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Germany in Science

THE GERMAN CLAIM TO
SCIENTIFIC LEADERSHIP REFUTED

By W. J. HOLLAND

Director of The Carnegie Institute

ADDRESS DELIVERED BEFORE THE
HUNGRY CLUB, DECEMBER 3, 1917

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Germany in Science

By W. J. HOLLAND

*(Address delivered before The Hungry Club, Pittsburgh,
December Third, Nineteen Hundred and Seventeen.)*

SCIENCE is ordered knowledge. Reverently be it said, the greatest scientist is the omniscient Author and Preserver of all things. We, the creatures of a day, are permitted to some extent to think His thoughts after Him.

Human knowledge as it exists today represents a gradual development. The science of the twentieth century is different from the science of the first century, as that differed from the science of the sixtieth century before our era. In comparison with the accumulated learning of the priests of Isis, the accumulated learning of today differs as light differs from darkness.

The greatest advances in science have been made in the last four centuries. The most rapid steps in the acquisition and ordering of knowledge have been taken within the past one hundred and fifty years. I will not now endeavor to point out the reasons for this.

There are many sciences. The divisions of *science*, using the word in its most comprehensive sense, are determined by the

nature of the subjects under investigation.

Various classifications of the sciences have been proposed. I take a moment to point out a few of the major subdivisions, at the outset warning you that all the sciences are more or less correlated.

There is a science of mind, and there is a science of matter. Mental science deals with mental phenomena and the laws controlling them. The physical sciences deal with material forces and the laws to which they are subject. Matter may be inorganic, or it may be under the control of that marvellous force to which we give the name of life. Accordingly the science of chemistry, which deals with the ultimate composition of matter, is properly divided into inorganic and organic chemistry. The science which deals with matter in the gross, and seeks to explain the actions and reactions taking place between inanimate masses of matter, without reference to their ultimate composition, is known as the science of physics. The science which deals with the extramundane universe is called astronomy, and is strictly speaking a branch of physics. The science which deals with the origin and evolution of the world upon which we live, and which may in some respects be regarded as the sister of astronomy, is called geology. The science which deals with the present configuration of the earth's surface and its political divisions is called geography. The science which deals with life in its various manifestations is biology. The science which deals with the ancient and mainly extinct life of the globe is called paleontology. The science which deals with the life and evolution of vegetable form is called botany. The science which deals with the evolution and classification of animate forms of life is called zoology. And there are innumerable subdivisions in these major divisions of the sciences. For instance the botanist who devotes his attention to the study of the mosses is known as a bryologist. It may interest you in passing to know that *The Bryologist*, the only monthly publication in America devoted to the publication of papers upon the mosses, is issued here in Pittsburgh, the Editor being one of my associates, the Curator of

Botany in the Carnegie Museum. This journal is one of a great number, which are annually published for the purpose of giving to the world the latest truths ascertained by botanical research.

In zoölogy the man who studies mammals is known as a mammalogist; the man who studies birds is an ornithologist; the man who studies fishes is an ichthyologist; the man who studies insects is an entomologist. My friend, Lord Walsingham, in an address some years ago, stated that there are no less than three millions of species of insects in the world; and so it has come about that the science of entomology has been subdivided: a man who studies beetles is a coleopterist, and the science for which he stands is coleopterology; the man who studies butterflies and moths is a lepidopterist, and his science is lepidopterology. I will not weary you. There are recognized today a thousand or more different branches of scientific research.

Another valid distinction is between *pure* and *applied* science. Pure science is knowledge sought for its own sake, without reference to any use which may ultimately be made of it. Applied science, on the other hand, involves the use of ascertained truth in such a way as to promote inventions and the arts. The student of physics, for instance, may devote himself, as did my former colleague, Dr. Samuel P. Langley, to ascertaining the laws which govern the levitation of bodies heavier than air, and in stating in the form of mathematical formulæ the amount of energy which is requisite to propel a slanting plane against the air in such a way that it will lift upward a given weight. The Wright brothers, taking the results of Langley's observations originally published by the University of Pittsburgh, and applying the theoretical knowledge acquired, succeeded in producing an aeroplane which flies, as Langley himself afterwards did. We must not forget that since Langley's death Glenn H. Curtiss has made successful flights in Professor Langley's aeroplane. This illustration serves to show the distinction between pure and applied science.

I come now to the theme, upon which it has been announced

that I would speak to you today, that is the place which is held by Germany in science. I am moved to this because for many years I have inwardly revolted against the abject acquiescence on the part of multitudes of Americans in the belief, which has been sedulously cultivated, that so-called "German science" may justly claim leadership, and that young men in order to finish, and thoroughly round out an education should be sent to German Universities. While I shall not attempt in what I say to withhold honor where honor is due, and while I am, I trust, entirely too magnanimous to minimize or detract from the intellectual efforts of those who have searched with success for truth in any land or clime, and love to think of the community of scientific men as constituting a republic, like that of letters, which gathers into its fold the seekers for truth in all nations, I cannot fail before this audience to express my deep-rooted conviction that for at least fifty years a gullible world has been stuffed with more or less mistaken ideas as to German achievements in the field of science.

Since in the limits of a brief address like this I cannot go deeply into the subject, I am going to rapidly point out a few facts for the purpose of showing you how much has been accomplished by men who lived and wrought outside of Teutonia and how comparatively small, in reality, have been German achievements in many important fields.

Let us take up the science of Mathematics, which deals with quantity, whether expressed in number or form. The science of pure numbers, or algebra, as its name implies, had at first its most striking development among the Arabs, who taught it in the schools of Bagdad and other centers. It was brought to Spain by the Moors, and by them was transmitted to the races of western Europe, to be refined and amplified in later times. Now who were those who effected this later development? One of the greatest names in this connection is that of Sir Isaac Newton. He invented the calculus. He was followed by Leibnitz, a German. A long and bitter controversy arose in this connection, some claiming that the work of Leibnitz was done

without the knowledge of the prior work of Isaac Newton, others taking a less favorable view of the labors of Leibnitz, who it was claimed had "pirated" the work of the great Englishman. Another great name in pure mathematics is that of Pascal, the Frenchman, one of the most precocious intellects of all the ages, who at seventeen brought out his work on conic sections, and somewhat later invented the calculus of probabilities, upon which in part all the work of our modern insurance companies is founded. The system of computing by means of logarithms, indispensable in engineering practice whether on land or sea, was invented by Napier, an Englishman, and in one of its forms by Briggs, another Englishman. While Germans have successfully used mathematical methods in research, I venture to make the claim that the science of mathematics in its most advanced stages reflects the genius and application of men, who almost without exception were not Germans, and certainly none of whom were Prussians. Among the many applications of mathematical science let us not in this connection forget that Germans universally employ the metric system of weights and measures, which is strictly a French invention, and compute the distances marched by their armies in meters, and sell their beer in Munich and Berlin by the liter.

Let us pass on to the science of Physics, which deals with matter and the various forms of energy resident in it, and therefore treats of gravity, sound, light, heat, magnetism, electricity, and radio-kinematics.

Leaving out of sight the work of the ancients, and coming down to more modern times, the historic evolution of this science recalls the names of William Gilbert, the Englishman who in A.D. 1600 published his work on magnetism; of Torricelli, the Italian, whose experiments on the air led to the invention of the barometer; of Boyle in England and Mariotte in France, who studied the laws controlling the pressure and volume of gases; of Newton, whose discovery and statement of the law of gravity was epoch-making, and whose optical researches were scarcely less brilliant; of Descartes, the French philosopher, who stated the laws governing the refraction of

light; of Huyghens, the Dutchman, who greatly advanced the science of optics, to which the immortal Galileo, an Italian, had already contributed much. The invention of achromatic lenses and of the reflecting telescope were advances with which Germans had little, if anything, to do. The work of our Franklin, of Cavendish, Coulomb, Galvani, and Volta in the field of electricity; of Davy, Rumford, Carnot, and Joule in thermodynamics, the confirmation by Young and Fresnel of the undulatory theory of light; the demonstration that by the spectrum of incandescent bodies it is possible to determine their composition, which was achieved by Dr. David Alter, a physician of Allegheny County, years before Kirchhoff, the German, announced the same observation, although Alter's papers had been translated and published in Germany; the experiments of Faraday, Oersted, and Joseph Henry, of Draper, Langley, Rowland, and J. J. Thompson, of Clerk-Maxwell, Sir William Ramsey, Henri Becquerel and Marconi, all represent forward strides in physical science of enormous importance to the world. None of these names are those of Germans. The only really important contributions to the science of pure physics made by Germans are attributable to Clausius of Bonn, who shares with Rankine and Thomson, Scotchmen, the honor of placing the science of thermodynamics upon a scientific foundation; to Fraunhofer, who discovered the lines in the spectrum, which bear his name; to Kirchhoff, who applied and amplified the discoveries of Alter; to Helmholtz, who wrote upon the physiological effects of sound; to Dr. Walther Nernst, whose work upon electrical incandescence is well known; and to Roentgen, whose name is associated with the rays, the utility of which in producing skiagraphs he demonstrated. The actual contributions of German thinkers to the science of pure physics are, in comparison with those made by the rest of the world, exceedingly few. The great names in physics, which are German, may be counted upon the fingers of one man's hands.

When it comes to the practical application of physical science in art and industry through mechanical processes and in-

ventions, the fact that leadership does not belong to Germany is so evident that the contrary claim becomes laughable. Let us glance at a few of the things which give our modern civilization its form and its color.

The steam-engine was made a useful machine by Watt, a Scotchman.

The locomotive was made a mechanical success by Stephenson, an Englishman.

The steamship was invented by Fulton, an American.

The first gas-engine was designed by a Frenchman.

The bicycle, as it exists today, is also a French invention, improved and developed by American and English mechanics and artisans.

The automobile, as we know it, is the product of French, Italian, and Anglo-Saxon brains, the basic inventions being French in their origin. The subject is too vast to go into at length, but if the world had waited for a German to produce such a thing as the automobile, it would have waited beyond the present hour, and the thing would not yet be.

The dynamo is based upon the discovery of inductive electrical energy by Michael Faraday in 1831. In its present forms and applications to use it represents the labors of a host of men, but it is no perversion of truth to say that the principal steps in its evolution have been brought about by Americans, Englishmen, Frenchmen, and Italians.

The development of turbine water-wheels almost wholly reflects the skill of Frenchmen, and Americans.

Steam turbines are the product of the thought of De Laval, a Swede, C. A. Parsons, an Englishman, and Dr. Curtis of New York.

The air-brake was invented by our fellow-townsmen, George Westinghouse.

The screw-propeller was invented by a Scotchman named Weldon, but its successful employment to drive vessels through the water was left to John Ericsson, a Swede, resident in the United States. Do not forget in passing that this same John Ericsson was the inventor of the "Monitor", the

first iron-clad war vessel provided with a movable gun-turret, and that he revolutionized by this invention the art of marine warfare.

The first successful submarine was invented by R. M. Holland of New Jersey.

The application of electricity to traction purposes is almost altogether the product of American thinking and experiment, and is associated with the names of Sprague, Elihu Thomson, Brush, Houston, Westinghouse, and Tesla.

The telegraph is the invention of Morse, an American.

The laying of the first transoceanic cable was due to the efforts of Cyrus Field, still another citizen of the United States.

The telephone, as everybody knows, became a practical commercial possibility as the result of the researches of Alexander Graham Bell and Thomas Edison, both citizens of this country.

The graphophone in its various applications reflects American ingenuity.

Wireless telegraphy is forever associated with the name of Marconi, an Italian, though in its later development, it owes something to a former colleague of mine, Reginald A. Fessenden, who for a while taught electrical engineering in our University.

Balloons were invented by the brothers Montgolfier, Frenchmen. They used hot air, generated by burning chopped straw, to fill the bag, which was made of paper. A few months later Mons. Charles of Paris inflated a balloon of oiled silk with hydrogen gas, and in 1783 made three successful flights. The first dirigible balloons were built in France by the brothers Tissandier and made slow but successful flights. Then came Santos Dumont, a young Brazilian, who in 1901 flew in his dirigible around the Eiffel Tower. Later he was followed by Count Zeppelin, the German, whose exploits are familiar to you.

I have already alluded to the labors of Professor Samuel P. Langley, which paved the way for the invention of the aer-

oplane. The great fleets of aerial vessels which sweep the skies today may be said to be the outcome of the thought of a former Pittsburgher, and in this connection let me remind you that the first transcontinental flight in an aeroplane was accomplished by Calbraith Perry Rogers, a Pittsburgher, whom in his infancy I remember once to have carried to his home "pick-a-back" through a snow-storm, little dreaming as I turned the rosy-cheeked boy over to his mother, who met us at the door, that I had been bearing on my shoulders a child who later "on the wings of the wind" would fly across the continent from sea to sea.

Thus far I have been thinking mainly of devices intended to effect transportation of masses or of force from point to point in space. Let us turn to another set of instrumentalities, which in many respects are no less important.

"Wherewithal shall we be clothed?" This important question was answered by Arkwright, an Englishman, who invented the power-loom. A close study of the basic improvements in the art of weaving by machinery, which enables a peasant today to wear clothes which six centuries ago a king could not afford, reveals the fact that the inventions which are dominant in this industry are the product of the ingenuity of American, English, and French mechanics. Eli Whitney of Westborough, Massachusetts, invented the cotton-gin. Without it, how small would be the production of cotton goods! The weaving of damask-patterns in linen, the weaving of velvet, and of velvet tapestries are arts, which were chiefly developed in France. It always interests me to recall the fact that King William III of England in 1698 invited one of my own Huguenot kinsmen. Louis Crommelin, then a refugee in Holland, to repair to Ireland to establish the linen industry in that country, made him a grant of lands in Antrim, at Lisburn, promised to pay him eight percent upon the £10,000 sterling which Crommelin agreed to put into the industry, and made him "National Manager of the Linen Trade." Some of you know the part played in commerce by Irish linens today. Germany had nothing to do with this development.

From cloth I pass in my thought to sewing. You all know that the sewing machine is strictly an American invention.

Machinery for the manufacture of shoes is almost all of it the product of American ingenuity, and most of it is made in the United States.

The type-writer is an American invention. Adding machines, such as are used today in banks and counting-houses, reflect the cunning skill and concentrated efforts of American machinists.

We cheerfully grant to Guttenberg, an Alsatian, the credit for inventing the process of printing by movable types some years before Columbus discovered America, but the great power-presses of today, which with lightning rapidity roll off of their cylinders the daily papers, and books by the millions, are the result of the ingenuity of Americans and Englishmen for the most part. In this connection the name of Robert Hoe of New York stands forth pre-eminent.

Harvesting machinery is American in its origin. Think of Cyrus McCormick.

But I might go on indefinitely along these lines, and only desire to say before closing my remarks about the application of physical laws in the field of industrial invention that the manufacture of machinery capable of doing its work with precision is one of the most important things in our modern life. Any one who has read the life of Watt and of Stephenson realizes the difficulties they had to contend with in getting true surfaces, flat or curved, in the machinery they invented. The standardizing of parts is also an important matter. To American mechanics is due much of the precision attainable today with the help of machine-tools. Planers, lathes, drills, punches, shapers, slotting machines, as used the world over in the best practice, are largely the product of English, but more particularly of American brains. At the close of the Franco-Prussian War the German Government gave orders amounting to millions of dollars to an American firm to set up machinery for the manufacture of rifles with standardized parts, and to send over men to instruct the Ger-

man workmen in their use. By the by, the same Eli Whitney, who invented the cotton-gin, was the first to originate the making of fire-arms with standardized parts in the arsenals of the United States, for which he received the thanks of the Government. Machinery for threading screws capable of detecting errors the twenty-thousandths of an inch are the product of American machine-shops, and are in common use.

Let us pass from physics to chemistry. The Germans have perhaps done more in chemistry than in any other branch of science, and deserve recognition for the applications of chemical knowledge which they have made along certain lines. There are some great names among those who have belonged to the army of German chemists, such as Brandt, Claus, Stromeyer, Klaproth, Ostwald, and van't Hoff, neither of the two latter, however, being in fact Germans, the first having been born in Russia, the latter in Holland, but both having held chairs in German universities. Nevertheless the greatest names in chemistry are not these. Contrast with them the names of the great founders of the science: in England, Boyle, Priestley, Dalton, Cavendish, Wollaston, and in later times such men as Lord Rayleigh, and Sir William Ramsay; in France, Lavoisier, Laurent, Ampere, Gay-Lussac, Dumas, and recently the Curies; in Sweden, Berzelius, *nomen venerabile!* in Italy, Avogadro and Cannizzaro.

While cheerfully admitting that German chemists have done noble work, they were nevertheless building for the most part on foundations already laid for them by others who were not of German origin.

We hear a great deal in these days about Germany's supremacy in the manufacture of dyes derived from coal-tars, and the story of the invention of synthetic indigo has been so often told that it is becoming threadbare; but let me remind you that the distillation of coal-tars and benzene had its origin in England, and though anilin, produced through the reaction of nitric acid with benzene, was first discovered by the German chemist, Unverdorben, in 1826, it was not until W. H. Perkin, an Englishman, in 1856 had derived from it the

color *mauve*, also known as *Perkin's purple*, that the discovery of anilin came to have commercial importance.

Let us glance at the chemistry of iron and steel. You who are before me know that the great names in this field are not principally those of Germans. Germany has no name to compare with those of Bessemer, Siemens, and Martin, Englishmen, and Mushet, the Frenchman. I pass over the host of great names I might cite in the metallurgy of iron and steel, which bear not upon its chemical but mechanical processes.

The production of aluminum by electrolytic methods, which has grown to be a great industry had its origin in America. It is indelibly associated with the name of Charles M. Hall, who used often to occupy a pew in the church of which I was the pastor, while with the help of my dear friends, Capt. Alfred E. Hunt and his partner, Mr. George H. Clapp, he was working out the utilization of his discoveries in a practical way.

The discovery of carborundum, an abrasive invaluable in the arts, which has almost entirely replaced emery, was made here in Pittsburgh by Edward Goodrich Acheson, whose experiments were carried on in a shed, which he always kept locked, and which stood on Fifth Avenue near the site of the present Hotel Schenley. He used electric power which he obtained from the lines of the street railway passing the spot. Like Hall he often came to the church at the corner of Bellefield Avenue, but he never told me what he was doing in his shed near by; and I only came to know about it afterwards when the great plant for the manufacture of carborundum was established at Niagara Falls.

Photography is an art which combines the application of the laws of physics with the results of chemical research. It had its origin in France and is forever linked with the name of Daguerre.

But I must hasten forward.

Let us take a passing glance at the science of astronomy, the most ancient of the sciences, the most aristocratic, the most expensive, and the least capable of directly serving the needs of humanity, save as it helps to make us humble and feel our

utter insignificance in the universe.

There are a few great names in astronomical science which were borne by men in Germany, all of whom are now long dead and turned to dust. We can never forget Kepler, Argerlander, Bessel, Hansen, and Roemer. Great as are these names, how much more glorious is the galaxy of names which follows: in England, Sir Isaac Newton, the Hershels, Lord Rosse, Airy, Adams, Halley, Rutherford and Sir John Huggins; in France, Arago, Cassini, Delaunay, Gassendi, Lagrange, Le Verrier, and the greatest of them all, Laplace; in Italy, Galileo Galilei, Schiapparelli, Secchi; in Poland Copernicus, who was educated at the University of Bologna in Italy, but is buried in Prussia. (which by the way, makes a specialty of burying the good and great); in Russia, the Struves, Backlund, and Belopolsky; in the United States Young, Langley, Newcomb, Harkness, Burnham, Keeler, Pickering, Peters, Hale, Campbell, and our own Schlesinger.

When it comes to the tools which astronomers use you know that the biggest and the best telescopes in the world have been made in America, and that there are not anywhere in Europe such telescopes as those designed and erected by Alvan Clarke for the Lick, the Yerkes, and other great observatories. When the astronomers of the world need good spectroscopes, or photographic lenses they send here to Pittsburgh to "uncle John Brashear" to make them. When Prof. Max Wolf of Heidelberg a few years ago wanted an exceptionally fine set of lenses with which to do a piece of exceptionally fine photographic work, he commissioned Dr. Brashear to make them.

Turning from physics, chemistry, and astronomy, to geography, I may say that in the field of geographic discovery Germany has done absolutely so little that it is hardly worth mentioning. Germany came into the field too late to be of much use. She makes good maps, and her teachers have written some good text-books dealing with the science, but her chief function in geography has been latterly to fool with existing political boundaries, which her neighbors naturally do not like. Germany did not discover America, she was not

the first to circumnavigate the globe, she did not discover the route to China by way of the Cape of Good Hope, she did not discover either the North or the South Pole. She has sent out a great many travellers, who have wandered hither and thither, and reported their observations, men like Humboldt, and Barth, and Schweinfurth, who have botanized, and collected bugs, and described the aspects of nature in the lands they have visited, but whose additions to real geographical science have been for the most part rather negligible.

In geology the work of Germans is not much more important than it has been in geography. Again her professors have compiled most excellent text-books, and have laboriously constructed many charts and maps, which are useful in high-schools, but outside of her own little Middle-European domain German geologists have done nothing which deserves mention as epoch-making. Werner of Freiburg, who died in 1817, has been styled by Germans "the founder of scientific geology," and it is true that his influence as a teacher led not a few to address themselves to the study of the science, but his views embodied in the so-called "Neptunian Theory" have long ago been discarded as rubbish. My dear old friend, Dr. Suess of Vienna, who died a few years ago, has given us in his great work, "*Das Antlitz der Erde*" a fine resume of what is known by geologists, and it has recently been translated into French by another friend of mine, Emmanuel de Margerie, but it is the result of reading and reflection, rather than of original research.

Geology is so young a science, and the most important advances in it have been made so recently, that to mention the names which bulk largest in it would compell me to speak of many of my contemporaries, and raise distinctions, which might seem invidious. I therefore content myself with speaking of only a few of the great men of the past, and remind you that Germany, has few names to be compared with those of Lyell, Murchison, Geikie, Elie de Beaumont, Charpentier, Louis Agassiz, Dawson, LeConte, Hayden, Powell and Tschernychev. The greatest geologists are living men, and some

of the greatest of them are alive today in England, France, and the United States.

What I have said of geology is in large part true also of paleontology. What names can Germany call which may fitly be compared with those of Cuvier, Gaudry, Lartet, Filhol, and Boule, in France; of Sir Richard Owen, Thomas H. Huxley, C. W. Andrews and Henry and Arthur Smith Woodward, in England; of Leidy, Marsh, and Cope among the recently deceased in the United States, not to speak of the small army of living Paleontologists in America, a score of whom are doing work today which is being equalled nowhere else in the world, certainly not in Prussia. The great compendium of the late Dr. Zittel of Munich falls into the class of text-books, of which German professors have prepared so many in all the sciences, but it does not illustrate to any great extent original research or investigation. It is the fruit of erudition, but nothing more.

Coming now to the biological sciences I may say that the field is so vast that to do justice to the subject would involve far more time than is at my command, and I can only attempt to touch lightly upon it.

Who bears the proud title of "The Father of Natural History"? It is borne not by a German, but by a Swede, the immortal Linnæus. Botany and Zoölogy as modern sciences date from the publication of the Tenth Edition of his *Systema Natura*. To him we are indebted for the binomial system of nomenclature. He laid the foundation for the classification of all living things in orders, families, genera, species, and varieties. It is true that his system for the classification of plants, known as "The Artificial System", has been superseded by "The Natural System" proposed by his friend Jussieu, the French botanist, but, in spite of that, he still stands forth as the great leader and founder of our most advanced systematology.

There have been not a few able botanists and zoologists in Germany, and science owes a large debt to their labors, but after giving them all the credit which is due to them, how relatively small in the last analysis is the result of their labors, when contrasted with the greater labors of their contem-

poraries in other lands.

Let me take up the science of ornithology as an illustration. What work ever appeared in Germany which can of one moment be compared with Audubon's *Birds of America*, Gould's *Birds*, Dresser's *Birds of Europe*, or some of the great monographs which in the past fifty years have issued from British, French, and American presses. What German work may be put alongside of Bowdler Sharpe's *Catalogue of the Birds in the British Museum*. I recognize the value of the labors of Cabanis, of Reichenau upon the *Birds of Africa*, of the writings of Hellmayr, and of the late Count von Berlepsch, but creditable and important as has been their work, it is altogether dwarfed before the vaster labors of the scores of eager inquirers in other lands who with better facilities and longer purses have led the race.

Take the science of entomology. Germany has made valuable contributions to it, which I, as an entomologist, am the last man to deny. But taking all the literature upon my favorite science from German pens, and placing it against the results of the labors of Englishmen, Frenchmen, Belgians, Italians, Russians, Swedes, Danes, Dutchmen, Spaniards, Japanese, and Americans, how really small in amount, and how relatively poor in appearance it is. And the remarkable thing in some of the later and more pretentious works issued from German presses is the fact that the work is in reality not the work of Germans. As an illustration let me cite the great *Treatise* issued in Leipzig entitled "*Die Gross-Schmetterlinge der Erde*" finely illustrated, intended to give an epitome of all the species of butterflies and larger moths on the globe. The text is, so far as the work has issued from the press, principally from the pens of such men as Dr. Aurivillius, of Sweden, and Jordan and Warren of England.

What names in German biological science can compare with those of Jussieu, of Bonpland, Decandolle, of the Hookers, or of Asa Gray in botany? With those of Buffon, Cuvier, Milne-Edwards, Wallace, Darwin, Huxley, and E. Perrier in zoölogy? We are not oblivious of the writings of Mendel, of Weiss-

mann, or of Hæckel; but if the writings of all those who have labored in these fields in other lands were left out of the account or obliterated there would be no science worthy of the name left, either in botany or zoölogy. Germany has "done its bit", but set against what has been done by scientific investigators in other lands it has only been a bit.

A word as to medicine and surgery.

If we except certain coal-tar products, you will discover that the bulk of the curative remedies employed in medicine and given in the Pharmacopœia, owe their discovery and use to chemical investigators and physicians outside of Teutonia. Let me cite quinine as an illustration. The use of the bark of the *Cinchona* was learned from the Indians by the early Spanish settlers of South America. Sulphate of quinine as an alkaloid was first separated by a French chemist in the early part of the last century. Its manufacture on a large scale was begun by Powers & Weightman in Philadelphia shortly afterward. Today it is still manufactured to a larger extent in the United States than in any other country on the globe. The manufacture of drugs and medicines in this country is one of its great and important industries, and so far as this field of effort is concerned Germany can claim no superiority over us.

Take dentistry as a branch of surgical science. The Kaiser himself and all other crowned heads in Europe give the palm to American dentists. "Amerikanischer Zahn-Artzt" is a sign you might have seen anywhere in Germany before the war, and the foremost dental school in America is located in Pittsburgh.

Who discovered antiseptic surgery? Sir Joseph Lister, an Englishman.

Who discovered and first practised anæsthesia? Doctor Horace Wells of Hartford, Connecticut, a dentist, who used nitrous oxide; Dr. Morton, of Boston, who performed surgical operations with success upon etherized subjects; and Sir James Simpson of Edinburgh, Scotland, who, acting upon the suggestion of J. P. Flourens of Paris, who had ascertained the anæsthetic property of chloroform, employed it in

midwifery and later in surgery.

Vaccination against small-pox is due to Jenner, an Englishman.

In this connection we should not lose sight of the results of the remarkable series of investigations which led to the classification of the unicellular plants, known as bacteria or bacilli, and the changes brought about by their presence in organic substances, resulting in the formation of toxins and antitoxins. The great names in bacteriology are those of Leeuwenhoek, a Hollander; Pasteur, a Frenchman; Marshall Ward, Duguid, Burdon-Sanderson and Greenfield, Englishmen; Metchnikoff, a Russian; Ravenel an American; Klebs, Löffler, Koch, and Ehrlich, Germans. Koch had the honor of discovering the bacillus of tuberculosis and of cholera. His claim to have discovered a remedy for tuberculosis was afterwards disproved, and his reputation became clouded.

The discovery that malarial fever, so-called, is due to the presence in the blood of the patient of a one-celled animal known as *Plasmodium malariae*, which is introduced into the circulation through the agency of a species of mosquito belonging to the genus *Anopheles*, and the kindred discovery that yellow fever is produced by an animal, which is likewise transmitted by a mosquito belonging to the genus *Stegomyia*, and the further discovery that sleeping sickness and various deadly diseases attacking man and other warm-blooded animals are due to protozoans belonging to the genus *Trypanosoma*, which are communicated by flies, are among the more recent results of highly interesting researches, in which English, French, and especially American investigators have played the chief rôle.

As a practical result of these discoveries it seems likely that vast regions hitherto regarded as uninhabitable by men may be reclaimed to their use. The Campagna about Rome, the climate of which was deemed deadly, is rapidly being made habitable, and its fertile soil is being made to bear crops, the systematic disinfection of its mosquito-haunted pools by the simple use of coal-oil applied to them having brought about a

wonderful change in conditions. The building of the Panama canal was made possible by the discoveries to which I have alluded. Where in the days of DeLesseps men died like flies by scores and hundreds, under Dr. Gorgas men lived as healthily as they would here in Pittsburgh.

But I hear some of you ask "What about military science"? Well, it was Mirabeau who said that "The national industry of Prussia is war." But Sir Roger Bacon, an Englishman, invented gunpowder. A Swiss chemist invented gun-cotton. The bayonet is French in its origin. Cannon were first used by the English against the Scotch in 1327, and by the French against the Flemish in 1338. Cannon were at first cast hollow, and the balls were made of stone. Later they were cast solid and bored out, but while this improved their appearance it lessened their strength. General T. J. Rodman, Chief of ordnance of the U. S. Army, whose wife, by the way, was a daughter of the Rev. Dr. John Black, one of the early professors in the University of Pittsburgh, reverted to the method of casting cannon hollow over a core which was cooled by running water. The work was done here in Pittsburgh, and the big guns used in the civil war, known as "Rodman guns," which won their way to victory, were mostly cast at the old "Fort Pitt Foundry," belonging to the firm of Knapp & Wade. Cannon are now "built up" as you know, rings of steel being successively shrunk around the barrel-tube within. The first built-up guns were made by Chambers & Treadwell, Americans, and by Blakely, an Englishman. Breech-loading devices are quite old in their origin, and go back to a time when there were no Prussians to use them. The rifling of small gun-barrels we must allow to be a Teutonic invention, the claim to have first employed it being in dispute between Gaspard Kollner of Vienna, who is said to have rifled gun-barrels in 1498, and Augustus Kotter of Nuremberg, who is said to have practiced the art from 1500 to 1520. It is proper to state that the invention was originally intended to enable the barrel to be more easily cleaned, and not to improve the trajectory. Machinery for turning gun-stocks and other irregular shapes

is the product of the genius of Thomas Blanchard, an American, who patented the device the year 1820. The first successful machine-gun was invented by Dr. Gatling of Indianapolis, Indiana, but is replaced to-day by others among which is the Lewis gun, an American invention, now used by the British Army.

Rapid-firing field-guns, and marine guns bear the names of Hotchkiss, and Maxim, Americans; of Nordenfeldt, a Swede, of Armstrong, an Englishman. These were later followed by Herr Krupp of Essen.

The science of war! That is a science, which I suppose we must cultivate when madmen get the reins of power into their hands, and inflamed by jealousy, greed, and hate, set about crushing every man who stands in their pathway.

It is not a noble science, nor is war a noble art. We resort to it as a last dire necessity, as we resort to the use of clubs, stones, and pistols when a mad dog is loose in the streets. Wars of conquest undertaken by ambitious and greedy men and races deserve in this age to be looked upon as nothing more than murder, and "glorious war," in the case of those who begin it should find an end for them in a slip-noose, or the electric chair.

When rulers seek to do God's will on earth as it is done in heaven, the art of war will cease. But as long as the devil sits incarnate on earthly thrones I suppose we shall have to fight him with his own weapons, and when we have to do it, it ought to be with all our might, and soul, and strength.

Some one asks "What about the metaphysical sciences and the science of ethics?" Germany once had some great philosophers and ethical teachers: but they are all dead. Luther is dead, Kant is dead. The Germany which sent to Pennsylvania a Zinzendorf, a Zeisberger, and a Heckewelder to preach the Gospel of good-will and brotherly kindness to the poor and the savages has vanished. The Germany which gave us a Steuben, a Muhlenberg, a Sigel, and a Schurtz is a Germany which has past away. We stand confronting a Germany, mad with lust for gold and world-power, which in school and church is teaching a "doctrine of devils," proclaiming that the crime

which individuals may not commit, may with impunity be committed by men in their collective capacity as states. To-day it is not necessary to be "set down" "somewhere east of Suez" to find a place "where there aint no Ten Commandments." It may be found wherever Prussian militarism has planted its cloven hoof upon the soil of Europe. We are facing a Germany which has affiliated itself with Muhammed, which in certain circles openly advocates plural marriages and like Muhammed demands the subjugation of the world to itself by the might of the sword, a Germany unmoral, brutal, inhuman, which builds its policies upon broken oaths, which shrinks from no falsehood which seems to serve its purpose, a Germany without conscience and without heart, which is the fellowship of nations, when it comes at last to recover its sanity, will hang its head with shame. We, who know Germany best, who are still proud of our descent from those who came to this land from her soil, seeking, as did the Pilgrim Fathers, freedom to worship God according to the dictates of their consciences, and who are in this generation "Americans of the Americans," are filled with inward loathing today as we contemplate the crimes which Germany, while invoking the aid of Heaven, is committing against the poor and the defenseless, her violation of solemn oaths and covenants, her resurrection of human slavery, her defiance of the principles of truth and honor, her utter lack of chivalry, her cold-blooded brutality, her cynical indifference to all the dictates of a refined and generous manhood.

But I have said enough. It only remains for me in conclusion to repeat, what I intimated at the outset, that it is a gross delusion to imagine that the German intellect today holds a supreme place in science in any field. When you hear the claim made, deny it! Except as science has helped in recent years to fill the German pocket-book or the graves of a hundred battle-fields with the dead, there has been little attention paid to it. (Even at his best the German has mainly been adaptive and imitative, not creative.) He has been a plodder, assimilating and using the results of the work of other men,

whom he had not always thanked, and whose labors he has often appropriated without due acknowledgement. He has been intellectually as well as otherwise dishonorable and dishonest. Science in Germany has for years been more or less decadent. Six years before this war broke out I walked with one of the leading scientific men of Germany through one of its museums. I commented upon the appearance of things, and asked him why some of the shabby and disreputable furniture I saw about me was not replaced with something more modern and up to date. He answered me by saying: "Heutzutage in Deutschland giebt's kein Geld fuer die Wissenschaft; alles muss fuer's Militaerwesen verwendet werden." *There is no money today in Germany for science, everything must be spent in preparation for war.* That is the secret of Germany's backward state, for morally and intellectually, as well as physically and financially Germany, in spite of all her boasting, and her vain-glorious claims to human leadership, is two centuries behind the times. Her government is a tyrannical despotism, her spirit is that of the ancient Hebrews and Philistines, her voice reflects the language of the imprecatory Psalms, and not that of Him, "who spake as never man spake." Her "Gott" to-day is a creation of the imagination like Moloch or Baal. She has exalted the sword of steel above "the sword of the spirit," and instead of preaching good-will to men, she chants "songs of hate" born of hearts filled with the vanity of parvenus and the gall and worm-wood of envy. Germany by the acts of her bloody dynastic rulers has had the mark of Cain set upon her forehead. No wonder that the world, from the palaces of the rich, to the huts of the savage poor, despises her, and will in coming years have as little as possible to do with her.

Shall we in coming years send our sons to be educated in her universities? Never again. I say NEVER! They will learn little science, and as for ethics, they might as well be sent to school to old Satan himself. *Exchange professors!*—we have had too many already; we wish no more. The scheme of exchanging professors was a part of the German propaganda, cunningly devised to help promote the scheme of world-dominion, hatched by the Kaiser and his confederates.

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