your summer meeting, and look forward to talking over with each other your discoveries and your difficulties, and as you are willing to do this in public, the whole community as your place of meeting comes to a better knowledge of the beautiful, earnest, skilful effort which makes up the life of a man of science. It is not a congress to adjust conflicting interests or for displays of oratory which lead to no conclusions. We get to know the man himself, and I think he would be even more popular than he is at present if we could invent some suitable name for him. Scientist is a most ill-sounding word. The French term savant —a knowing one—might provoke a smile, when contrasted with the simplicity of character of many men of science, but perhaps after all this is your best title to fame. Your discussions do not often degenerate into disputes, because for the first time in the history of the world methods of work have been found so sure that the results can be accepted almost without discussion. Even the geologists come to an eventual agreement about their theories, and the account which Bret Harte has given about their meetings must not be taken too literally. You are good witnesses and generally agree upon your facts, and when facts lead to differences of interpretation the single-minded desire to reach the truth brings you into accord at last.

We have good reason for welcoming you among us, and although you do not come as missionaries we shall find ourselves the better for your coming.

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*DESTRUCTIVE AND CONSTRUCTIVE ENERGIES OF OUR GOVERNMENT COMPARED.**

WE have been witnessing during the past five months an extraordinary exhibition of energy on the part of the government of the United States in making sudden preparation for the war with Spain and in prosecuting that war to a successful issue. As men of science, or teachers or promoters of science, we have a special interest in the lessons of the war, because the instruments and means used in modern warfare are comparatively recent results of scientific investigation and of science applied in the useful arts. Moreover, the serviceable soldier or sailor is himself a result, not only of moral inheritance and instruction, but of training in the scientific processes of exact observation, sure inference and accurate manipulation. It is not the linguistic side of school training which makes the effective soldier or sailor; it is the scientific side. His vocabulary may be limited, though expressive, and his grammar false; but his eye must be true, his judgment sound and prompt, and his hand capable of using instruments of precision. The first-relief package, which every soldier carries, is crammed with surgical knowledge which the world waited for till the last quarter of the nineteenth century. Physiological science has really arrived at valuable conclusions with regard to the soldier's diet—the indispensable foundation of his effectiveness. Financial science is also a contributor of prime importance, since success in war depends more and more on the command of money and credit. To this war with Spain we owe the most effective revenue bill, or rather the only comprehensive revenue bill, the country has had within a whole generation.

It cannot be doubted, then, that the energy put forth by our government for the immediate purpose of capturing or destroying Spanish vessels, forts, towns and war material, and incidentally killing, wounding and starving Spaniards has been a great exhibition of power in applied science, and as such must commend itself especially to

* Abstract of an address given by President Eliot, of Harvard University, before the American Association for the Advancement of Science, in Saunders Theater, on August 26, 1898.

the attention of this Association. I hear already a protest against the thought that men of science can have any special interest in war—war, the supreme savagery, the legalization of robbery and murder, the assemblage of all cruelties, crimes and horrors set up as an arbiter of international justice. But the man of science has another view of war. He regards it as the worst survival of savage life, still occasionally unavoidable because of other survivals of the savage state, such as superstition, passion uncontrolled, and lust of wealth and power. He recognizes the fact that war makes a temporary and local hell on earth, and that all its characteristic activities are destructive; whereas all the normal activities of a free government should be constructive, and intended to promote the good of its citizens and general civilization; but he does not accept Sumner's dictum in his oration of 1845 on the 'True Grandeur of Nations'—"there can be no war that is not dishonorable." He recognizes that occasional war, and therefore constant preparedness for war, are still necessary to national security, just as police, courts, prisons and scaffolds are still indispensable to social order and individual freedom in the most civilized and peaceful States. Moreover, the man of science perceives that, while the immediately destructive objects in war are savage and barbarous, the instrumentalities and forces used in modern warfare are closely akin to the great constructive agencies and forces in human society. The applications of Bessemer steel in war are not its primary uses; its peaceful constructive applications give it its primary value. The application of compressed air for the transmission of power was not invented for the dynamite gun, but for tunnelling and mining. No nation can now succeed in war which has not developed in peace a great variety of mechanical, chemical and biological arts. Now, the normal activities of these arts must and do tend to advance human civilization. Their application to the destructive cruelties of warfare is abnormal. Yet, inasmuch as they are applied in war with a prodigious energy and intensity, it may well be that the acute horrors of even the shortest war may have a lesson for the long normal periods of peace.

Men of science, so far as I have observed, do not consider the martial virtues—courage, endurance, loyalty and the willingness to subordinate self-interest to the interest of clan, tribe or nation—to be the supreme and ultimate objects towards which the human race must struggle on. They regard these virtues as the elementary, fundamental, preliminary virtues, which can be cultivated in man's savage state, and so become the stepping-stones of his moral advance; but they know, on the demonstrative evidence of both history and natural history, that these virtues may co-exist with cruelty, rapacity and lust, and an almost complete indifference to both truth and justice. Civilization, in their eyes, means the adding of justice, truth and gentleness to the martial virtues, an addition which does not necessarily involve any countervailing subtraction. Truly, it is not war which prepares men for worthy and successful lives in times of peace. On the contrary, it is worthy life in time of peace on the part of individual men, or a nation of men, which prepares for success in war. Do we not all believe that the normal activities of peace under free institutions are the best possible, though not the only necessary, preparation for inevitable war, and that such normal activities never need to be, and never can be, purified or uplifted by avoidable war? Nevertheless, we may believe that some lessons for times of peace can be drawn from the prodigiously stimulated activity of the government and the sacrifices of the people in time of war.

The first important inference which may

be drawn from the experience of our government and people during the past five months is anthropological—it is the permanence of the martial virtues and their commonness. In any vigorous race these virtues may fairly be called inextinguishable. Civilized society is always maintaining a perilous conflict against natural forces, which ordinarily serve man's purposes, but sometimes try to overwhelm him. Fire, the greatest of man's inventions and his humblest servant, suddenly breaks out into destructive fury; wind ordinarily fills his sails, turns his mills and refreshes the atmosphere of his cities; but now and then in spots sweeps from the surface of the earth and sea all man's works—crops, buildings, vehicles and vessels. The mineral oil which every night lights so brilliantly the humblest homes in every clime occasionally kills the ignorant or careless user or sets a huge city in flames. Any single-minded worm or insect will be too much for man, unless man knows how to set some other creature of one idea at destroying the first invader. How small is the range of the thermometer within which men can live with comfort or even safety! A change of a few degrees below or above the normal range sets him fighting for his life. This conflict with external nature is the great school of mankind in courage, persistence, patience and forethought, and mankind never needs any other. It is, then, the regular pursuits and habits of a nation in times of peace which prepare it for success in war, and not the virtues bred in war which enable it to endure peace.

The second lesson to be drawn from the recent experience of the nation in war is the immense value of long prepared, highly-trained public service. The instant efficiency of our navy is a striking demonstration of this principle, which, of course, needs no enforcement before men devoted to science, but does need to be brought home to the great body of our people. The preparedness of our regular army for immediate service, and the comparative unreadiness of the militia, even in those States which have paid most attention to volunteer military organization, enforce the same lesson. Would that the plain teaching of this short war in this regard might sink into the minds of our people, and convince them of the immense advantages they would derive from a highly-trained, permanent, civil service in every branch of the public administration.

Another lesson of these pregnant months relates to a principle which underlies our form of government, but is often seen but dimly by portions of our people. I refer to the principle that the government of the United States should do nothing which any other visible agency—State, city, town, corporation or private individual—can do as well. This seems a strange principle to be enforced by the action of our government in time of war, since the government has a monopoly of this hideous activity; but this war has brought out in a very striking way the fact that, when it comes to the pinch, the source of victory is in the personal initiative of each individual commander and private soldier or sailor. In warfare, as in industries, the automaton counts for less and less, and the thinking, resourceful individual for more and more. The automaton is the natural result of despotic institutions, civil and religious; the resourceful, initiating individual is the natural product of free institutions, under which the citizens are as little restricted as possible in the development and training each of his own will-power and capacities. To secure this fundamental advantage of free institutions, as many fields of activity as possible must be left open to the individual and to voluntary associations of of individuals. The maxim 'in time of peace prepare for war' means, therefore,

vastly more than it used to. It no longer refers chiefly to the provision of vessels, forts and weapons, but rather to the bringing-up of generations of young men trained by school, college, political life and the great national industries to habits of self-direction and of disciplined cooperation. This bringing-up is best secured under free institutions, which leave everything possible to the initiative of the citizen.

This principle—that government should do nothing which any other agencies can do as well—being admitted and established, the next question to be considered is whether the legitimate activities of our government in time of peace, activities directed toward constructive and wholly beneficent objects, should not be increased. On this point I cannot help thinking that the lesson of the war is plain and convincing. It is undeniable that our people have rejoiced in the exhibition of power which the government has given during this war. We have all derived great satisfaction from our government's display of power, exercised with promptness, foresight and the sagacious adaptation of means to ends. It is human nature always and everywhere to enjoy such success as the government has won, even when it costs heavily in blood and money. To have the consciousness of possessing power, and to display the power possessed, is a national gratification. Now, this sort of satisfaction ought to be obtainable in peace as well as in war; so that the power of the United States, displayed in peace for ends wholly constructive and beneficent, ought to be in some measure comparable with the power the government is capable of displaying for destructive ends in war. How can the United States put forth, during the long periods of peace, a beneficent power comparable to the destructive power it wields in war, without violating the principle of leaving to its citizens every field of activity which they can till to advantage.

If we examine the fields of activity which must perforce remain to the government we shall find that they will amply suffice for the exercise of power enough to gratify the most ambitious and the most benevolent citizen of the Republic. Let us briefly survey some of these fields. The first I shall mention is the fostering of commerce. This function obviously belongs to the general government, which has power not only to regulate, but to annihilate at will, the trade of its citizens with foreign countries. The war with Spain has distinctly enlarged the moral outlook of our people. It has presented to them wholly unexpected problems concerning the responsibility of a fortunate people for the welfare of the less fortunate. It has suggested to them that a policy of political seclusion and commercial isolation is not worthy of a strong, free and generous people, and that such a policy is not the way to the greatest prosperity and the most desirable influence.

Another great field of beneficent activity for our government is the procuring of just and humane conditions of labor in industries which cannot be carried on within the jurisdiction of any single State, because they necessarily cover several States. The great functions of the national government in this respect are now only beginning to be exercised. In the Ninth Annual Report of the Inter-State Commerce Commission on the Statistics of Railways in the United States, a report dated June 30, 1897, I read that in the year 1896 the number of railroad employees killed in the service was 1,861, and the number injured 29,969, the number of men employed on the railroads of the United States in that year being 826,620. In the same year there were killed and wounded in coupling and uncoupling alone 6,614 trainmen, 1,744 switchmen and flagmen, and 328 other employees, making a total of 8,686 killed and wounded in coupling and uncoupling alone. Do not

these terrible figures suggest that our government has not yet undertaken to discharge its duty of protecting by legislation large classes of its citizens engaged in indispensable service to the community?

As time goes on, it appears that more and more industries have a national scope. Thus, it may be doubted whether the mining of soft coal can be successfully regulated by the separate legislation of single States; for coal mined in Virginia is necessarily in competition with coal mined in Ohio, for example, and the unprotected condition of laborers in Ohio may prevent the adequate protection of coal miners in Virginia. Interests common to many States certainly suggest that the common government has duties in regard to them.

An established function of our national government is the execution of public works for the improvement of rivers and harbors—works which redound to the advantage of the localities where they are situated, to be sure, but also to that of the people at large. These works are too often executed in a slow, wasteful manner, which no private person or corporation could possibly afford. As an illustration of bad government methods, and, therefore, of the possibilities of improvement in governmental efficiency, I take the Columbia River at the Cascade Gorge. This improvement comprises works on a lock and on a canal about three thousand feet long. The original estimate of the cost was a million and a-half dollars, and the work was actually begun in 1878. At the end of 1891, when $1,609,324.94 had been expended on the work, the estimate for its completion was a million and three-quarters dollars. It is not yet finished, after the lapse of twenty years. It is impossible for the nation at large to take satisfaction in grand works so feebly conducted. Such a process impairs, rather than increases, the self-respect of the nation; for everybody perceives that it is a stupid and discreditable process. Whenever a public work must be completed before the country can derive any benefit from it the government should prosecute the work with all the dispatch consistent with thoroughness of execution. This single instance illustrates the opportunities which exist for immense improvement in the conduct of the operations of our government on public works.

To illustrate further the directions in which the beneficent expenditures of our government might reasonably increased, I now invite your attention to certain comparisons between items of military and naval expenditure which the war has forced on our attention, and the cost of some government establishments which are of special interest to the Association. The annual cost of the lighthouse establishment, on the average of the five years from 1893 to 1897 inclusive, was three million dollars. The cost of maintaining naval vessels in commission during the year 1897—a year of peace—was nine millions of dollars. Now, the lighthouse establishment is one of the most interesting and useful departments of national expenditure. It has a high scientific quality, and also a protecting, guiding, friendly quality. It calls forth in high degree the best human qualities—intelligence, fidelity and watchfulness. With our resources and our commercial needs, and our thousands of miles of coasts and rivers, our lighthouse establishment ought to be the best in the world, as well as the most extensive. Indeed, it ought to be absolutely as good as it can be made.

The progress of medical science imposes upon modern governments a new duty toward their citizens—the duty, namely, of protecting them from contagious or infectious diseases. This protection has to be provided by means of inspection stations, quarantines and other methods proper to secure the isolation of infected persons.

The diseases against which protection is most to be desired are cholera, smallpox, leprosy and yellow fever; and these diseases come in at the coast on vessels which are sailing under national authority and regulation. It is impossible to see how an effective control can be exercised over them except by the national government. Now that our government has driven Spain out from its West Indian possessions, and has assumed possession of Porto Rico and temporary control of Cuba, an opportunity is afforded of organizing this department and putting it upon a much more effective footing than would have been possible before. The island of Cuba has been the great source of yellow fever infection, and we now have, temporarily at least, the opportunity of ridding ourselves of this source of danger and dread. At the same time Congress can reconstruct what is now called the Marine Hospital Service, and render it, under some other name, a thoroughly effective agent for the protection of the people of the United States from imported preventable diseases. An effective bureau once established would undoubtedly find new opportunities of usefulness to the people. The preservation of the public health against the invasion of preventable disease is really one of the great interests of the American people, health and the protection of life to the normal period being infinitely precious to the individual and desirable alike for the happiness and the productiveness of the whole people. Indeed, the public health more directly concerns the public happiness than does agriculture, mining, trade or any other of the national activities. The present expenditure of the government for the Marine Hospital Service has been about $650,000 a year, on the average for the five years 1893 to 1897. This budget ought to be greatly increased. It would be wholly reasonable for the government to spend as much on behalf of the public health as it costs to keep three battleships in commission for a year in time of peace, say, one million of dollars.

The Life-Saving Service of the United States deserves to be greatly enlarged. The seacoast of the United States is of great extent, even if we do not include the deep indentations of a coast like that of Maine. On June 30, 1895, the number of life-saving stations was only 251, and of these 251 stations 53 were on the Great Lakes, 1 on the Ohio river and 13 on the Pacific coast. The mere mention of these figures demonstrates at once the inadequacy of the number of stations. The men employed must possess skill in surf-work and in the use of the various appliances for life-saving, and must be also men of unquestionable courage and good judgment. They are exposed in their routine of duty to many hardships and dangers. They struggle with wind and cold on the shore, and with some of the most formidable dangers of the sea. They must patrol beaches or rock-bound shores in the worst weather, and must be always ready for prompt service by night and by day. They need all the martial virtues, and these virtues are displayed not in killing and wounding, but in rescuing from death and injury. Shall we not all agree that this noble service should not be limited in its scope by any pecuniary consideration, but only by the probability of rendering service?

The Department of Agriculture is of comparatively recent creation, dating from 1893. The proper objects of the department are the discovery, study and development of the agricultural resources of the United States. It is primarily a scientific and technical department. Its main work is not done in Washington, but at scattered stations all over the country. Thus, there are outside of Washington 154 observing

stations and 152 signal stations of the Weather Bureau. There are also 152 meat-inspection stations in different towns and cities of the country, 21 quarantine stations for imported cattle, 9 stations for inspecting exported stock and 19 for inspecting stock for Texas fever. The division of statistics affords a measure of protection against combination and extortion in buying and selling the products of agriculture. When we consider the large proportion of our population engaged in industries which this department serves, and the importance of these industries to our national budget, may we not reasonably be surprised that the department is crippled by the parsimony of Congress with regard to salaries? On account of the low salaries authorized for scientific and technical services, the department is constantly losing some of its ablest and best workers. Apart from the Weather Bureau, which is now one of its divisions, the cost of the Department of Agriculture during the financial year 1896–97 was rather more than two millions of dollars—about the cost of one day of the war with Spain.

Next to agriculture in importance to the country comes the mining of coal and the metallic ores. The mineral wealth of the United States, including coal, is immeasurable, and there lie the foundations of all our manufacturing industries, and of the household comfort with which our population is so greatly blessed. One would naturally have supposed that the government of the United States would have been inclined to spend liberally on the discovery and investigation of our mineral resources, but such has not been the history of the Geological Survey of the United States. The expenditure upon it has never been generous, and has often been parsimonious. For the average of the five years 1893–97 the expenditures of the government on the Geological Survey and the issue of geological maps was about $450,000 a year, or less than the cost of six hours' war with Spain during the last four months.

The Weather Bureau of the United States, on which the nation spends less than a million dollars a year, contributes greatly to the comfort and health of the people and to the protection of their property, yet its number of stations for weather observation is manifestly insufficient, and the number of places at which warnings are conspicuously given is also insufficient. In the year ending June 30, 1897, that is, before the war, the country spent twice as much on mere repairs of naval vessels as it did on the Weather Bureau.

The coast and Geodetic Survey of the United States has often been crippled in its work by lack of steady, timely and adequate appropriations. Its annual cost for the five years 1893–97 averaged $418,000, or only a little over what it cost to maintain in commission the armored cruiser New York for the year 1697.

A new department of our government ought to be at once organized to secure the permanent protection and utilization of the forests on the national domain. The experience of other nations has already demonstrated that well-managed national forest reserves not only pay their expenses, but yield a revenue. The objects of such forest administration are of the utmost importance to a mining and farming population, being briefly, to ensure a permanent supply of timber, to protect the water-supply in agricultural regions adjacent to the forests, to prevent floods and to store water which in arid and semi-arid regions can subsequently be utilized for irrigation. The efforts thus far made to protect the national property in forests have not been successful, the greatest destruction being wrought, first, by fire, and secondly, by pasturage, but much harm being done by simple stealing of the forest product in districts where

there is no adequate policing of the reservations. In arid or semi-arid regions reforesting, when once the original timber has been removed, is extremely difficult or in many cases impossible. Anyone who has traveled through the comparatively treeless countries around the Mediterranean, such as Spain, Sicily, Greece, northern Africa, and large portions of Italy, must fervently pray that our own country may be preserved from so dismal a fate. A good forest administration would soon come to support itself; but it should be organized in the interest of the whole country, no matter what it may cost. The estimate of the cost of the organization, as made by the Forestry Commission of the Academy, was two hundred and fifty thousand dollars a year for the first five years. This is about the annual cost of the maintenance of the protected cruiser San Francisco.

The government has carried on for many years past an inquiry into the habits, feeding grounds and modes of breeding and migration of the fish which make an important part of human food, and inhabit the western Atlantic and the eastern Pacific, the Great Lakes and the rivers and brooks of the continent. It is obvious that no power but that of the general government can carry on effectively a research of this magnitude, covering such enormous areas and dealing with such a variety of creatures, and it is obvious that such researches require expensive outfit, long time and highly-trained observers. Now, in this great enterprise the expenditures of the government during the five years 1893–97 have been $360,000 a year, which is less than the annual cost of maintaining one of our battleships.

One other mode of beneficent expenditure the United States government has maintained for a generation, namely, the annual appropriation of money for certain colleges of agriculture and mechanic arts, which were founded under the Act of 1862. In aid of these colleges the government appropriated in 1897 a million of dollars. Can any one of us see with satisfaction our government spend as little on the annual support of education in agriculture and the mechanic arts throughout the country as on the annual maintenance of three battleships in time of peace?

In instituting these comparisons between military and naval expenditure, on the one hand, and expenditure for purely beneficent objects, such as the advancement of science, the development of technical skill, the saving of life, the improvement of industries, and the support of education, on the other, I have no intention of even suggesting that the expenditures on military and naval preparation should be diminished, much less stopped, as Charles Sumner proposed. As war becomes more and more a matter of science—chemical, physical, biological and fiscal—and of highly-trained skill on the part of all who direct or operate the complicated machinery of war, it is manifest that it is the duty of the United States to build and maintain the most perfect instruments and appliances of war that the utmost skill of our engineers and mechanics can produce, and to keep in training adequate bodies of men to use effectively this elaborate machinery. But is it not equally clear that the nation which can afford to make this expenditure can afford to make much freer expenditures than our nation has ever made on the wholly beneficent agencies of the government, which save life, increase food and ore production, avert evils, facilitate transportation, promote industries and commerce, and foster education.

After everything possible has been said in favor of martial virtues and achievements, whenever our people really take up the question how best to win glory, honor and love for free institutions in general,

and the American Republic in particular, whether in our own eyes or in the eyes of other nations and later times, they will come to the conclusion that more glory, honor and love are to be won by national justice, sincerity, patience in failure and generosity in success than by national impatience, combativeness and successful self-seeking—and glory, honor and love more by as much as the virtues and ideals of civilized man excel those of barbarous men.

A HALF-CENTURY OF EVOLUTION, WITH SPECIAL REFERENCE TO THE EFFECTS OF GEOLOGICAL CHANGES ON ANIMAL LIFE (II.).*

THE APPALACHIAN REVOLUTION AND ITS BIOLOGICAL RESULTS.

UNLESS we except the great changes in physical geography which took place at the end of the Tertiary period, when the mountain chains of each continent assumed the proportions we now see, the Appalachian revolution, or the mountain-building and continent-making at the close of the Paleozoic age, was the most extensive and biologically notable event in geological history. In its effect on life, whether indirect or direct, it was of vastly greater significance than any period since, for contemporaneous with and as a consequence of this revolution was the incoming of the new types of higher or terrestrial vertebrates. Through the researches, now so familiar, in the field and study of the two Rogerses, of Dana and of Hall, we know that all through the Paleozoic era at least some 30,000 to 40,000 feet of shoal water sediments, both marine and fresh-water, derived from the erosion of neighboring lands, were accumulated in a geosynclinal trough over the present site of the range extending from near the mouth of the St. Lawrence to northern Georgia.

* Address of the Vice-President before Section F—Zoology—of the American Association for the Advancement of Science, August, 1898; continued from SCIENCE, August 27th.

At the end of the era ensued a series of movements of the earth's crust resulting from the weight of this vast accumulation, which in a geologically brief period sank in, dislocated and crushed the sides of the trough, and folded the strata into great close parallel folds, besides inducing more or less metamorphism. These folds rising from a plateau formed mountain ranges perhaps as high as the Sierra Nevada or Andean Cordillera of the present day. The plateau emerged above the surface of the Paleozoic ocean, and was carved and eroded into mountain peaks, separated by valleys of erosion, the rivers of the Appalachian drainage-system cutting their channels across the mountain ranges.

But this process of mountain-building and erosion was not confined to the end of the Paleozoic era. Willis* has shown that there were several successive cycles of denudation, covering a period extending from the end of the Paleozoic era to the present time. And it is the fact of these successive cycles of denudation both on the Atlantic and Pacific slopes of our continent that is of high significance to the zoologist from the obvious bearings of these revolutions on the production of variations. Indeed, it is these phenomena which have suggested the subject of this address.

We can imagine that this great plateau, in the beginning of the Mesozoic era, with its lofty mountain ranges and peaks rising from the shores of the Atlantic, presented different climatic zones, from tropical lowlands, with their vast swamps, to temperate uplands, stretching up perhaps to alpine summits, with possibly glaciers of limited extent filling the upper parts of the mountain valleys. New Zealand at the present day has a subtropical belt of tree ferns, while the mountains bear glaciers on their summits; and in Mexico, only about

* National Geographic Magazine, 1889, Vol. I., pp. 291–300.