Chapter Three

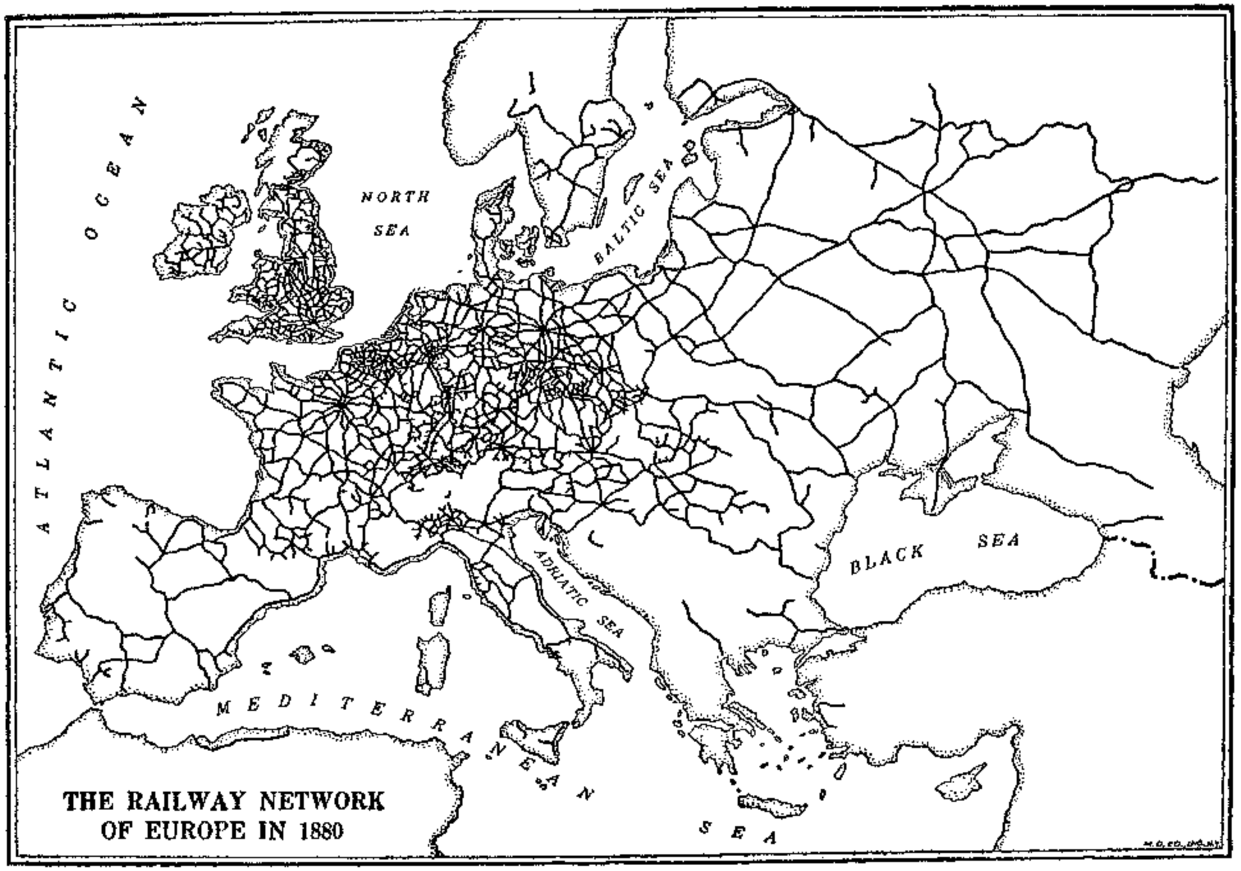
THE RAPID MECHANIZING OF WORK AND THOUGHT

I. PERFECTING OF MECHANICAL TRANSPORT

Two events of 1869—the opening of the Suez Canal and the completion of the first transcontinental railway across America—nicely presaged the perfecting and expansion of that steam-powered mechanical transport which had begun in England forty years previously. Western Europe was already familiar with glistening iron rails, screeching locomotives, and fast rolling trains of passengers and goods. By 1900 these phenomena were commonplace in eastern Europe (and throughout the world). In the interval, the growth of railway mileage in Europe from 66,000 to 172,000 was chiefly in Russia, Austria-Hungary, and the Balkans, while outside Europe new construction not only over American prairies, but across Siberian steppes and Argentinian pampas, up Indian rivers, down Japanese coasts, and into the interior of Australia, raised the total world mileage from 130,000 to nearly 600,000. Railway building was almost if not quite done by 1900. The capital invested in it was estimated at forty-five billion dollars, divided about evenly between Europe and the rest of the world.

Meanwhile, improvement in the efficiency and ease of steam-and-rail transport, though hardly sensational, was steady. Steel rails were gradually substituted for iron and made heavier. Roadbeds were better ballasted. Locomotives and rolling stock were improved. Mechanical safety appliances were installed. Sleeping cars (*wagons-lits* in Europe and Pullmans in America) were introduced in the '70's and dining cars in the early '80's. In the '90's came refrigeration cars.

It was similar with the steamboat, which had had a history before the opening of the Suez Canal in 1869. Thirty years later it was omnipresent on the high seas and in all the ports of the world, far


ATLANTIC OCEAN
NORTH SEA
BALTIC SEA
BLACK SEA
ADRIATIC SEA
MEDITERRANEAN SEA
THE RAILWAY NETWORK
OF EUROPE IN 1880

more common than the sailing vessel. It, too, had undergone constant improvement. It was now normally of steel, rather than of iron or wood, and was operated by screw propellers. With new demands of trade and travel, it was employed for differentiated types of refrigeration ships, tankers, and the more elaborate and specialized passenger liners. Toward the close of the '90's came Parsons' marine turbine and Diesel's heavy-oil engine. The enormous growth of water as of land transport, during the era from 1871 to 1900, was accomplished by machines of steel and steam. Persons and goods might still be delivered at one's door by horse and wagon or carried by sailboat, but just as the extension of railways registered the universal popularity and utility of mechanical transport by land, so the enlarging of the Suez Canal in the '80's and the projecting of a Panama Canal in the '90's witnessed to the ubiquitous triumph of mechanical transport by water. For any considerable distance, inside and outside Europe, one traveled and dispatched one's wares, as a matter of course, by powered machinery.

Nor do steam locomotive and steamboat longer tell the whole story of mechanical transport. There were new auxiliaries. For example, the bicycle appeared, at first in the '70's as a sportive curiosity with its big front wheel and its ridiculous little rear wheel, but presently in "standard" form as a valued means of getting to work about town or out to play in the country. Ball bearings were introduced in 1877. Safety rear driving was generally adopted about 1885. Pneumatic rubber tires were added in 1889. In the '90's it became popular alike with classes and masses, and by 1900 its number was legion. There were five million bicycles in France, five million in Britain, four million in Germany, two million in Italy, and comparable numbers in other countries.

Then, too, in the late '60's rails had begun to be laid on city streets, and the tramcars drawn along them by horses were replaced in the '80's by electric tramcars. But hardly was electric traction established when it was challenged on streets and country roads—and on water too—by the internal combustion engine. In 1887 Gottlieb Daimler, a German inventor, put his "petrol engine" into a "four-wheeled, wood-built, light waggonette," and the gasoline-powered automobile was born. Its adolescence, however, was characterized by a bit more than normal trial and error, and its maturity was not reached, with revolutionary consequences, until the twentieth century. Henry Ford was to organize his motorcar company in 1902. In the meantime, the "petrol engine" was being experimented with for motor launches, for submarine boats (which stem from an American inventor, John Holland, in 1875), and also (*mirabile dictu*) for flying machines, about which the human race had dreamed even before it was conscious of any biological or atavistic relationship with birds.

Transport not only of persons and commodities but also of letters, messages, and news was immensely expedited and extended by mechanical devices. Railways and steamships carried ever larger quantities of mail, and on the several national post offices which consequently flourished was superimposed by international agreement in 1875 a Universal Postal Union with headquarters at Berne. Moreover, to the electric telegraph, which had paralleled railways since the 1840's, was successfully added in the late '60's, underneath steamship lanes, the submarine cable. Europe was thus put into direct telegraphic communication with the United States in 1866, with India and the Far East in 1870, and with South America in 1874. Then came the amazing work of Alexander Graham Bell, a Scotsman who had emigrated to America in 1870 and become professor of "vocal physiology" at Boston University. In 1876 he exhibited an apparatus embodying the results of his experiments with the transmission of sound by electricity. It was the telephone. It was immediately accepted in Europe and America, and before long the mileage of telephone wires surpassed that of telegraph wires.

But why any wires at all? Utilizing the theories of electromagnetism propounded by Maxwell in 1873 and proven by Hertz in the late '80's, Marconi patented in 1896 the practical machinery for wireless telegraphy and organized a company for its commercial exploitation. In 1898 wireless telegraphic communication was inaugurated over the English Channel. In 1900 it was tested in naval maneuvers. In 1901 a message—a single letter S—was sent by wireless across the Atlantic.

II. GROWTH OF MACHINE INDUSTRY AND THE CRISIS IN AGRICULTURE

In 1880 John Ruskin wrote of "the ferruginous temper" which in the preceding thirty years "has changed our Merry England into the Man with the Iron Mask."[1] While he wrote, the mask was visibly turning into steel and transforming not only England's aspect but the Continent's—and the world's. For machine industry, already preponderant in Britain (and Belgium) prior to 1871, acquired a like supremacy during the next thirty years in other countries—Germany and the United States, most strikingly; France, to a large extent; and, in lesser and varying degrees, Italy, Austria, Sweden, Spain, Russia. Its basis everywhere, of course, was in engines made of iron and stoked with coal, and its applications were to large-scale fabrication, as well as transport, of commodities. Indeed, the association of mechanical transport with mechanized industry was intimate. In Britain the industrial use of iron and coal led to railway and steamboat; on the Continent the building and operating of railways evoked "the ferruginous temper" and with it a general industrialization. After 1870 the inventors and promoters of industrial machinery were no longer limited to "Anglo-Saxons" and a few Frenchmen and Germans domiciled in England; they were as polyglot and cosmopolitan as the machinery itself.

Between 1871 and 1900, while the British production of pig iron increased by a third, the world output more than tripled. Of this a rapidly growing proportion went into the manufacture of steel. In 1871, when both the Bessemer "converter" and the Siemens "open hearth" were in their infancy, steel production amounted to scarcely a million tons, of which half was British. Then in 1878 came the "basic process" of Gilchrist and Thomas, permitting the utilization of phosphoric iron ores and hence the rich ones of Lorraine, with the result that by 1900 some thirty-three million tons of steel were being made, of which less than a sixth was British, while a fifth was German and a fourth was American. An age of steel was succeeding an age of wrought iron, and it was fittingly climaxed by

[1] *The Seven Lamps of Architecture* (1890 ed.), 70 *n*, quoted in J. H. Clapham, *An Economic History of Modern Britain*, II (1932), 47.

the new marvel of chromium-tungsten steel which the Bethlehem Steel Corporation of America (a curious title for a generation of materialism!) dramatically displayed at the Paris Exposition of 1900.

It was equally an age of coal. To fuel the railway locomotives and ocean liners, the smelters, and the spawning engines in factory and mill, to heat houses, to operate the swelling gas works which by the 1880's were giving light and cooking food in most urban centers and incidentally providing fertilizers for rural fields, and also to support the chemical industry newly and wondrously founded on coal-tar products, the mining of coal was vastly extended. Between 1870 and 1900 its output about doubled in England and Belgium, tripled in France, quite quadrupled in Germany, and increased eightfold in the United States. The world total waxed from 218 to 765 million metric tons.

If the latest material civilization rested on coal and iron (and steel), it was embellished by numerous other earthy extractions, such, for example, as copper and tin, aluminum and concrete. Quantities of copper, needed especially for novel electrical apparatus, were obtained from Rio Tinto in Spain and from the American states of Michigan and Montana. Tin, demanded particularly for the new canning industry, was supplied by bigger imports from the Malay peninsula, the East Indies, and Bolivia. For aluminum a multitude of uses led to its large-scale production by an electrolytic process patented in France and America in 1886. Concrete, made of "Portland cement," was notably improved in the '70's through a lessening of the water content and thenceforth was extensively employed. Many piers and docks were built of it, and in the '80's, "reënforced" by iron as "ferro-concrete," it entered into the construction of houses and factories.

Iron, coal, and auxiliary metals seemed the tangible sustaining buttresses of progressive life and work in Europe—and the Europeanized world—during the Generation of Materialism. But they had antedated and given rise to that generation. What that generation most distinctively originated had to do with electricity—something less tangible, something bordering on mystery, something which might perversely be described as a soul, rather than the body, of materialism. For while electricity remained, in theory, an incompletely explained phenomenon, its practical applications occupied after 1870 a central place in European interest and achievement. The only significant applications before 1870 had been to telegraphy, electroplating, and the arc light. Then in the '70's were devised the telephone, the incandescent filament lamp (by the American Edison), and, perhaps most important of all, the successful dynamo (by the German Siemens). Soon electric lighting was competing with (and later supplanting) gas lighting, and electric traction was supplementing steam traction. Parsons patented his high-speed turbine and an accompanying high-speed dynamo on the same day in 1884, and his first installations were for generating electricity on shipboard. In 1888 followed the induction motor by Tesla, a person who neatly symbolizes the cosmopolitan character of electrical progress: born in Croatia, the son of an Orthodox priest, educated at Vienna and Prague, employed as electrical engineer by the Austrian government, then emigrating to America and associated for a time with Edison, Tesla was one of the first to effect the successful transmission of electrical current from central power plants through lengthening systems of electric lighting and traction. To what diverse uses electricity would eventually be put was quaintly indicated by New York's enactment in 1888 that the death penalty for crime should no longer be inflicted by "hanging" but by a supposedly more scientific (and therefore humane) "electrocution."

Among novel industries, a close second to the electrical were the chemical. Of these, one of the most startling and epochal was the manufacture of synthetic dyestuffs, developing chiefly in Germany. Another was the chemical treatment of wood pulp or cellulose, for the making of paper much cheaper and far more plentiful (and fleeting) than that obtained from linen and rags, and also for the fabrication of artificial silk, or "rayon." Wood pulp paper appeared first in Britain in the '70's, and wood pulp "silk" was first patented by a Frenchman in the '80's. Still another great chemical (and physical) industry was photography. It had begun before 1870, but afterwards its advance was swift. In 1884 the roll film was invented. In 1888 was marketed the first "kodak." In 1891 color photography was introduced, and in 1895 the patenting of the "cinematograph" in France pointed to a coming craze of motion pictures.

For the chemical as for the electrical industries, and in fact for all the spreading and intensifying industrialization, machines became ever more numerous and complex. A pair of machines produced frequently and automatically, as it were, a litter of other machines, and the rabbitlike progeny furnished material evidence of the soundness of Herbert Spencer's philosophical dictum that "progress is from the homogeneous to the heterogeneous." Hand sewing was largely replaced in the '70's by the sewing machine, and an electric sewing machine was patented in 1889. Writing by hand was revolutionized and rendered easier and far more copious by the typewriting machine, invented in America in the early '70's and brought to Europe in quantities at the end of that decade. The first shift-key typewriter appeared in 1878, and the first "visible" writer in 1883. A tabulating machine was first employed for assembling the data of the United States census of 1890, and decimal tabulators were in use by 1898. In the meantime, the setting of type for printing was speeded up by the rotary typecasting machine introduced and improved by the London *Times* in the '70's, and still more by the linotype and monotype machines devised and perfected in the '80's and '90's.

The art of war, also, was progressively mechanized. The first machine gun, the Gatling, had been a by-product of the American Civil War of the '60's. Another, the mitrailleuse, was produced in France and utilized in the Franco-Prussian War. Then, in 1889, Sir Hiram Maxim, an American who acquired an English title, designed a truly automatic machine gun, which subsequently was widely adopted. Improved rifles, too, were poured out by the Vickers and the Armstrongs in Britain, the Krupps in Germany, the Creusot works in France; and amidst the deluge of guns and munitions were the dynamite and other high explosives contributed by the inventive and promoting genius of the Swede, Alfred Nobel, whose materialism was beguilingly decorated with the lavender of humanitarianism and the lace of pacifism.

Machines multiplied and whirred faster for the making of thread and cloth. The number of cotton spindles in Europe and America almost doubled between 1870 and 1900, and much more than doubled in Germany, Italy, Bohemia, and Russia. Ring spinning, little known in 1885, was a usual process fifteen years later, and power looms were made so completely self-acting—so robotlike—that by 1900 they were commonly called just "automatics." Two or three score of them could be tended by a single person. Machine-made ready-to-wear clothes budded from factories in the '80's and blossomed in the '90's in the fashionable blouse and skirt, in the modish suit and two pairs of pants. Laundering was done by machinery from the '80's. By the later '90's machine-made boots were being extensively sold in standardized sizes and half-sizes. Pottery entered a new machine age when wheels became power-driven in the '70's, and the grinding of grain when, in the '80's, steel rollers superseded the traditional millstones.

If by the '90's one already ate machine-made food in machine-made dishes, wore machine-made clothes and shoes, wrote and calculated as well as sewed with machines, and shot off machine guns, one as certainly traveled and dispatched all manner of machine-made goods by steam engine or electric engine and was beginning to use the petrol engine for speeding over highways and soaring into the trackless heavens. Transportation was mechanized along with all other major industries, not least among which was agricultural industry.

Farm machinery evolved apace. The reaper and binder followed the mere reaper from America to Europe, ever faster after 1878. The cream separator was first exported from Sweden in 1879. Wire fencing was introduced in the '70's and barbed wire in the '80's. Glass "hothouses" became common. Chemical fertilizers were in universal demand. In the '70's "canning" of fruits and vegetables and "tinning" of meats grew into huge industries in America, in Australia, in Argentina. Many of the cans and tins came thither empty from European factories, and thence returned full to the machine-operating populace of Europe. Presently the freezing machine, which had been invented in England in 1867, was perfected, and mechanical refrigeration assured to Europe still bigger imports of foodstuffs.

Until the 1870's the agricultural prosperity of a country had pretty uniformly attended its mechanizing of industry and the concomitant growth of its factory towns. Mounting demand for farm produce had been mainly supplied from fields within national frontiers and by relatively short haul of canal boat, railway train, or coasting steamer, and this had meant rising prices and profits for farmers in industrial countries. In Britain, for example, where industrialization was earliest and most thorough, even the removal of tariffs on foreign imports had not offset the advantage which native farmers possessed of proximity to their home market, with the result that an agricultural boom continued from 1840 to 1874.

From 1874, however, British farmers were staggered by an astounding spread of grain growing in the United States and in Argentina, Canada and Australia, Russia and Rumania, and by a still more astounding expansion of speedy long-haul shipping, whereby the plentiful cheap grain of those hitherto distant countries came flooding into British cities and underselling British-grown grain. In the circumstances the grain area of England and Wales shrank from eight and a quarter million acres in 1871 to five and three quarters million in 1901; and the financial profits from what remained tended to disappear. For a time the decrease of grain growing was partially compensated for by an increase of pasturage and animal husbandry. But by the '90's, through the perfecting of refrigeration for long-distance shipments, British cities were obtaining the major part of their meat, as well as their grain, from overseas. Not even British dairy products, or the woolen staple of Britain, were proof longer against foreign competition. Great Britain was at last clearly dependent on the outside world not only for the bulk of raw materials for her factories but also for most of the food for her congested industrial population. Her agriculture, despite mechanical and chemical aids, had ceased to be economically profitable.

A similar crisis in agriculture threatened every other country of western and central Europe in the '70's and '80's, and for similar reasons. With transport costs little heavier between continents than they had previously been between provinces, only the bulkiest and most perishable farm produce remained outside the range of international competition—hay, garden vegetables, fresh milk, butter, eggs, etc. That the issue in Europe as a whole was less disastrous than in Britain must be attributed in part to a specialization in dairying and truck gardening which strategically situated countries like Denmark and the Netherlands sedulously fostered, and in part to artificial tariff dikes which other countries, notably Germany, France, Italy, and Austria, reared against the natural inflow of cheap competitive farm produce from Russia and overseas. Thanks to this essentially illiberal device—this revival of a supposedly discredited mercantilism—Germany, for instance, well maintained her acreage of grain crops, vineyards, fruits, and hops, added to her potato acreage, built up a magnificent sugar-beet industry, and increased the quantity and bettered the quality of her livestock. While Germany approached Britain in industrialization, she thus contrived, like France and Italy, to keep a large measure of agricultural self-sufficiency and prosperity. But the story of the neo-mercantilism which made this possible concerns physical machines less than political action: it belongs to a later chapter.

III. GROWTH OF MATERIAL WEALTH AND CORPORATE BUSINESS

Certain fables of ancient Phrygia assumed strange verisimilitude in a modern Europe otherwise most critical of myths. French revolutionaries had donned Phrygian "liberty caps," and the whole European generation from 1871 bade fair to exercise the "golden touch" of Phrygia's King Midas and to exercise it without embarrassing consequences. For from the spreading and speeding-up of prosaic mechanical manufacture and transport were derived fabulous accumulations of material wealth. Not only were there more things to eat and wear and enjoy, but there was much more money both to spend on them and to put back into the business of producing still greater quantities. Beyond multiplying sums expended by persons and governments on immediate necessities and luxuries, capital investments in profitable enterprise at home and abroad rose with a rush. These at least doubled within Great Britain and France and tripled within Germany, while the amounts of British capital invested abroad increased from four to twelve billion dollars, of French from two and a half to six billion, and of German from none to four.

In fact, the flow of profits from the live springs of mechanized industry into banking and other credit reservoirs, and thence through the pumping stations of corporate "promotion" to the nourishment of ever bigger and newer industrial plants, seemed itself to go on with mechanical precision and efficiency. The mechanics of capitalism had, of course, been provided with "scientific" bases and given practical application during the century prior to 1870. Afterwards it merely underwent a perfecting (and extension) like the mechanics of locomotion or mass production.

The most significant novelty in financial organization was the trend toward combination and monopoly. Previously the family business firm or small common-law partnership, with unlimited liability for all partners and full freedom for masterful personalities, had wrought the major industrialization. It was such "private" firms or partnerships which had developed mining, metallurgy, shipping, the textile and a host of other mechanized industries, and which actually continued long after 1870 to own and operate all over Europe a vast number of petty establishments for the manufacture of *articles de luxe* and likewise of plebeian commodities like shoes and wagons and beer. In Latin Europe, especially, small personal businesses remained the rule rather than the exception. In Germany as late as 1907 a third of the industrial workers were attached to establishments employing not more than five persons. In Britain the Cunard steamship line was a family affair until 1878, the Stephenson locomotive works until 1880, the Guinness brewery until 1886.

Already in 1871 joint-stock manufacturing companies (*societés anonymes, Aktiengesellschaften*) existed, though they were still rare and generally unimportant except in the field of public utilities. Presently, however, they emerged into prominence in response to the growing need for big long-term investments in railways, gas and electric works, insurance companies, banks, and a wide range of perfecting and expanding machine industry. The process was expedited by contemporaneous legislation of Liberal parliamentarians. A British act of 1862 authorized any seven persons to constitute themselves a company with limited liability by simply subscribing a memorandum of association; and similar easing of corporate creation was effected in France and Germany by acts of 1867 and 1870 respectively. As the jester of Victorian England put it:

> Some seven men form an Association
> (If possible, all Peers and Baronets).
> They start off with a public declaration
> To what extent they mean to pay their debts.
> That's called their Capital.[2]

When individual manufacturers were slow to take the initiative, a new species of "promoters," perceiving a golden opportunity, appeared on the scene and through their persuasive powers (heightened by "promoting fees") succeeded in convincing the manufacturers that combination through limited-liability corporations would be to their advantage. Concurrently, moreover, the growing familiarity with stock exchanges, the increasing facilities for underwriting loans and selling stocks and bonds, the expansion of financial columns in the press, the accumulation of spare funds in the pockets of the middle class and in the tills of insurance companies and savings banks, the widespread formation of investing and speculating habits, all contributed to make the promoters' role pleasant and profitable and to endow the trend toward impersonal and large-scale business corporation with the appearance of a supreme and most beneficent law of nature.

The new type of business corporation dispersed nominal ownership and centralized actual control. It enabled a few directors and officials to enrich themselves on other peoples' money and to become irresponsible "captains of industry," tsars of paper-credit empires. At the same time it imparted to a mass of investors a blissful ignorance of sordid details and a heavenly manna of bond interest and stock dividends. It also promoted monopoly. For the corporation was big and rich compared with most individual and family enterprises, and the big fellow might buy up the little fellow, or, still more simply, might crush him in free and open competition.

By the 1880's industrial and financial combination was striding over the industrial world. It took somewhat different forms and names in various countries: in Britain, for example, the joint-stock merger, with "Ltd." written after it; in America, the "trust" or

[2] W. S. Gilbert, "Utopia Limited," *Plays and Poems* (1935 ed.), 620.

"holding corporation"; in Germany, the "cartel," an arrangement among major companies for limiting competition. Everywhere the cartels or trusts or mergers were extending to banks,[3] department stores, oil and sugar refineries, whisky distilleries, steamship lines, electrical, chemical, and metallurgical industries. Nor was such combination confined within national frontiers. In 1883 a market-sharing agreement was arranged among the steel companies of Britain, Germany, and Belgium, and, though itself short-lived, it led to other and more successful experiments in treaty making by bankers and industrialists and in the rationing of producers. International shipping "rings" fixed freights and fares and rebates. Domestic manufacturers of firearms and war munitions, the Armstrongs, the Krupps, the Creusots, etc., shared foreign markets with skill and a fine disregard of the narrow chauvinism they sometimes exhibited at home. In 1886 the enlightened Nobel established the first international trust—the Dynamite Trust, Ltd.—with subsidiary monopolistic companies in Sweden, Germany, Britain, France, and the United States. In the '90's the sewing-cotton firm of J. & P. Coats, Ltd., by amalgamating rival British firms and then others on the Continent and in America, created a virtual world monopoly.

The Midas touch of big business was truly golden. Profits flowed from machinery (and monopoly) as never before, and the profits were now reckoned almost universally in gold currency. Until 1870 only Great Britain had based her currency exclusively and unswervingly on gold. In France and her associates of the Latin Monetary Union bimetallism had prevailed, and in central and eastern Europe silver alone. But thereafter, one country after another emulated Britain in adopting the single gold standard: the German Empire in 1871, Scandinavia in 1872, the Netherlands and the United States in 1873, Austria-Hungary and Russia soon after, France and the other Latin nations in 1878. Only very "backward" and out-of-the-way countries such as China, Mexico, and Ethiopia clung to silver.

Yet the actual supply of gold lagged seriously behind the rapidly increasing demand for it; and this shortage of the precious metal

[3] In Britain alone, there were over a hundred banking amalgamations in the decade of the '90's.

served, in conjunction with technological improvements in industry and agriculture, to lower the general price level of commodities. In fact, from the financial "panic" of 1873, the movement of prices was steadily downward. The nadir was reached in the early '90's. By this time the continuing universal demand for gold was far outstripping its supply, with the consequences that money was extraordinarily dear and that, while creditors and traders profited, the debtor and farming classes faced ruin. Hence ensued another peculiarly painful depression and, especially in Germany and the United States, a popular agitation for bimetallism and the cheap money which it would provide. Only the development of a new process for more productive utilization of gold ores[4] and the opening up of rich new gold fields in South Africa at the close of the '90's stilled the complaints of the farmer and the pleas of the bimetallist.

Nevertheless, with the exception of "hard times" in 1873-1876 and again in 1893-1896—which were explained by professional economists as natural cyclical disturbances—the materialist generation from 1870 to 1900 could view with optimistic satisfaction a steady access of wealth, of corporate business enterprise, of material well-being, and of that precious golden metal by which all things were measured and treasured.

IV. GROWTH OF URBAN POPULATION AND THE GREAT MIGRATIONS

Never had there been a century so prolific as the nineteenth, and the climax came in its last three decades. The population of Europe, which had grown by 11 per cent during the twenty years prior to 1870, increased during the next thirty years by almost 32 per cent. The birth rate, it is true, began to decline after reaching its recorded maximum in the '70's, but the death rate declined faster, and the mounting surplus was hailed as a normal and presumably constant accompaniment of material progress. In 1900 a quarter of the human race dwelt in Europe, the smallest of the five major continents, though the one most thoroughly industrialized. There were now ten Europeans for every four a century previously. Only Frenchmen failed to do their proper share of procreating (they

[4] The "cyanide process," patented in 1890 by MacArthur and Forrest.

added barely 600,000 a decade), but since the Franco-Prussian War their decadence was common knowledge. Between 1870 and 1900 the population of England rose from 22½ to 32½ million; of Austria-Hungary, from 20 to 26; of Italy from 26 to 32½; of Germany, from 40 to 56; of European Russia, from 74 to 105.

This remarkable increase of population throughout Europe redounded almost entirely to the growth of cities. While the birth rate remained as high in rural as in urban areas, a stationary or even dwindling number of people in the former sufficed, with the aid of agricultural machinery and foreign imports, to feed ever larger aggregations in the latter, and the excess of country-born persons naturally sought and usually found employment in manufacturing, commercial, or mining towns. Hence to the normal increment of cities was added an abnormally large migration from the countryside. Already in the '70's the major part of the British nation was street-bred; and London streets were England to nearly one Englishman in seven. On the Continent, where industrialization had been more belated, urban growth after 1871 was still more rapid. In Germany, for example, there were only eight cities of over 100,000 inhabitants in 1870, whereas in 1900 there were forty-one, of which eleven had over 250,000 inhabitants, and five had over half a million. Altogether the increase of Germany's urban population equaled the increase of her whole population during the era. Even in relatively backward European Russia, the number of cities with over 100,000 inhabitants grew from six in 1870 to seventeen in 1900, the population of Warsaw increasing by half a million, of St. Petersburg and Moscow by 400,000, of Odessa and Lodz by 300,000, of Riga by 200,000. Only France, of the major European countries, made no addition to the number of its large towns, although one of these, the capital city of Paris, registered a gain of over 800,000 inhabitants—almost half the increment of all France.

Not merely a better chance of gainful employment beckoned mass migration from country to city. The city was becoming peculiarly attractive as a habitation. By the middle of the '80's it was apt to be more healthful than the country and to afford greater opportunities for recreation. Its water was being made abundant and pure, and its scavenging, paving, lighting, and sewerage reasonably good. Slums and dingy tenement houses there still were, but there also were schools and libraries, parks and playgrounds, a variety of free amusements, and a profusion of cheap beer gardens, *brasseries*, or "pubs."

In vain professional uplifters among well-to-do and well-fed bourgeois urged on their poorer neighbors a "return to the land." No matter how poor these might be, they were held to the city as by a spell, and no migration from town to country offset that from country to town.

European migration, a prime and ubiquitous feature of the decades following 1870, was not confined within national frontiers or to Europe itself. Into England, chiefly into London, filtered a stream of Germans, Poles, and Jews, and a still bigger stream of Irish. Into Germany, especially into the industrial towns of Westphalia and the Lower Rhine, moved some 200,000 Poles. Into France came thousands of casual laborers from Italy, Spain, and Belgium. Every metropolis took on a more pronounced cosmopolitan character.

From almost every European nation, moreover, went forth across the seas to the ultimate frontiers of Europe, principally the American continents, a migration without parallel in the history of the globe. The early barbarian migrations into the Roman Empire were puny in comparison with this, and they had lasted for three centuries. Now, within three decades, at least twenty-five million Europeans—men, women, and children, with their lares and penates—took passage on ocean liners for new homes over 3,000 miles from natal soil. The large majority of these emigrants were peasants from rural regions of Europe, but most of them tended to settle in the cities, rather than on the farms, of the New World. Thus it befell that the migration of the era contributed to urban growth not only in Europe itself but still more notably in the Europeanized portions of the world outside—in the United States, in Argentina and Brazil, in Australasia.

Neither religious persecution nor political oppression was an important factor in stimulating this latest and climactic mass-migration. Outbreaks of anti-Semitism in Russia and Rumania doubtless speeded up Jewish emigration from those countries to England and Germany and more largely to the United States; and a desire to escape military conscription probably accounted for some of the emigration from Italy and Austria-Hungary. Yet the main motivation everywhere was economic. The depression of European agriculture, a common phenomenon of the period, served to unsettle multitudes of peasants in Ireland, Scandinavia, Spain, Italy, and Slavic lands; and the high-pressure salesmanship of steamship companies, together with reassuring news and remittances from relatives and friends who had previously emigrated, pointed such peasants—and likewise some of the floating population of European cities—toward New York or Boston, Rio or Buenos Aires, Montreal or Melbourne. Generally speaking, European emigration was greatest when economic conditions were relatively bad in Europe and good in America—in the early '70's, the middle '80's, and the end of the '90's. It fell off most sharply in the early '90's, when crises and depressions beset countries of both hemispheres.

During the era occurred a notable shift in the proportionate number of oversea emigrants from the several countries of Europe. Ireland continued to lead all the others in the percentage of emigrants, but Norway dropped from second place in 1871 to fifth place in 1901, Germany from fifth to twelfth, Spain from sixth to fifteenth, and England from eighth to sixteenth. On the other hand, Italy climbed from eleventh into second place, Poland from sixteenth into third, and Russia from thirteenth into seventh. In this respect, too, France was unique: she was the only European country where immigration constantly exceeded emigration.

If it is borne in mind that the 25 million who left Europe between 1871 and 1900 were additional to the almost 100 million by which population within Europe increased during the era, and further that the population of the European overseas "frontier" in the Americas and Australasia simultaneously rose by 60 million, the "expansion of Europe" ceases to be an idle phrase and becomes a basic literal fact—one of the most significant facts of the Generation of Materialism.

V. MEDICAL PROGRESS AND PUBLIC HEALTH

The stupendous growth of European population in the last third of the nineteenth century resulted less from an increase of the birth rate than from a decrease of the death rate, and this in turn was a consequence of fructifying progress in medical science combined with an extraordinary solicitude for public health. What centrally characterized medical progress during the period was the refinement and application of the discoveries which the chemist Louis Pasteur had made by microscopic research in the '60's as to the role of microbes in the twin processes of fermentation and putrefaction. Microbes, he had showed, were a prime cause of disease, indeed they were enemy number one of human health and happiness; and the clearly posed problem was how to fight and conquer them.

A method of destroying microbes, or overcoming their evil effects, in wounds and abscesses, and in surgical cases generally, by the use of carbolic acid, was announced by Joseph Lister in 1867.[5] It was subsequently improved, and antisepsis was replaced by asepsis, but Lister's work began a veritable revolution in surgery and led incidentally to a notable diminution of deaths in childbearing and to a widespread reform of hospitalization. A grateful British government honored Lister with a baronetcy in 1883 and a peerage in 1897.

The relationship of microbes to cellular pathology and their breeding in sewage and sewage-polluted water and milk were the particular concern of Rudolf Virchow, a scientist of great energy and many interests. Physician with a large practice, professor and popular lecturer in the University of Berlin, and withal a leading Liberal member of the Reichstag, he yet found time to provide the German capital with a scientific sewage system and a pure water supply. Virchow was thus a pioneer in a new sanitation, and his attack on microbes at their source, so to speak, was speedily extended by others throughout Europe (and America).

The tracing of particular diseases to particular microbes and the

[5] Lister's discovery of antisepsis had been anticipated by the Hungarian Ignaz Semmelweiss, whose achievement, however, had been neglected by the rest of Europe much as Mendel's was.

preparation of specific vaccines and antitoxins for coping with them became the crowning lifework of Pasteur himself and of a younger German disciple of his, Robert Koch, professor of hygiene and bacteriology at Berlin. In 1876 Koch obtained a culture of the anthrax microbe (or bacillus). In 1882 he announced the discovery of the bacillus of tuberculosis, and in 1883 that of cholera. In 1885 Pasteur began the practice of inoculation for hydrophobia.

Bacteriology emerged as a full-fledged science, theoretical not only, but highly practical; and from a host of newly established research centers, including the Pasteur Institute at Paris, Lister's Institute of Preventive Medicine at London, Koch's Institute for Infectious Diseases and Virchow's Institute of Pathology at Berlin, came a rapid succession of brilliant discoveries. Germs were detected of leprosy, malaria, pneumonia, tetanus, erysipelas, typhoid, influenza, and bubonic plague; and against some of them means of immunizing were found. By the end of the century such scourges as cholera, plague, and typhoid were disappearing from the European world, and progress was being made in the control of diphtheria.

Knowledge of bacteriology, asepsis, and inoculation might have remained the *esoterica* of scientists, had its utility not been appreciated by a multitude of laymen and its application been enforced by governments. Under the newer industrialism, with its impetus to mass migration, mass working, and mass living, individual health was becoming a cardinal object of public concern. Epidemics were more serious in large than in small communities, among a mobile population than among a stationary one; and disease was a major economic burden to employer and employee alike and ultimately to the commonwealth. Hence the knowledge that many kinds of disease were caused by microbes and that these could be overcome by simple scientific procedures was acclaimed by the public and acted upon by state authorities. Even Liberal regimes did not cavil about violating the sacred precepts of *laissez faire* and invoking the most stringent police powers in the cause of public health.

Until 1900 the public-health movement had to do chiefly with environmental factors, with germs of disease and conditions which might favor their spread; and its mode of action was mainly through state and local health officials empowered by law to exercise drastic control of water supplies and waste disposal, of milk, meat, and markets, of sanitary conditions in schools, shops, and hospitals, and to vaccinate individuals against specific diseases. The next step in public health—the educating of the masses in positive health practices—was to come after 1900, and then there would be a sharp decline in death rates, especially in infant mortality. But the way for this was already paved. The death toll of infectious diseases was being lessened and the span of life lengthened.

VI. MECHANISTIC NATURAL SCIENCE

The cosmos, a popularizer of science concluded shortly after 1900, is "simply a machine, so orderly and compact, so simple in construction, that we may reckon its past and gauge something of its future with almost as much certitude as that of a dynamo or a water-wheel. In its motions there is no uncertainty, no mystery."[6] Such a conclusion seemed to be inescapably drawn from the then known facts of physics and chemistry and quite consonant with the best informed and most prevalent thought about them.

Since the days of Galileo and Newton, scientific knowledge had been piling up and pointing ever more clearly to the material nature and mechanical operation of the whole physical universe. Matter was conceived of, in a common-sense way, as something substantial and eternal, something that could be accurately weighed and measured, something too which functioned mechanically through an iron interplay of cause and effect. Toward confirming this conception and stimulating the search for still more facts in support of it, the mechanical industrialization of the nineteenth century contributed immensely.

By 1870 the steam engine had already given rise to the physical science of thermodynamics with its epochal twin laws of the conservation and the degradation of energy. By this date, moreover, the kinetic theory of gases was formulated, the wave theory of heat and light established, the atomic theory of the structure of matter capped by Mendeléyev's periodic law, and a new means found in

[6] Carl Snyder, *The World Machine*

spectrum analysis of identifying matter in the heavens with matter on earth.

Along all these lines much confirmatory progress was made during the next thirty years. By help of Mendeléyev's law, for example, new chemical elements were discovered: gallium in 1871, scandium in 1879, germanium in 1886. Helium, also, which by aid of the spectroscope Lockyer had detected in the sun in 1868, was found in 1895 by Ramsay in the earth in the mineral cleveite. Obviously the whole universe was constructed of the same material elements.

Furthermore, it was disclosed in the '80's by the Dutch physicist van't Hoff that the osmotic pressure of chemical solutions conforms with the principles of thermodynamics governing gas pressure, and by Arrhenius, a Swede, that it is likewise connected with the electrical properties of solutions. These disclosures were the cornerstone of a vast superstructure of physical chemistry, in which thermodynamics and electrical science were combined in ever-extending theoretical knowledge and practical industrial applications.

Probably the most novel scientific achievement of the last third of the nineteenth century, theoretical as well as practical, was in the domain of electrical phenomena, and certainly in generalizations about natural science the dynamo supplanted the steam engine as the favorite metaphor. In 1873 appeared Clerk Maxwell's great treatise on *Electricity and Magnetism*, a classic attempt to make the known facts of electricity fit the then generally accepted pattern of mechanics. It maintained the theory that electricity is matter moving in waves like those of light and radiant heat.

Toward the end of the century two new events of far-reaching importance occurred in electrical science. One was the promulgation of the electron theory. As far back as 1756 Benjamin Franklin had spoken casually of electrical "particles" and in the 1830's Faraday had based some interesting experiments on an atomic theory of electricity, but the significance of all this was long unperceived. Now, however, Joseph Thomson, working in his celebrated research laboratory at Cambridge on the conduction of electricity through gases, reached the certain conclusion that electricity is composed of particles (to which he gave the Newtonian name of "corpuscles") and demonstrated that these were constituent parts of atoms. Simultaneously Hendrik Lorentz, a Dutch physicist, pursuing a different line of research, arrived at much the same conclusion, except that, while Thomson explained electricity in terms of matter, Lorentz expressed matter in terms of electricity and named the particles "electrons"—a name which prevailed over Thomson's "corpuscles." At any rate the converging investigations of these two eminent physicists solved the problem—old as the Greeks—whether different kinds of matter have a common basis. The answer at last was an unqualified "yes."

The other event was the discovery of radio activity. It began with a German physicist, Wilhelm Röntgen, who accidentally stumbled upon X rays in 1895. The next year Henri Becquerel, professor at the Polytechnic in Paris, found radio-active properties in uranium, and at the turn of the century Pierre Curie and his equally gifted Polish wife managed to extract radium from pitchblende. Knowledge of X rays was immediately serviceable in experiments which confirmed the electron theory and also, most practically, in medicine and surgery.

The edifice of physical science as built up laboriously and continuously throughout three centuries appeared at the end of the nineteenth quite secure and well-nigh complete. In the future little would remain to be done, it was imagined, beyond measuring physical constants to the increased accuracy represented by another decimal place, investigating a bit more the mechanics of electrons, and resolving some recent doubts about the ether. The electron theory of Lorentz and Thomson assumed that the electrical particles moved within an atom in accordance with Newtonian dynamics and that the atom was like a solar system in miniature, with electrons revolving within it as planets swing around the sun. Further investigation, it was predicted, would prove this assumption—though the next generation of physicists learned with shock that it didn't.

The doubts about ether were already bothersome. Ether had been postulated as an intangible something filling all space, and it was very convenient to nineteenth-century physicists. It provided for a medium through which waves of heat, light, and electricity could undulate, like sea waves through water. It also validated the Newtonian conception of absolute motion, always and everywhere the same, for inasmuch as all stars were moving in the ether their motion could be considered as absolute by reference to it, just as a bird's motion can be referred to the air through which it flies. Unfortunately for the certitudes of physical science, a delicate experiment of two Americans, Michelson and Morley, in 1887 showed that motion through the "ether," and indeed the ether itself, could not be detected empirically. It thus discredited the whole ether hypothesis. Again and again the Michelson-Morley experiment was repeated in the hope that it might turn out differently. Only the generation of scientists after 1900 could bring themselves to do without "ether," and then Einstein would formulate his new doctrine of relativity.

VII. DETERMINISTIC BIOLOGICAL SCIENCE

To older and sustained interest in physics and chemistry, the latter part of the nineteenth century added a new and surpassing interest in biology. Just as physical science inspired confidence in its mechanistic and materialistic assumptions by reason of its practical contributions to technology, industry, and material wealth, so biological science, by its promise of promoting human health and happiness and raising up a superior race, obtained a most respectful hearing for its deterministic theories. In a period when, incredible as it may appear, health was even more eagerly sought after than wealth, the novelties of biology naturally attracted more attention than the somewhat staid and prosaic course of physics.

Biological investigation during the period followed two main lines which rarely converged. One was biochemical, physiological and microscopic, leading to a big access of precise knowledge about embryology, cellular structure of living organisms, pathology, and bacteriology. This was the province of such biologists as Pasteur, Virchow, and Koch, whose revolutionary achievements in medical science, particularly in the detection and prevention of germ diseases, have already been sketched.

This line of research carried into problems of heredity. In 1839

ore Schwann had formulated a "cellular" theory, that all
hings orig.nate and grow in very small structural units, or
and shortly afterwards other physiologists had recognized
stence within these cells of vital material to which was as-
the suggestive name of "protoplasm." Then in the 1870's
: Weismann, professor at Freiburg, distinguished between
:y bodily (or somatic) cells, which die with the individual,
:productive (or germ) cells, which transmit a continuous
of protoplasm from generation to generation and are poten-
mmortal. Weismann reasoned further in the '80's that inas-
as hereditary characters can be transmitted only through germ
all acquired characters, which are variations occurring in
c cells, cannot be inherited.

he same time it was well known, at least to practical garden-
.d farmers, that new varieties of plants and animals could
ate in "sports" and be maintained by cross-fertilization and
on, and the article on "Horticulture" in the ninth edition of
ncyclopædia Britannica (1881) noted the fact: "An inferior
y of pear may suddenly produce a short bearing fruit of su-
quality; a beech tree, without obvious cause, a shoot with
divided foliage; or a camellia an unwontedly fine flower.
ı removed from the plant and treated as cuttings or grafts, such
; may be perpetuated. Many garden varieties of flowers and
have thus originated."

t none then knew outside a corner of Bohemia that an Augus-
ı monk, Gregor Mendel, had discovered the hereditary princi-
y means of which "sports" could be bred scientifically. Already
.e '60's Mendel had conducted in the garden of his cloister a
; of ingenious experiments with the crossbreeding of peas and
reached the conclusion that in the germ cells are determinants
articular characters, which, when transmitted, become "domi-
" or "recessive" according to fixed mathematical laws. But this
nant conclusion, which confirmed and refined the deterministic
ılar theory of Weismann and likewise explained the phenomena
ariation and mutation, was buried away for thirty years in dust-
.ering tomes of a local scientific society. Not until its resurrec-
by De Vries and Bateson at the beginning of the twentieth

century did Mendelianism come into its own and make of heredity an exact experimental and industrial science.

In the meantime most biologists pursued another and quite different line of investigation, the one opened up by Darwin and leading to emphasis on environment. As we remarked in the first chapter, the distinctively Darwinian doctrine of natural selection attained a great vogue in the early '70's, partly because of its simplicity and seeming applicability to a wide range of human interests, and partly because of its concurrence with a high tide of industrial and military competition. The vogue remained throughout the era and gave continuing direction to a vast deal of inquiry, not only in biology but in psychology and the so-called social sciences. And the further the inquiry was carried, the more the results verified, or seemed to verify, the Darwinian thesis. Biologists themselves, with the help of anatomists and geologists, accumulated such a mass of confirmatory evidence as to leave no doubt in the mind of any well-informed person that all life was essentially one and that it had been differentiated into multitudinous species of plants, insects, reptiles, fishes, birds, and mammals by a perfectly natural evolutionary process.

Darwin himself did not regard natural selection as a complete explanation of the evolutionary process. He had buttressed it with Lamarck's hypothesis of the inheritance of acquired characters, and had still recognized its basic shortcoming. It explained why variations survived or failed to survive, but not how the variations actually occurred. Nevertheless his own early interest in a study of heredity which might meet this difficulty and his sympathetic attitude toward the first endeavors of Weismann were largely abandoned by his disciples. These (and Darwin too in his last years) engaged in most unedifying controversy with Weismann over the inheritance of acquired characters, and in total ignorance of Mendel and his work they went gaily on their way, brushing aside the specialists in heredity as though they were mosquitoes, and blithely assuming that natural selection was the proved and adequate cause of evolution and the origin of species.

Before long, of course, almost all biologists came to agree with Weismann in rejecting the inheritance of acquired characters, but not so a large number of evolutionary philosophers and sociologists. Herbert Spencer to the end of his days carried on bitter controversy with Weismann, and many others clung stubbornly to what they regarded as the chief prop of Darwinism and the surest pledge of human progress. And the Darwinian school that accepted the Weismann amendment only concentrated the harder on natural selection. By natural selection alone Haeckel in 1898 evolved the whole human race in twenty-six stages from chunks of carbon through simple structureless bits of protoplasm and on through the chimpanzee and the *pithecanthropus erectus*.[7] The physicist Helmholtz, under the spell of Darwinism, suggested that all life on earth might have evolved from a few germs brought hither from distant worlds in the interstices of meteoric stones. And Darwinian social scientists imagined even greater marvels.

An essential feature of Darwinism was its idea that external circumstances rigidly determine the nature of living creatures, including man himself; that environment is more significant than heredity; that neither human reason nor human will can act independently of its fateful past conditioning. Natural selection was a blind and brute process, operating under inexorable laws of its own and assuring existence and development only to such forms of life as were adapted to their physical milieu and enabled to survive the fierce and constant struggle waged against them from outside. Francis Galton, it is true, based his special science of eugenics on the supposition that intelligence or the lack of it is an hereditary quality, but his notion of heredity was more in keeping with the reasoning of his cousin Darwin than with the discoveries of Weismann and Mendel.

The vogue of Darwinism synchronized, we must recall, with the ascendancy of mechanical and material conceptions in physics and chemistry, and the one colored the other. To evolving life were applied the principles of the conservation of matter and energy, and this fed the belief that all the various activities of living organisms would presently be disclosed as mere modes of atomic motion and manifestations of mechanical or chemical energy. Already some

[7] This amusing family tree was presented quite seriously by Haeckel to the International Zoölogical Congress at Cambridge on August 26, 1898.

progress toward this end was being made in physiology. Physical activities of the body were traced to the chemical and thermal energy of the food taken into it. Phenomena of nervous action were found to be accompanied by electrical changes. The variety of idiocy known as cretinism was proved to be due to the failure of the thyroid gland.

Here and there a scientist or philosopher raised his voice in criticism of the prevalent trend, declaring that even if the problems of life were reduced to those of physics and chemistry the concepts of matter and force were but abstractions without ultimate explanation. Ultimates, it was said, could not be arrived at by methods of experimental science, whether physical or biological.[8] But voices of dissent were pretty effectually drowned in the wave of materialistic and deterministic certitude induced by the coalescence of Darwinian biology with physics, and the high-water mark was reached in 1899 with Haeckel's dogmatic book of revelations,[9] according to which life is but a form of matter and the highest faculties of the human mind but properties of brain cells evolved automatically from unicellular protozoa and thence spontaneously from inorganic compounds. Though direct evidence for this conclusion was unluckily lacking, it was widely accepted on faith, proving that even with scientists, or at any rate pseudo-scientists, faith may transcend knowledge. And as a hopeful addendum to Haeckel's faith, a publicist could prophesy that "in forty or fifty years" laboratory technicians might be manufacturing from inorganic materials "endless varieties [of life] as readily as they do new chemical varieties of sugar now."[10]

VIII. PHYSIOLOGICAL PSYCHOLOGY

The rise of "scientific" psychology with its laboratory methods was a conspicuous feature of the era of materialism, a whirling eddy

[8] Such *caveats* were expressed, for example, by the brothers du Bois-Reymond, Emil in *Über die Grenzen des Naturerkennens* (1872), and Paul in *Über die Grundlagen der Erkenntniss in den exacten Wissenschaften* (1890). Cf. Ernst Mach, *Die Mechanik in ihrer Entwickelung* (1883); R. H. Lotze, *Mikrokosmus*, 3rd ed., 3 vols. (1876-1880); A. J. (Earl) Balfour, *A Defense of Philosophic Doubt* (1879); J. S. Haldane, *Essays in Philosophical Criticism* (1883); J. B. Stallo, *The Concepts and Theories of Modern Physics* (1888); F. A. Lange, *The History of Materialism*, 3 vols. (1873-1875).

[9] *Die Weltratsel*, Eng. trans. as *The Riddle of the Universe* (1900).

[10] Carl Snyder, *op. cit.*, p. 440.

in the merging streams of biology and physics. Its spirit, if one may so denote a very material thing, had been neatly prefigured by a German physician before 1871: "Just as a steam engine produces motion, so the intricate organic complex of force-bearing substances in an animal organism produces a total sum of certain effects which, when bound together in a unity, are called by us mind, soul, thought."[11] But its true foster father was another German physician, Wilhelm Wundt.

While professor at Heidelberg in 1863 Wundt had published some famous preliminary studies on the "human and animal soul." Then in 1874 appeared his *Foundations of Physiological Psychology*, the first monumental exposition of the physical bases of thought and behavior and of the affinity of human minds to those of the lower animals. Called the next year to the University of Leipzig, Wundt opened there his celebrated psychological laboratory, in which knowledge of human behavior was deduced from experiments on cats and dogs, rabbits and mice, and in which, too, a generation of younger men from all over Europe (and America) were inspired and equipped, when they returned home, to start similar laboratories and to conduct similar experiments.

Laboratory investigation of man's "animal mind" and of consciousness as a phase of physical activity yielded a considerable offspring, and the leading accoucheurs, appropriately enough, were medical men. Thus, an Italian physician, Cesare Lombroso, professor at Turin, won fame by his delivery of the "psychology of criminology." Criminals, it seemed, were born, not made. They were a special type of human animal whom evolutionary processes of degeneration and atavism had endowed with peculiar physical features[12] and necessarily therefore with peculiar behavior; they were not morally responsible for their acts. Subsequently, from quite a different slant, Sigmund Freud was to tackle the whole problem of psychological abnormality, and his fame would outstrip Lombroso's.

Meanwhile, in the early '90's, another physician, the Russian

[11] Ludwig Büchner, *Kraft und Stoff*, 10th ed. (1869), 147.

[12] You could recognize a criminal when you saw him by his "ape-like agility, projecting ears, thick head-hair and thin beard, square and protruding chin, large cheek bones, and frequent gesticulation."

Ivan Pavlov, following more closely in Wundt's footsteps, began a notable career by making detailed observation of animals and humans in terms of external physical stimuli and reactions and embodying the results in a system of "conditional reflexes." This, later described as behaviorism, fortified the notion that man's mind, no less than his body, consisted of matter and was governed machine-like by physical laws.

Also in the early '90's a French student of natural science and medicine, Alfred Binet, undertook in his psychological laboratory at the Sorbonne to construct simple tests for the gauging of intelligence and to correlate the mental differences thus disclosed with physical differences of head measurement and skin sensitivity. Although the search for such a correlation proved remarkably elusive and was eventually abandoned, Binet's work on intelligence tests prepared the ground, after the turn of the century, for a luxuriant crop of educational psychologists, including, as tares among the wheat, no small number of charlatans.

Still another and more "philosophical" product of the age was pragmatism. Its chief spokesman was an American trained in medicine in Germany, William James, who passed in 1875 from the chair of physiology at Harvard to that of psychology. James rebelled against the mechanical and fatalistic presuppositions of his contemporaries and yet distrusted reason and felt scant sympathy for earlier "idealism" or any system of absolutes. He viewed the world we live in as a world of change and chance, variety and variation, chaos and novelty. Every human trait, he held, operates as an instrument in the individual's struggle to live, and each is validated or invalidated by its effects upon the struggle. Such a pragmatic attitude fitted nicely into the mood of the age. It enabled one to scoff politely at logic and orthodox philosophy, and at the same time to entertain the hope that through trial and error and adaptation an irrational and purely material world could continue to progress. There was, of course, no absolute morality; but what "worked" was good and what didn't was bad. The proof of the pudding was in the eating. To a generation which began with Prussia's defeat of France and ended with Britain's triumph over the Boers and witnessed in the interval a steady advance of science and technology, the gospel of pragmatism was peculiarly attractive.

IX. POSITIVISM AND THE SOCIAL SCIENCES

Positivism was likewise attractive. Auguste Comte had died more than a decade before 1870, but his works lived after him. There were so many things in his positivist philosophy to appeal to the ensuing generation. It was like James's pragmatism in that it enshrined evolutionary conceptions, eschewed all ultimate explanations, whether "theological" or "metaphysical," and concentrated upon scientific fact-finding. Furthermore it exalted social science, that is, sociology, as queen of the sciences, just when industrialism was begetting mass movements and new social problems, and it ascribed to social science the same exact methods and the same fruitful principles as those characterizing physical science; in fact sociology was "social physics." Besides, Comte had imbued his scientific precepts with a rosy coloring of optimism and a faint aroma of benevolence which titillated a generation still distant from the World War. Humanity was to him and to his immediate disciples a mystical as well as a positivist phenomenon, not alone the subject of meticulous research but the object of religious worship, a substitute, as it were, for the Christian God. The highest service which could be rendered to humanity was the "good works" of collecting all possible facts about it and letting them speak for themselves, and this service its high priests, the research professors, would perform to the ever greater glory and progress of mankind.

Probably the number of persons who conned Comte's *Positive Philosophy* between 1870 and 1900 and fully absorbed it was but a fraction of the host of social scientists who emerged in those years. But consciously or unconsciously almost all of these—sociologists, economists, statisticians, political scientists, historians, anthropologists, archaeologists—were conditioned by the climate of positivism and adapted, as by a process of natural selection, to the pursuit of its method and its goal.

Sociological studies, multiplying after 1871, were of two main kinds. One was the synthesizing of data of history, economics, and politics with data of natural science and physiological psychology into generalized statements of the "laws" and "trends" presumably governing the behavior and evolution of human society. This was represented most elaborately by the three volumes of Spencer's *Principles of Sociology* (1877-1896), in which the opinionated author treated of society as an evolving organism, of religion as stemming from the worship of ancestral ghosts, and of the struggle for existence as evidenced by a constant natural antagonism between nutrition and reproduction and between the productiveness of industry and the waste of militarism. The other kind was the analysis, through detailed "field" investigation, of the existing status of particular social classes or groups. This was the aim of Le Play's notable studies, over a score of years, of family life in France and elsewhere throughout Europe, and likewise of numerous social surveys of urban centers, especially of their poorer population. The most monumental of these was the inquest into the "life and labor of the people in London," directed and financed by Charles Booth, a British capitalist and philanthropist, and reported *in extenso*, with maps and charts, by his staff of "experts," first in three volumes (1889-1891) and later in eighteen (1903).

Sociological viewpoints and methods were increasingly adopted by specialists in allied fields. Historians, for example, concerned themselves less with individual biography and political narrative, and more with social movements, with the evolution of social forces and social institutions. Political scientists, too, were moved to stress the practical rather than the theoretical aspects of government and to deal not so much with its structure as with its historic functioning in and on society at large. Economists also turned from *a priori* reasoning and the abstractions of the earlier classical school, either, as in Germany, to concrete study of the setting of economic problems in history and national society, or, as in Austria and England, to an appraisement of economic phenomena in terms of mathematical and physical science. Thus, while Gustav Schmoller and Adolf Wagner preached a kind of national socialism from their academic chairs at Berlin, Jevons, the leading English economist, demonstrated at least to his own satisfaction a correlation between commercial crises and sun spots.

A special importance attached after 1870 to statisticians, in part because of their indispensability to expanding business corporations and improving governmental censuses, in part because of their helpfulness to sociologists, mathematical economists, and social historians, and in part, also, because of the scientific airs they assumed. They claimed that the statistical method was the "exact" method of social science; nay more, that their method was science itself. As the foremost of them, Georg von Mayr, said: "Statistical science is the systematical statement and explanation of actual events, and of the laws of man's social life that may be deduced from these, on the basis of the quantitative observation of mathematical aggregates."

In emulation of physical and biological science and under the influence of positivism, vast masses of factual data were collected and published about man's present and past occupations and activities, about his social life, about his economic life, about his political life, about his cultural life. Never before had there been such an outpouring of doctoral dissertations, such a profusion of "scientific" monographs, such a proliferation of co-operative research and publication. Nor had there ever been such implicit faith in the social scientist's ability, by a mere marshaling of reported facts and figures, to discover the true inwardness as well as the whole outwardness of man and of human society.

The most original and reassuring contributions came from anthropologists and archaeologists about man's extraordinarily long history and his gradual ascent from savagery to civilization. A few specimens of what Boucher de Perthes called "ante-diluvian men" had been unearthed just prior to 1870. Afterwards many more were dug up, together with sufficient geological and archaeological evidence to indicate that they must have lived at a time long antedating Noah and his flood-riding ark. As excavating went feverishly on, the duration of man's "prehistoric" past rapidly lengthened. In the '80's it certainly reached to a "neolithic age," perhaps to a "palaeolithic age," anywhere from 20,000 to 100,000 years back. In the '90's the discovery of a few strange bones in faraway Java and the reconstruction from them of the singular *pithecanthropus erectus* pointed to the existence of evolving man half a million years ago and spurred on the search for still earlier creatures, half-human and half-apish, that must have climbed out of ancestral trees and laboriously learned to make fist hatchets.

Simultaneously archaeologists were re-examining the ancient classical foundations of European civilization. Schliemann, that German-American adventurer in high finance and deep digging, settled in Greece in 1868, and during the next score of years uncovered and identified the site of legendary Troy and unearthed at Mycenae and Tiryns ample proof of a civilization far antedating that of the historic Greeks. By the end of the century, thanks to the efforts of Schliemann and of many other and abler (if less self-advertised) archaeologists, it was possible to trace the history of the Aegean lands, Egypt, and Mesopotamia back several thousand years B.C.

Anthropologists, too, were exceedingly busy. Some, the "physical" group, were indefatigable in measuring skull shapes and other anatomical features of the quick and the dead and utilizing the results to classify the "races" of mankind. True, there were almost as many classifications as there were classifiers. But any such confusion failed to arrest the growing faith that there must be different races in different stages of evolution. By many physical anthropologists, notably by Francis Galton, the conclusion was drawn that an existing race could pull itself up to a higher plane, could transform its men into supermen, through obedience to "laws" of eugenics requiring the physically fit to breed and the physically unfit to practice birth control or be sterilized. In this respect, unfortunately, Galton's "fit" got mixed up about the dictates of "science"; it was they who proceeded to practice birth control.

Other anthropologists, the "cultural" sort, zealously gathered an immense miscellany of data about the speech, customs, crafts, and myths of primitive tribesmen all over the world, collated it with similar data concerning European peoples, and facilely hypothesized the evolutionary stages of man's cultural rise. Tylor published his standard textbook in 1871, and Frazer brought out the *Golden Bough* in 1890.

Comte had counseled social scientists to stick to "facts" and to refrain from metaphysical explanations. Though the generation after 1870 detested the word "metaphysical" with a horror and vehemence worthy of the master, they were too much under the spell of contemporary physics and biology, too much impressed by obvious progress in machine industry, and withal too human, not to perceive in the myriad facts they amassed a co-ordinating principle of mechanical evolution which was really metaphysical. Actually it was social scientists, more than natural scientists, who implanted this principle in the popular consciousness; and it was the postulates of social scientists, more than their facts, which inspired the most distinctive (and most varied) intellectual movements of the era: agnosticism in religion and realism in art, Marxism and integral nationalism, racialism and pacifism, enlightenment for the masses and quest of the superman.