benefit of their knowledge, accumulated through many years of hard work—men, too, who are prominent in research, in originality, in organization, in altruism and in energy. If all, or a large proportion, of such men from every line of technics were combined into an academy, having a membership limited to two hundred, is it not evident that the amount of good which they could accomplish would be enormous and that the results of their efforts would be far-reaching and invaluable? It is mainly of such men that the American Academy of Engineers is and will be composed. The fifty names of the charter members are a proof of the correctness of this assertion; but additional evidence is given by the following quotations from the temporarily adopted Constitution and By-Laws:

Professional Objects.—These shall be: To dignify and to exalt the profession of engineer in the broad sense, and to place it upon the highest plane amongst the liberal professions; to bring the different branches of the engineering profession into closer touch and harmony with each other; to bring American and foreign engineers into closer relations with each other; and to secure for the engineering profession as a whole the recognition that is commensurate with the importance of its services to the world.

National and Civic Objects.—These shall be: To render to the government of the United States of America or to any commonwealth of the nation, when so requested, service in the field of engineering, industrial technology, and applied science; to cooperate, in rendering such service, or for any purpose involving the welfare and interests of the country, and to subserve the same, with American national academies, institutes, societies, or bodies interested in pure and applied science, technology, and engineering.

Ways and Means.—The academy will strive to accomplish these objects by all proper, honorable, and legitimate ways and means; by fostering, stimulating, and encouraging the growth and development of the highest professional spirit, ideals, and ethics uniformly in all branches of engineering; by promoting a better understanding and sympathy between these different branches; by advocating more homogeneous and consistent rules and precepts for their guidance in their relations with each other and with the rest of the world; by working for general cooperation and solidarity; by fostering an *esprit de corps* in the profession as a whole; by doing all in its power to elevate the standards and promote the interests of the profession; and by urging its claims, or those of its more distinguished and eminent votaries to due and proper consideration for public or private honor or recognition. . . .

Members.—Members shall consist of properly qualified engineers having eminence or distinction in one or more branches of engineering, by reason of their professional attainments, learning, or experience, and of their contributions to the progress and advance of their branch or branches of engineering or of the engineering profession as a whole.

The qualifications of a candidate for member shall include the following requirements:

(*a*) He must be a citizen of the United States of America.

(*b*) He must be at least forty years of age.

(*c*) He must be a member, in good standing, of the highest grade, in at least one national engineering or technical society in the United States of America.

(*d*) He must have practised or else taught engineering, or some cognate branch of technology (such as chemistry), continuously for a period of not less than fifteen years, and he must be still engaged actively in practising or teaching or both; or else, in lieu thereof, he must have been identified with work of importance, either by reason of its magnitude or else because of its novel or special character; and it must be shown that he has made a satisfactory record and has obtained a good standing in his branch of the profession through his technical work.

(In the case of a teacher of engineering or of technology, the publication of original books relative to his branch or branches of the profession shall be taken as the equivalent of engineering work.)

(*e*) He must have a personal as well as a professional record, reputation, and standing, entitling him to the highest consideration as a professional gentleman who is devoted to the progress and advance of the engineering profession and who is interested in promoting the welfare and sustaining the dignity of that profession.

Other qualifications, constituting criteria of eligibility to membership, are prescribed in the By-Laws. . . .

Eligibility.—The additional qualifications, referred to in Article II of the Constitution as constituting criteria of eligibility of a candidate for member of the American Academy of Engineers, shall be such as indicate the general education, the technical training, and the professional experience and record of the candidate. They shall include the following requirements:

(*f*) He must have a degree from a university or technical school of recognized standing.

(*g*) He must have a reading knowledge of at least one European language, or else of Esperanto, besides the English language.

(*h*) He must have been in responsible charge of engineering or technical work or design for a period of not less than five years. If teaching, he must have been in charge of a department in a school of recognized standing for a period of not less than ten years.

(In the case of candidates who have taught and practised at different portions of their careers, two years of teaching shall be considered the equivalent of one year of engineering practise.)

(*i*) He must be the author of at least one important original publication on some subject or topic related to at least one branch of engineering.

In general, the intellectual status of the candidate, and the personal traits or qualities making him a credit to the profession of engineering, and, especially, his zeal and devotion to that profession, shall be the paramount considerations in determining his fitness. His financial status shall be of no consideration whatever.

Waivers.—Any of the foregoing requirements may be waived in any particular case in behalf of a candidate otherwise very desirable; but the said waiver shall be only by the unanimous vote of the Board of Directors. . . .

Scope and Program.—The academy shall avoid encroaching upon the scope and program of any of the engineering and technical societies representing special branches of the engineering profession, and it shall limit and confine its activity to questions of such nature and character as are likely to interest and to affect the profession as a whole. These questions may include ethics, relations with other professions, matters of general professional policy or expediency, questions of political or commercial economy involving engineering, national and international engineering topics, etc.; and the program shall specifically exclude engineering and professional papers of the types usually presented before the various engineering and technical societies.

Communications from non-members, when introduced by a sponsor member of any class, may be presented and published with the approval of the publication committee.

Annual Publication.—This shall contain the proceedings of the meetings, and the reports, including discussions, of papers and communications presented before the academy and approved by the publication committee for publication.

A copy of the annual publication shall be sent gratis to every member, emeritus member, and honorary member of the academy; to every important national engineering society in the world; to the governor of each state and territory, to the library of every university and technical school of recognized standing in the United States, and to the libraries of certain foreign institutions of learning. The list of institutions and individuals to whom copies are to be sent gratis shall be subject to the approval of the publication committee. Copies shall also be available at a reasonable price to any person desiring the same, if ordered before publication, or otherwise if there be copies available.

An apology is due for the length of these quotations from the constitution and by-laws; but the purpose the writer has in mind in making them could not well be accomplished by shortening them in any way. These extracts show not only that the American Academy of Engineers is to be a technical and scientific society of the highest possible order, but also that its aim is to supplement—not to supplant—the other national technical societies.

Through its honorary members, who are citizens of foreign countries, American engineers will be brought in contact with their professional brethren abroad; and a large amount of business for our country will certainly result from this connection —business which otherwise would naturally go to other countries than ours.

It seems to the writer that no truly broad-gauge man in any walk of life can oppose the incorporation of the American Academy of Engineers as a national organization; for, unless it were given governmental recognition, it would not be regarded by people in general as the national association of engineers chosen from every line of technics, nor as the select body of practitioners which it is intended to be; and, therefore, its capacity for doing good would be most effectually curtailed. Again, it would not be properly recognized, at least for many years to come, by foreign governments and foreign technical and scientific societies, nor could it act, in the manner intended, as a court of last appeal for American engineers in all lines of the profession. Moreover, the national and the state governments would not feel that they have the right to call upon it for advice and assistance to be given gratis, unless it were a national body; nor could it properly take the initiative in many important movements affecting the welfare of the commonwealth. For these reasons, and for other important ones too numerous to state, it is to be hoped that nothing will prevent the granting of a national charter to the American Academy of Engineers at the present session of Congress.

The principal existing "deficiencies, shortcomings, or defects" in the engineering profession in general, as indicated by a consensus of the answers to questions *A* and *B* of the circular letter which, as previously indicated, the writer sent to some of his technical friends before starting to prepare this lecture, are, in the indicated order of importance, as follows:

A. Lack of appreciation of the profession by the public.

B. Deficiency in general education on the part of most engineers.

C. Lack of culture.

D. Failure of the technical schools to provide proper instruction in the English language.

E. Failure of the technical schools to give a broad, general education.

F. Uncertainty as to the definition of the term "engineer" and exactly the class of men which it should include.

G. Too small compensation for engineers.

H. The fact that engineering is too largely a profession of regularly employed men; or, as it has been rather pithily but inelegantly stated, that "too many engineers wear the brass collar."

I. Need for a license system—federal, but not state.

J. Lack of publicity concerning engineering achievements and general technical news and interests.

K. A tendency among some engineers for one man to appropriate another's inventions or ideas.

L. Undue criticism of one engineer's work by a brother engineer.

M. Failure on the part of engineers to recognize what the profession really is.

N. Need for a clearer appreciation by engineers of the rôle they are called upon to take.

O. Lack of loyalty to the profession and to the members thereof.

P. Giving of advice and doing of preliminary work gratis.

Q. Deficiency in accurate thinking.

R. Lack of accuracy in doing work.

S. Carelessness and slovenliness.

T. Lack of address, and inability to speak well.

U. Inability to write well.

V. Lack of initiative in public affairs.

W. Improper methods of instruction in technical schools.

X. Ignoring of individuality in students by teachers of technics.

Y. Lack of direct connection between research and engineering practise.

Z. A tendency to usurp the title of consulting engineer by those who are not equipped to bear it.

a. Inability of many engineers to handle men.

b. Need in this country for a better patent system.

c. Opposition in America to the trying out of new devices and processes, and waiting instead for Europeans to make the trial.

d. Favoritism instead of merit as the reason for promotion of employees in large companies.

e. Need for a fixed minimum-fee basis for engineers' compensation.

f. Need for greater standardization of engineering practise.

g. Need for "abbreviated engineering data."

h. The study of one branch of engineering at school and subsequent practise in another branch.

The preceding is a rather appalling list of the alleged "deficiencies, shortcomings, or defects" that exist in the engineering profession; but it must be remembered that it represents the combined complaints of more than twenty engineers, representing all the leading branches thereof, each individual, of course, contributing his pet grouch; nevertheless a careful study of the list will convince one that each allegation is fairly well founded, and that the existence of many of them is beyond dispute. Remember, too, that these deficiencies apply to the profession as a whole, including the rank and file, and by no means to all of its members.

A study of the list will show that most of the deficiencies are of such a character that they are not corrigible by any of the existing technical societies; but they certainly are by an organization of the peculiar character and scope of the American Academy of Engineers.

Dr. C. O. Mailloux in his presidential address to the American Institute of Electrical Engineers spoke as follows:

> We must show to the rest of the world that engineers are, by education, training, and experience, as well qualified as any professional class, to discuss and deal with public questions and problems, and that in the case of technical questions we are better qualified than are the other classes.
>
> We not only fail in our duty to our professional class, but we also fall short of doing our full duty to the community by remaining silent in the social and civil background, and by hiding the important light which we are most able to shed on many public matters by virtue of our scientific and technical training.

It is a certainty that much remains to be done to put our profession upon the high plane where its importance to humanity entitles it to stand, and that reforms can be instituted only by concerted effort. The large national technical societies have gotten into ruts, and it is hard to jog them out—besides, the unwieldiness inherent in their great bulk militates strongly against a combination of all their efforts. It is far better to choose a limited number of the most live, energetic, earnest and altruistic members of each group and form them into a new organization which will act in concert and harmony with all the other national technical societies, as has been done in the case of the American Academy of Engineers. The new society could take the initiative and then apportion most of the work among the other organizations, reserving for itself the unusual or general tasks which no one of the other societies is specially fitted to handle. If the academy, after having been granted by Congress a national charter, were properly officered and systematically operated, there would be, ere many years, a wonderful improvement in the general status of the engineering profession; and most of the evils complained of would be fairly well corrected. Perfection, of course, can never be attained, but it is practicable to approach it by an asymptotic curve.

The present is the psychological time for bringing the engineering profession into its own; because never before in history has mankind been so dependent upon the engineer. The existing war is essentially a war of engineers; for it is they who are manufacturing the guns, ammunition, vessels, motors, and the other paraphernalia requisite for carrying on the struggle, and who are attending to the transportation of men, munitions, food, and all other supplies by both land and sea, besides doing their fair share of the fighting. The public is now beginning to recognize the truth of the sayings that, "when something of importance has to be done, it is necessary to call in the engineer," and that "engineers are preeminently the producers of results."

Concerning the relative importance of the engineer's work in the world to-day, it may be stated, without any reservation, that it is he who is responsible for our present civilization in the material sense and even, possibly, also in the mental sense. It is truly an engineer's age. Countries are built up and torn down by the engineer. He is a creator; he brings together elemental forces and gives them direction. He takes the natural things from the earth and makes of them the complex things of life. If his work were to cease, the world would retrograde to uncivilization as we understand the word to-day.

The speaker has stated that "the present is the psychological time for bringing the engineering profession into its own," but he wishes to add to this another claim, viz., that it is also the psychological time for our country to secure the trade of Latin-America as well as to prepare for obtaining the lion's share of world-reconstruction after the war. Both of these tasks are work for the engineer, because it is he who first will have to go to those countries in order to spy out the land, determine what works of construction are necessary, and do missionary work for American manufacturers, capitalists, and contractors; and it is a *sine qua non* that the reconstruction mentioned is essentially his *métier*. Such being the case, now is the logical time to improve the engineering profession in America so as to enable its members to render the most effective service possible in these activities of national importance.

Perhaps the most outstanding factor at the present time, bearing upon the future of engineering, is the new standard of values brought about by the war. This is, undoubtedly, the most widespread and revolutionary change in the history of mankind. Not only have money values varied greatly in a short period of time, but the war, on account of its widespread nature and because of the vital principles affecting the future progress of mankind, for which the Allies are fighting, has brought us face to face with one of the most important stages in the cycle of civilization.

Engineering works are the surest index to the state or degree of civilization to which a nation has arrived; and, owing to the rapid progress and readjustments which will be the outcome of the war, these same works will undergo a more rapid change and growth in a given time than history has yet shown. What may have seemed a colossal engineering work a few years since will become commonplace henceforth. An illustration of this is the growth in the size of steamships. How many times we have heard of huge vessels having been constructed and regarded as the final word in marine architecture! Drydocks have been built to take care of the largest vessel that would ever be constructed, yet in a few years these same docks are found to be totally inadequate to handle anything but that which has come to be considered a vessel of ordinary size. The same remark applies to bridge loadings. Many bridges have been built to take care of all possible future loads, and yet the weights of locomotives and loaded cars have increased so fast that the structures are out of date long before they show any sign of deterioration from the elements. This analogy could be continued indefinitely to apply to actual cases concerning transportation systems, office buildings, canals, waterworks, etc.

The increase in requirements or demand seems to be in an ever-augmenting ratio, the curve varying with the periods of business prosperity and depression. In short, engineering works will always meet the demand; and the demand is increasing steadily. It is quite reasonable to imagine the City of New York as having grown to a city of twenty million inhabitants; and when such a change exists, there will be engineering works such as bridges, tunnels, water-works, transportation systems, etc., in which almost inconceivable sums of money have been invested. If there is a compelling need for a structure of unprecedented size, then that structure will be built—the cost is merely a relative matter. Given enough money (and the money will be found, if the need is sufficiently imperative), there is almost no engineering feat that can not be accomplished.

(*To be continued*)

CHANGES IN FACTORS THROUGH SELECTION

By Professor T. H. MORGAN

COLUMBIA UNIVERSITY

MOST interesting of all the mutations that are now engaging the attention of students of mutation are those in which genetic factors or genes occur, or appear, whose most obvious action is to enhance or diminish some other more conspicuous character. These genes may be called specific modifiers. They do not differ from ordinary genetic factors in any essential respect, but, since their presence can not be detected, except when other factors are themselves producing some particular effect on the individual, it is convenient to give them a special designation.

For the correct interpretation of the results of selection, it is essential to have some means of finding out whether any effects that are produced are due to specific modifiers or to a change in the principal gene itself. For instance, there are several cases where a mutant character is known to be due to a single Mendelian factor, and selection has caused the character to change in the direction of selection, either plus or minus. Since the character is demonstrably due to a single factor the first conclusion that was drawn was that the change in the character *must* be due to a corresponding change in the factor that produces it. Such a conclusion may be fallacious, however, for the change may be due to the appearance during selection of specific modifying factors, or to their segregation if they were present at the start in a mixed stock. Until suitable tests were made, one interpretation was as valid as the other and without such test the wrong inference might be drawn.

It is obvious that it could never be shown that genetic factors do not change under the influence of selection if each time progress took place the results were ascribed arbitrarily to modifying factors. Conversely those who claim that progress comes about through modifying factors could never hope to establish their view so long as the possibility of the chief factor itself changing and producing the observed effects was open to discussion. But a modern technique has been worked out along several lines by means of which crucial evidence can be obtained that will make probable or even demonstrate whether the main gene or modifying genes are involved. Let us examine the ways in which a decision may be reached.

1. Starting with a mixed population in which the principal gene and one or more specific modifiers are present (the latter irregularly distributed amongst its members) and breeding in pairs along definite lines, we should expect to find in the first five or six generations that selection in a plus or minus direction would cause a definite change in the direction of selection and that then the process would slow down. This is the result that McDowell obtained when he selected flies for the number of bristles on the thorax, and it is in harmony with the view that modifying factors were present at first, irregularly distributed, and were sorted out by selection. If selection had really caused a principal gene for bristle number to change in the direction of selection it is not apparent why its progress should slow down and cease after a few generations, especially when selected in a minus direction. This argument gives results that are intelligible on the hypothesis that the change is not in the gene itself, but the method is insufficient to disprove that the gene changes; for, it might still be claimed that genes yield more at first to the treatment of selection and less later on.

2. It has been pointed out especially by East that the variability (spread) in the first hybrid generation (F_1) is often characteristically less than in the second (F_2), and this is expected on the theory of multiple factors, because the F_1 individuals are in their hereditary composition more likely to be uniform than the F_2 generation that results from the sorting of all the kinds of factors present in the F_1 generation.

3. The fact that there is less correlation between the "grade" of each F_1 individual and F_2 offspring than there is between each F_2 individual and its offspring (F_3) is expected on the multiple factor hypothesis, because all the differences of the F_1 individuals are not so probably due to genetic differences as are the differences between the F_2 individuals.

These and other correspondences between the expectation for modifying factors and the facts that are known in several cases create a strong presumption in favor of the theory, even though they do not pretend to demonstrate conclusively that modifying factors are present.

4. We may next turn to cases that furnish an actual demonstration that selection has produced its observed results through the isolation of genetic factors. This evidence is furnished by

linkage. Owing to the fact that in several cases linkage of factors is known, it may be possible to identify the presence in individuals of modifying factors when these are linked to visible ones. To run down modifying factors in this way is tedious, and to be entirely successful presupposes that all the great groups of linked genes are known and that within each a considerable number of loci are available. At present *Drosophila* is the only type which fulfills these requirements, and here at least five cases are known where the presence of specific modifiers has been demonstrated in the same way as all other genetic factors are demonstrated. Two examples may be given to show how such a demonstration was possible.

FIG. 1. A female fly (Drosophila melanogaster) from a mutant stock called notch in which the ends of the wings instead of being rounded (see Fig. 3A) are serrated. The factor producing the character is sex linked and dominant. It is also lethal, so that no males with notch appear because the male has but one X-chromosome. In the female, however, with two X's, the lethal effect of the notch gene in one X is counteracted by the normal allelomorph in the other X; but the dominant effect of the gene remains.

The general procedure is as follows: By appropriate matings to be described below, two kinds of individuals are produced that differ from each other in known respects, *i. e.*, in having different combinations of chromosomes. By testing in turn all the possible chromosomal combinations the presence of specific modifiers can be made out with certainty. An example will show in detail how the test is made. There is a dominant character known as notch wing, Fig. 1, whose gene lies in the sex chromosome. The character was found to be very variable in the original stock; a few flies in each generation that carry the factor have normal wings. By means of linkage experiments these normal-appearing notch females can be picked out from the real normals. By selecting such females for several generations the stock was changed to such an extent that more than half of the notch females had normal wings, and the rest had only faint indications of the notch. Females from the selected stock were bred out to males of another stock in which one of the third chromosomes contained a dominant factor (dichete) by means of which its presence could be identified. It was found that when both of the original third chromosomes were present the selected type of notch occurred, but when a dichete-bearing third chromosome was present the atavistic type of notch was present. The inference was that the modifier was present in the third chromosome and the inference became a demonstration when by means of similar tests for the other chromosome no modifier was found in them. The details of the test for the third chromosome alone are shown in Fig. 2, but the general nature of the test can be understood without need of this somewhat technical diagram.

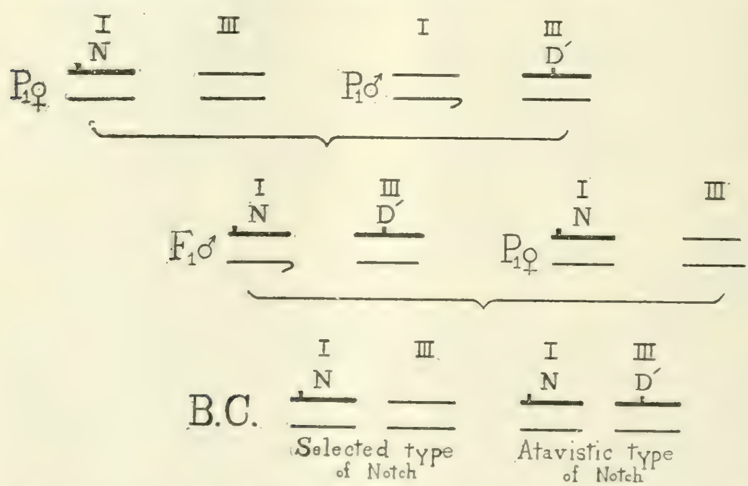


FIG. 2. Diagram to show how a specific modifier was located. The principal gene N for notch wing was carried in the first chromosome, I. A notch female (P_1) was mated to a male (P_1) that had a dominant gene for dichete bristles, D^1, in the third chromosome, III. A dichete son (F_1) was back-crossed to a notch female of stock (P_1). Two kinds of notch daughters are expected (BC), one having the original pair of third chromosomes should be like the original selected stock; the other with one of the original third chromosomes and its mate from the dichete grandfather. This female should be like the original (atavistic) type since the influence of the modifier in the third chromosome is dominated by its normal allelomorph in its mate, the dichete chromosome.

Another experiment made by Sturtevant in a different selection experiment was essentially the same. Only a preliminary statement has been made as yet by Sturtevant, and the following report is, with his permission, based on the complete account in press at present. He made use of a race of *Drosophila* called dichete, Fig. 3, *B*, characterized by fewer thoracic bristles on the average than in the wild type. In the wild fly there are four dorso-central and four scutellar bristles, Fig. 3, *A;* the former vary from 3 to 6, the latter vary less. In the dichete flies the bristle number for both groups of bristles taken together is from 3 to 7, five being the most common type.

Selected in the plus direction a race was produced with 6 as a mode and with a range from 4 to 8, selected in the minus direction the mode became 4 and the range from 1 to 6. Brothers and sisters were obtained that were alike in the first and in the third chromosomes, but different in the second chromosome. A comparison between them showed that a

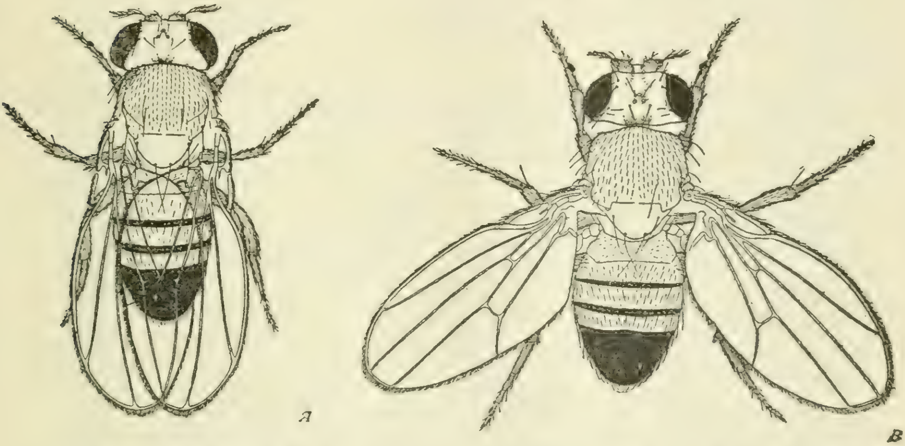


FIG. 3. A NORMAL MALE (Drosophila melanogaster), A, and a dichete male, B, that lacks certain bristles on the thorax. The gene is dominant and not sex-linked, but it is lethal in double dose. Hence all dichete flies (♂ and ♀) are heterozygous for the gene.

modifier was present in the second chromosome. In other words, selection for the number of bristles had changed the number, because a specific modifier for bristle number appeared in the course of the experiment in the second chromosome. Selection had produced its results by isolating a race in which the second chromosome pair contained a modifier.

A third example could be given in which the specific modifier appeared in the same chromosome that carried the principal gene itself. No doubt cases will be found in which two or more specific modifiers are present. Their detection becomes then more difficult but can still be accomplished by the same sort of procedure.

An analysis of this kind brings to bear on the problem really critical evidence. Until equally cogent evidence can be obtained in other cases where it is claimed that mutant genes are modified by selection I do not think that this conclusion can be accepted.

Mutants of Multiple Allelomorphic Genes

Another one of the interesting and important discoveries in recent years has been the demonstration that more than one modification of the same gene may appear. The discovery is important not only because it shows the untenability of a current view that all mutants are due to losses of normal factors, but also because it shows that such mutant factors behave towards each other in the same way as the mutant gene behaves towards its normal gene (its "allelomorph") and consequently makes somewhat probable a view difficult to demonstrate otherwise that the normal gene is itself a gene like the mutant gene.

Multiple allelomorphs have now been found in a number of different forms. In mice the characters for black, yellow, gray with white belly, and house mouse gray form a series of allelomorphs. A mouse may have two of these at the same time but never more. If the genes are carried by the chromosomes and occupy identical locations in the chromosomes we can understand why only two can be present in the same individual, since there are only two chromosomes of each kind.

In rabbits there are three members of a series, black, albino and Himalayan. In corn, Emerson has described several allelomorphs that represent different grades of striping of the seed.

In one of the grasshoppers, *Paratettix,* Nabours has found about 13 allelomorphs affecting the color pattern of the body. It is not certain that this series is due to allelomorphic genes, for the same results would happen if the genes in question were in the same pair of chromosomes and no crossing over takes place. If, however, it turns out that these factors are allelomorphs the case is interesting because the types are found in the wild state.

By far the greatest number of series are in the fruit fly,[1] where their origin is known and where in consequence we are in a position to demonstrate from their mode of origin that they do not necessarily arise in that orderly sequence which their degree of development or expression might lead one to assume. The latter point, as will be shown, has an important bearing on our interpretation of what selection might be expected to do in cases where multiple allelomorphs arise or are present.

So far as the absence hypothesis is concerned, it is evident

[1] There are about 12 groups of multiple allelomorphs. The most extensive one is an octuple modification of the eye color involving white, eosin, cherry, etc.

that if by absence we mean literally that mutant factors are absent genes, there could be but one kind of absence for each normal gene, hence there could not be a series of absences as the hypothesis of multiple allelomorphs assumes. If this is conceded and the hypothesis changed to mean that by absence only some part of a postulated organic molecule, or normal gene, is "lost," then a new point of view emerges. Suppose, for instance, the loss of a CH_2 group might give a new gene, the loss of another CH_2 group another gene, etc. On such an assumption several kinds of genes like several kinds of paraffines might be possible. But on the other hand the taking up of a CH_2 group, or a shift in position of two of the groups, might equally well make a new gene. There is at present no way of determining what kind of alteration produces a new allelomorph, hence the futility of insisting that such alterations must be losses rather than additions or alterations in position of parts of the gene. It need scarcely be added that there are no grounds for assuming that a deficiency rather than any other kind of alteration is the only change that will lead to a lessening of the development of the final product for which these genes are responsible. Fascinating as it might be to draw a parallel between the series of genes and the series of resulting multiple allelomorphs comparable to such series as the sugars or alcohols or paraffines with their corresponding graded differences in physical or chemical properties, such parallels are at present only in the speculative stage.

The demonstration that multiple allelomorphs are modifications of the same locus in the chromosome, rather than cases of closely linked genes, can come only where their origin is known and at present this holds only for Indian corn and for the fruit fly. If each member of such a series has arisen historically from the preceding one in the series by a mutation in a locus closely associated with the locus responsible for the first, they would be expected to give the wild type when crossed; and as the proof of their allelomorphism turns on the failure of members of the series to show the atavistic behavior on crossing, it is necessary, as stated, to know how they arose. This may be made clear by the following illustration:

Let the five circles of Fig. 4, *A*, represent a *nest* of closely linked genes. If a recessive mutation occurs in the first one (line B *a*) and another in the second gene (line B *b*), the two mutants *a* and *b* if crossed should give the atavistic type A, since *a* brings in the normal allelomorph of *b* and *b* that of *a*. If a third mutation should occur in the third gene, it, too, will give the atavistic type if crossed to *a* or to *b*. Similarly for a mutation in the fourth and in the fifth normal gene. Now this is exactly what does *not* take place when members of an allelomorphic series are crossed—they do not give the wild type, but one or the other mutant type or intermediate characters. Evidently independent mutation in a nest of linked genes will not explain the results if the new genes arise directly each from a different allelomorph.

But suppose, as shown in Fig. 4 (line C) after a mutation had occurred in the first gene a new mutant, *b*, arose from

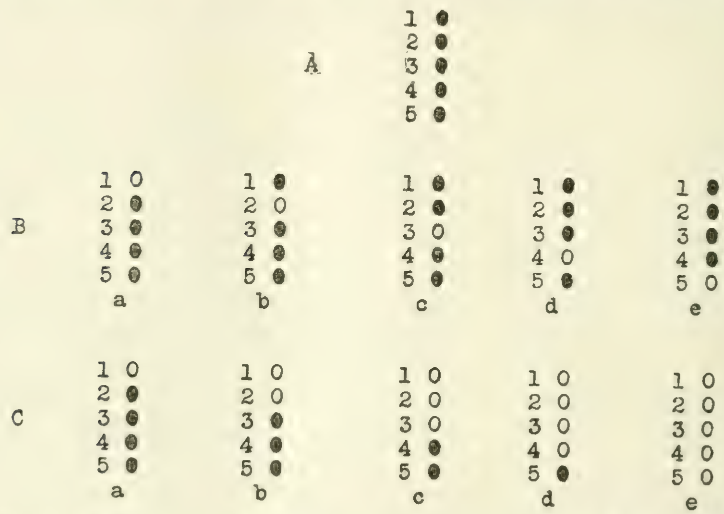


FIG. 4. Diagram of an imaginary "nest" of genes (A). In B the stages are independent mutations. If these stages *a*, *b*, *c*, etc., were crossed, the original type (wild type) of character is expected, since each stage would carry a normal allelomorph of the mutant gene in the other. In C the series of changes is indicated that might occur if *a* gave rise to *b* and *b* to *c*, etc.

a new gene, and from *b* a mutation arose in a third gene *c*, and *c* similarly gave rise to *d;* then *a* crossed to *b* will give *a* (or something intermediate if the heterozygote is an intermediate type). Likewise *c* crossed to *b* will give *b*, or *c* crossed to *a* will give *a*, etc. If mutant allelomorphic genes in a series such as *C a, b, c, d, e,* arise as successive steps, *i. e., Ca* to *Cb* and *Cb* to *Cc,* etc., then the hypothesis of closely linked genes would seem to be a possible interpretation, but if they do not arise in this way but by independent mutations from the wild type (or even from each other but not seriatim), then they must be due to mutations in the same gene; for, to assume that they are not, requires that, when the second mutation took place, both gene *a* and gene *b* mutated at the same time, and that when *c* appeared three genes mutated, when gene *d* appeared; when gene *e* five genes mutated at once, four of them bearing mutant genes that have already arisen independently. Such an interpretation is excluded, since it is inconceivable, even in a readily mutating form like *Drosophila,* that five mutations could have occurred at the same time in distinct but neighboring loci. As has been stated the evidence from Drosophila shows positively that multiple allelomorphs arise at random.

The other evidence for multiple allelomorphs comes from an observation on Indian corn. Emerson has shown that when a race of corn having red cobs and red seeds is crossed to a race having white cobs and white seeds only the two original combinations appear in the second (F_2) generation, viz., plants with red cobs and red seeds and white cobs and white seeds. It follows that either a single factor determines that both cob and seed are red in one case and white in the other, or if the color of each part is due to a separate factor these must be so closely linked that no "crossing over" occurs. Other races, however, have different combinations of these characters, such as white cobs and red seeds, etc., or red cobs and white seeds, or white cobs and striped seeds, etc., and these combinations hold together, when crossed to each other or to either of those first named. Here again each set of characters that go together may be caused by one factor or by a set of factors so closely linked that they do not separate (cross over). Now the striped seeds with white cob sometimes mutate to red seeds and red cobs. The combination acts as a unit toward the other known combinations. Therefore a single factor must have caused the change, for, if not, mutation must occur in two (or more) closely linked factors for seed and cob color at the same time, which is highly improbable.

Only two members of a series of multiple allelomorphs can be present in any one individual, and in the case of genes carried by the sex chromosome only one can exist at a time in the sex that has only one of these chromosomes. In the individual with two mutant allelomorphs one of them replaces the normal allelomorph of the ordinary Mendelian pair. The two mutant allelomorphs behave towards each other in the same way as does the normal and its mutant allelomorph. It is doubtful whether we can conclude from this relation much more in regard to the relation of Mendelian pairs than we knew before,[2] although there is at least a sentimental satisfaction in knowing that the normal allelomorph can be replaced by a mutant one without altering the working of the machinery.

[2] The substitution by crossing over really furnishes as good a demonstration of this point.

The linkage relation of each member of a series of multiple allelomorphs to all other genes of its chromosome is, of course, the same. While the theory of identical loci requires this as a primary condition it is not legitimate to use this evidence as a proof of the identity of the loci, because it is not possible to work with sufficient precision in locating genes by their relation to other linked genes to distinguish between identical loci and closely linked genes.

There is another question of some theoretical interest attached to the occurrence of multiple allelomorphs that calls for passing attention. If from the nature of the material mutation at a special locus were of such a kind that one step is essential before the next can be taken and if these genic steps give a progressive series of character changes, then it might appear to a person selecting for higher or lower grades of character in such a field that he was by his own efforts causing progress in the direction of his selection. In a certain sense he would be acting as an agent in hastening the possibility of the end result, because at each stage of progress he would breed as many individuals of the last stage reached as he could, and the number of individuals kept in stock would increase correspondingly the chance that some one of them would give the next mutant stage. Of course, the breeder here would be accelerating his end result not by controlling the conditions, so as to directly produce the change at will, but by making the chance that such an event would occur more probable by breeding a large number of individuals.

At present there is no evidence to show that multiple allelomorphic genes arise in the order of the development of the characters for which they stand. The few cases whose origin is known give exactly the opposite result. For instance, the octuple series of eye colors of *Drosophila*, grading from red to white, arose haphazard, so far as the amount of color shown by each mutant type is concerned. Mutation at this locus appears to take place more often than at any other locus, but not more often from the locus that has already mutated than from the wild type itself; in fact, more unit numbers of the series have appeared from the wild type, but this is expected if for no other reason than that more red-eyed flies pass under observation. It may be recalled in this connection that some other loci have been found that mutate to the same mutant type more often than do others, so that it may be that even some mutant loci may more frequently mutate than others or even than their own normal allelomorph. Since artificial selection is more likely to be followed up in cases where it is found to be giving results, it is not improbable that were such a condition realized it might easily mislead the breeder into supposing that his selection was producing progressive mutation changes, whereas he was succeeding because of a favorable situation that happened to fall into his hands.

While multiple allelomorphs present an extraordinarily interesting phenomenon of variation that has a profound bearing on our interpretation of the meaning of mutation, the facts indicate, so far as selection is concerned, that such allelomorphs fall into line with other mutants that supply selection with its material. The evidence shows in the most positive way that they originate as do other mutations, that the order of their appearance bears no fixed relation to the degree to which the character is displayed. Consequently they furnish selection with the same kind of material as all other mutations furnish. There is no evidence at present in favor of the view that selection has in itself any effect on the order of their appearance.

TECHNICAL PROBLEMS IN NATIONAL PARK DEVELOPMENT

By Professor FRANK A. WAUGH

MASSACHUSETTS AGRICULTURAL COLLEGE

OUR national park domain is already something quite unprecedented, something wholly glorious. The National Parks themselves comprise 17 splendid tracts amounting to 6,254,568 acres, including unique and unsurpassable features of landscape beauty. Nothing like this was ever brought under administration before, not even for the great military princes of the world; yet in this case we have a democratic reservation for the delight and the esthetic culture of all the people. Physically and ideally a new standard has been set in the world.

But in every proper sense our American national park system includes, not only the parks specifically so called, but other vast areas of land suitable for public recreation, and expressing in quite eloquent terms the great landscape forms of the North American continent. In other words, we must reckon in the wealth of our landscape equipment, in addition to the National Parks, also the 156 million acres of the National Forests; also some hundreds of thousands of acres of the National Monuments; while to these for many purposes we may further add the Indian reservations.

Still more: State parks and state forests have already been established in considerable numbers, and other important additions in this field may be expected in the coming years. These areas perform the same or a very similar service, and should be included in the general inventory.

In another paper I have tried to indicate some of the general policies which are likely to prevail in the development and administration of so magnificent a domain, but as we come nearer to the problem we see that it involves also a vast preparation of technical equipment, of specialized knowledge, of professional training for this peculiar work. The development and administration of a National Park must certainly prove to be as great and difficult a task as the training of a great symphony orchestra, the development of a modern service library, the making of a national art school, or the management of a state university. It seems self-evident that we shall need men of large capacity, highly trained for this sort of work. While an enormous amount of specialized technical training will be necessary, it is still more important that such men shall have a broad foundation in the arts and sciences. They must be men of liberal culture in the best sense of that abused word.

In fact the very first technical problem in the development of our national park system lies in the training of a suitable personnel. To some extent a parallel is offered by the work of the National Forest Service. It must not be forgotten that at the time our National Forests were established on their present basis there came into useful activity a number of schools of forestry connected with our stronger universities. These schools gave a highly specialized training in technical forestry; but what was equally important, they inculcated sound ideals of public service. While the management of these National Forests has never been turned over to the graduates of the forest schools, these men have nevertheless exercised a far-reaching influence in that field. It is not too much to say that the genuine success of the Forest Service as a branch of federal administration, achieved in the face of great difficulties, has been due to the high ideals of the men of academic training combined with their thoroughgoing technical preparation.

It is not now necessary to discuss at any great length the character of the professional preparation required by the men who in the future are to administer our National Parks of all sorts. The training already provided for forest rangers and forest supervisors will be useful to many men engaged in park service, whether in national or state parks, or in forests used for recreation. The men who control general policies and administration are the ones who must have a broader training. The education given by the engineering and forestry schools will of course be valuable, but a broader outlook on general economics and sociology, with specialized applications in recreation, will have to be given considerable prominence. It seems to me further that special training in landscape engineering will be possibly most important of all. This, of course, does not refer to the popular idea of landscape gardening, concerning itself with the planting of "ornamental" shrubberies and pretty flower beds. The larger questions of structural design, however, have the utmost importance in their applications to the design and development of large park areas, even where that development consists mainly in letting alone the natural landscape. The well-trained park administrator unquestionably must have a highly developed sense of landscape values.

Lake Josephine, Mount Gould, Garden Wall, Grinnell Glacier.

Such a sense, logically developed and properly disciplined, can come from no other source, so far as I am able to see, except from a broad training in the principles of landscape engineering.

Determination of Boundaries

As the various parcels of our great park and forest domain one by one come under the administration of these trained men, other big technical problems emerge. The first of these is the determination of boundaries. Already it has been found that the great Yellowstone, the first of our National Parks, in spite of its liberal conception, fails to include such vitally important areas as Jackson's Hole, which now plainly ought to be a part of this park. We may expect that in a majority of cases a careful technical examination of the situation will show that boundaries of nearly all parks will need to be rectified. This will mean not only the acquisition of areas left outside, but also in many cases the recession of other areas originally included, but which on more careful examination can be shown to have more value for other uses. Any one who has had any experience in the study of parks, even on the small scale of the ordinary city park systems, has learned that this determination of boundaries is a highly delicate, difficult and technical matter, and one which requires long study.

Land Classification

Even before a final decision is reached regarding exterior boundaries, it will be necessary to classify the interior spaces for use. Certain areas will be needed for camping, some for summer colonies, some for playgrounds, some will be reserved for hunting and fishing, others will be game sanctuaries, some will be kept for the protection of natural curiosities, and so on through an almost endless list of special uses. To decide wisely what the needs of the public really are is a great and complicated problem, and one which from the nature of the case will never be ended. To apportion the land wisely to these various needs will require a knowledge of landscape values, of engineering methods, and of administrative problems of much more than amateurish degree. Even in the National Forests where these problems are much simpler, the land classification has occupied many years of study both broad and intensive. Certain it is that these problems of classification must be brought clearly before the men who are to be especially trained for park administration.

TRAIL IN A STATE FOREST.

TRAFFIC CIRCULATION

Park designers generally consider traffic circulation to be the one fundamental problem. It is beyond question of the utmost consequence. Parks are made for the delight of human beings, and human beings to enjoy the parks must circulate through them. The routes of circulation can be located in such a way as to reach all the scenes of greatest charm, or they can be so laid out as to miss all the best things and to present the visitor with a thoroughly mediocre picture of the entire park. At the Grand Canyon in Arizona, for example, a clear majority of the visitors get only one view of the Canyon, namely, that from the hotel El Tovar. The principal line of circulation lies westward nine miles along the Hermit Rim Drive, disclosing additional views of the Canyon below. Only a part of those who visit the Canyon go as far as this. A still smaller percentage take the Bright Angel Trail trip to the bottom of the Canyon, thus multiplying by ten-fold their knowledge of this unparalleled scenic wonder. A very much smaller percentage of Grand Canyon visitors cover what is known as the Tonto Loop, including the beautiful Hermit Creek Trail. While this round trip of 25 or 30 miles is far beyond the experience of the ordinary Canyon visitor, it still reveals hardly more than a minor fraction of the Canyon glories. Miles and miles of trail will be necessary eventually to lead visitors into all parts of the Canyon, and to give them anything like an adequate experience of the place. The study of such a system of circulation is an engineering problem of the highest order, but a problem which requires a combination of engineering skill with a knowledge of landscape values.

Trail Design and Construction

A general plan of traffic circulation once determined, it becomes necessary to locate and construct the trails in detail. These may be automobile roads, carriage drives, mule trails or foot paths. The general principles of design involved are the same in either case. I have tried to state this problem and to outline the technical methods of its solution in my recent book on "The Natural Style in Landscape Gardening." At the present time it may be sufficient to point out that the artistic method involves the same procedure as prose composition. A definite landscape theme is adopted, and this theme is exclusively presented along a considerable section of trail. As in prose, so in landscape engineering, the theme is developed by paragraphs. The whole length of the trail is divided into sections, and each one of these presents some definite aspect of the theme in hand. Such paragraphs must have a logical se-

Typical Forest, Yellow Pine Country. This particular section has been set aside for purposes of recreation.

quence. There must be a definite statement of the theme in the first paragraph, there must be a varying treatment in successive paragraphs, running from grave to gay, from coquettish glimpses to broad expository views, and leading to something like a climax toward the end.

We are here in touch with the more technical problems of landscape engineering, but we are dealing with matters which plainly may have a very wide and useful application in the development of those great areas of natural landscape which constitute our National Parks and National Forests.

General Construction

All kinds of playgrounds, camps, summer colonies, etc., will have to be laid out on various park and forest areas, and their

Grand Canyon of the Colorado, from Hermit River Road, Arizona.

location and design also involve intricate technical problems. A camp has to be protected in sanitary ways; a water supply has to be provided which is beyond the suspicion of contamination; some adjustment has to be made relative to several kinds of public service. These are largely the questions which come up in city planning and civic design generally. They are pretty well understood; and especially in the schools of landscape architecture men have already been trained for such work. In the National Parks and Forests we shall fitly have a new application of the old principles. The problems will be infinitely varied and infinitely interesting.

Maintenance

Park superintendents experienced in the management of city park systems have learned to distinguish clearly between park design, construction and maintenance, and to organize their labors accordingly. Park maintenance indeed has come to be a sort of profession by itself. The importance and the intensive character of this work may be surmised from the fact that the average cost of city park maintenance throughout the country is well over $100 an acre a year. On our millions of acres of national park and forest lands a much lower rate of maintenance will be adopted, necessarily and properly; but the complex and highly technical quality of the problems involved will appear none the less. Such questions as the cost of lawn mowing, the application of dust layers on roads, the transplanting of trees, the breeding of wild-fowl, the protection of fish, the use of preservative solutions on fence posts, the policing of camps, guarding against fires, the operation of telephone lines, keeping ice clean for skating, and a thousand other practical matters will require attention. In this field thorough training and practical experience must be added to considerable natural aptitude to produce a park officer of high efficiency.

It is all of a piece with our greatest American problem, how to secure real efficiency in our public service while at the same time avoiding the deadly blight of bureaucracy. Everywhere we need trained men. We need to get away from the tempting idea that any free-born American can ex-officio do anything. We have taken a good many things out of the hands of grafting politicians and turned them over to willing amateurs, thereby gaining much. If now we can make the next move and place our public business in the hands of men highly trained in technical ways (always with high ideals of public service) we shall be gaining even more. In the park service which is to be we may realize these noble possibilities relatively soon, since the need is so obvious and the way so plain.

A Lecture on Anatomy. From the Italian translation of "Ketham," Venice, 1493.

THE PROGRESS OF SCIENCE

THE BEGINNINGS OF ANATOMICAL DISSECTION

THERE has been published by the Oxford University Press a scholarly volume, entitled "Studies in the History and Methods of Science," edited by Charles Singer, who contributes two of the seven articles. Sir William Osler has prepared an introduction in which he states that it was hoped to establish a journal on the history and methods of science and to organize a summer school for special students at Oxford. Owing to the war the plans have been abandoned, or at least postponed, and certain of the studies are now printed in this volume. Through a gift of Dr. and Mrs. Singer an alcove in the Bodleian Library has been fitted up with a collection of books and manuscripts to enable the general student to acquire a knowledge of the development of science and to assist special students in their researches.

One of the studies is an account of early Renaissance anatomy by the editor of the volume. It contains a number of illustrations of dissections, several of which are here reproduced. The dissection of the human body, first practised by the Alexandrian school, was revived by Mondino, who was professor at Bologna in the early part of the fourteenth century. The illustration here reproduced is from a volume containing a treatise by Mondino and other medical tracts, printed at Venice in 1493. The plate is of interest, both in relation to the history of anatomy and to the art of printing. It is said to be the best

THE EARLIEST KNOWN REPRESENTATION OF THE PRACTISE OF DISSECTION. From an MS. in the Ashmolean Museum, Oxford, of about 1298.

THE FIRST PRINTED PICTURE OF DISSECTION. From the French translation of Bartholomaeus Anglicus, Lyons, 1482.

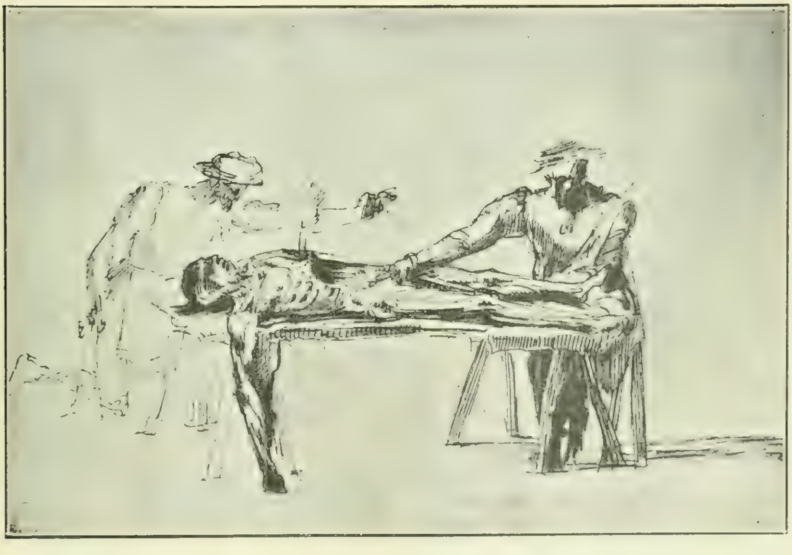
example of book illustration produced during the first century of typography, and it was the first attempt at a complete color scheme, four pigments being laid on by the use of stencils.

The illustration shows the method of teaching anatomy at that time. The professor, perhaps intended to represent Mondino, is portrayed standing at a desk, well removed from the subject of dissection. He reads from a manuscript or book a description of the parts dissected by the assistant. The professor of surgery may stand by with a pointer to indicate the different organs. At Bologna it was arranged that each medical student of over two years standing should attend a dissection or "anatomy" once a year, twenty students being permitted to see the dissection when the subject was a man and thirty for a woman. Men were used more frequently than women, owing to the fact that only the bodies of criminals were used, and there were more male than female criminals. This was all the practical instruction a student received, and in some universities there was only a single dissection each year for the whole body of students.

The lecturer was likely to depend more on Galen or on some other authority whom he read than on the facts disclosed, so that while dissection was usual in medieval universities, there was but little progress in anatomical knowledge until the time of Vesalius, born in 1514.

The earliest known representation of the practise of dissection, reproduced by Dr. Singer from a manuscript in the Ashmolean Museum, Oxford, is of the date of about 1298 and thus precedes the first dissections of Moldino at Bologna. A post-mortem examination is apparently being conducted surreptitiously, but the illustration from a

A Post-mortem Examination. From a manuscript in the library of the Montpellier School of Medicine, late fourteenth century.



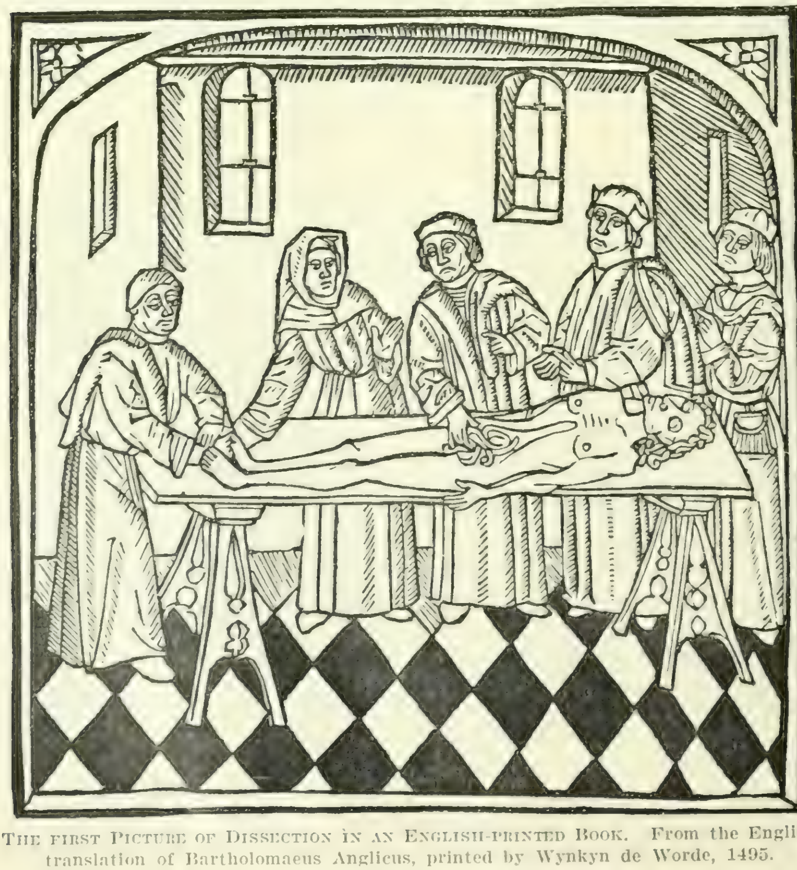
Two Figures Dissecting, traditionally said to represent Michelangelo and Antonio della Torre. From a drawing in the Ashmolean Museum, Oxford, attributed to Bartolomeo Manfredi (1574(?)-1602).

French manuscript of the fourteenth century shows a post-mortem examination conducted openly in the presence of the relatives of the deceased. The physician in full canonicals is at the extreme right. The actual process of examination is being made by three of his assistants. To the left, the first of these deepens, with a knife, the incision that has already been made over the sternum, the second is grasping with his two hands and rolling up the great omentum so as to display the viscera beneath, and the third holds the wand in his right hand, with which he points to the abdomen, while in his left he carries a book.

The artist who went direct to nature, dissecting with his own hands and observing with his own eyes, obtained better results than the professor with his formal methods. Leonardo da Vinci made admirable anatomical sketches. Michel Angelo is said to be one of the two figures shown in the last illustration, which dates from the end of the fifteenth century.

SULPHURIC ACID AND THE WAR

THE British government is having the foresight to consider problems that will arise after the war and has appointed a departmental committee to report on the post-war disposition of the sulphuric acid and fertilizer trades. Professor T. L. Thorpe



THE FIRST PICTURE OF DISSECTION IN AN ENGLISH-PRINTED BOOK. From the English translation of Bartholomaeus Anglicus, printed by Wynkyn de Worde, 1495.

gives in *Nature* an account of the report of the committee, which is of interest in this country as well as in England.

Sulphuric acid is indispensable for warfare and the enormous amount needed in the manufacture of explosives and for other purposes has led to an extraordinary development of the industry in England. Concentrating plants on a large scale have been everywhere erected, and the productive power of the country has reached an amount greatly in excess of the pre-war consumption. The problem of the committee is how this extension can be dealt with in view of the requirements when the war is ended.

According to Professor Thorpe there is one new source of sulphuric acid in England, created by the war, which should be maintained and extended, and that is the production of acid from Australian zinc concentrates. The manufacture of zinc was instituted in England before it was started in Belgium and Germany, but it has not been developed there to the same extent. Although London is the chief zinc market in Europe, the main production of the metal has been in the hands of Germans, who have also acquired a controlling interest in the Belgian concerns. It is said that Germany, with the view of maintaining her practical monopoly in the production and distribution of zinc, gained control of the rich deposits of zinc ores in Australia, and that the great bulk of the Australian concentrates found their way to Belgium and Silesia, mainly by way of Antwerp and Hamburg, Germany's own deposits being meanwhile conserved.

There is one outlet for sulphuric acid which is capable of far greater development, and that is in the manufacture of fertilizers, and especially of superphosphates. There can be no doubt that the food shortage in England has had a profound effect on agricultural policy, and will lead to a permanent increase in home production. This will necessitate a greatly increased demand for fertilizers, such as sulphate of ammonia, as well as of phosphatic manures. Much ammonia is at present absorbed in the production of nitrate of ammonia, which is needed in the manufacture of munitions. But this ammonia will be liberated after the war, and will be largely converted into sulphate for agricultural use. In the past about 60 per cent. of the sulphuric acid produced in England was absorbed in the manufacture of fertilizers, in which there was a considerable export trade, in addition to the home demands. The changed carrying conditions caused by the war may, it is said, lead to an extension of this export trade, induced, on one hand, by the comparative abundance of cheap sulphuric acid, and, on the other, by the greatly increased demand for fertilizers.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE annual meeting of the American Association for the Advancement of Science and of the national scientific societies affiliated with it will be held at Baltimore, from December 27 to December 31. Boston had been selected as the place of meeting this year, action recommending that the meeting be held in that city having been taken at the meeting in New York City two years ago. In view, however, of war conditions and of the large number of scientific men now working at Washington, it seemed desirable to select a place to which the amount of traveling would be reduced as much as possible, and where a meeting concerned with problems of national defense and national welfare could be held to best advantage. The situation was carefully considered at the meeting of the committee on policy held in Washington on April 22, and it was decided that it would be desirable to meet in Baltimore. President Goodnow and the professors of the scientific departments of the Johns Hopkins University having cordially welcomed the plan, it has been definitely decided that the meeting will be held in that city. A committee consisting of Dr. L. O Howard, the permanent secretary, Dr. W. J. Humphreys and Professor J. C. Merriam has been appointed to report on a general plan for a program that will make the meeting of the greatest possible service to the nation.

The committee on grants of the American Association has made the following appropriations:

$300, to Mr. William Tyler Olcott, secretary, American Association of Variable Star Observers, 62 Church Street, Norwich, Connecticut, for the purchase of a telescope of 5-inch aperture.

$250, to Professor A. E. Douglass, of the University of Arizona, Tucson, Arizona, for the length of record of tree growth of the Sequoias from about 2,200 to 3,000 years.

$500, to Professor Carl H. Eigenmann, of Indiana University, Bloomington, Indiana, for the study of the fresh-water fishes of South America.

$500, to Professor Edwin B. Frost, of Yerkes Observatory, Williams Bay, Wisconsin, for measurement and reduction of photographs of stellar spectra, already taken with the 40-inch telescope.

$200, to Dr. R. A. Porter, of the University of Syracuse, Syracuse, New York, for explanation of the hysteresis which has been observed in the potential gradients of the calcium-cathode vacuum tube.

$200, to Professor E. W. Sinnott, of The Connecticut Agricultural College, Storrs, Connecticut, for experiments to determine the ratio (in dry weight) between root, stem, leaf and fruit in the bean plant.

$500, to Professor O. F. Stafford, of the University of Oregon, Eugene, Oregon, for research on the distillation of wood.

$200, to Professor Herman L. Fairchild, University of Rochester, Rochester, New York, for the continuation and completion of his studies on the Post-Glacial continental uplift in New England and the Maritime provinces of Canada.

$250, to Professor S. D. Townley, secretary, Seismological Society of America, Stanford University, California, for the investigation of earthquake phenomena.

SCIENTIFIC ITEMS

We record with regret the death of Ewald Hering, the eminent physiologist, professor at Leipzig; of Dr. Ferdinand Braun, the German physicist who shared the Nobel Prize in 1905 with Guglielmo Marconi, for work in wireless telegraphy; of H. J. Helm, chemist of the British Government Laboratory, and of G. Meslin, director of the physical laboratory of the University of Montpellier.

Director William Wallace Campbell, of the Lick Observatory, University of California, has been elected a foreign member of the Royal Society.—The Geological Society of France has awarded to Dr. Henry Fairfield Osborn, president of the American Museum of Natural History, the Gaudry Medal, which was established by the society in the wear 1910 in honor of the distinguished French paleontologist, Albert Gaudry.—The Boston Society of Natural History has awarded the Walker Grand Honorary Prize, in the shape of a one-thousand-dollar Liberty bond, to Professor Jacques Loeb, of the Rockefeller Institute, New York, in recognition of his many published works covering a wide range of inquiry into the basic concepts of natural history.

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