A silent continent had been changed into a scene of industry; it was full of the din of machinery and the restless moving of men. Where there had been an unbroken forest, there were hundreds of cities and towns. To commerce were furnished in profusion some of the most important staples, as cotton, tobacco, breadstuffs. The mines yielded incredible quantities of gold, iron, coal. Countless churches, colleges, and public schools, testified that a moral influence vivified this material activity. Locomotion was effectually provided for. The railways exceeded in aggregate length those of all Europe combined. In 1873 the aggregate length of the European railways was sixty-three thousand three hundred and sixty miles, that of the American was seventy thousand six hundred and fifty miles. One of them, built across the continent, connected the Atlantic and Pacific Oceans.

But not alone are these material results worthy of notice. Others of a moral and social kind force themselves on our attention. Four million negro slaves had been set free. Legislation, if it inclined to the advantage of any class, inclined to that of the poor. Its intention was to raise them from poverty, and better their lot. A career was open to talent, and that without any restraint. Every thing was possible to intelligence and industry. Many of the most important public offices were filled by men who had risen from the humblest walks of life. If there was not social equality, as there never can be in rich and prosperous communities, there was civil equality, rigorously maintained.

It may perhaps be said that much of this material prosperity arose from special conditions, such as had never occurred in the case of any people before. There

was a vast, an open theatre of action, a whole continent ready for any who chose to take possession of it. Nothing more than courage and industry was needed to overcome Nature, and to seize the abounding advantages she offered.

But must not men be animated by a great principle who suecessfully transform the primeval solitudes into an abode of civilization, who are not dismayed by gloomy forests, or rivers, mountains, or frightful deserts, who push their conquering way in the course of a century across a continent, and hold it in subjection? Let us contrast with this the results of the invasion of Mexico and Peru by the Spaniards, who in those countries overthrew a wonderful civilization, in many respects superior to their own—a civilization that had been accomplished without iron and gunpowder—a civilization resting on an agriculture that had neither horse, nor ox, nor plough. The Spaniards had a clear base to start from, and no obstruction whatever in their advance. They ruined all that the aboriginal children of America had accomplished Millions of those unfortunates were destroyed by their cruelty. Nations that for many centuries had been living in contentment and prosperity, under institutions shown by their history to be suitable to them, were plunged into anarchy; the people fell into a baneful superstition, and a greater part of their landed and other property found its way into the possession of the Roman Church.

I have selected the foregoing illustration, drawn from American history, in preference to many others that might have been taken from European, because it furnishes an instance of the operation of the acting principle least interfered with by extraneous conditions. European political progress is less simple than American.

Before considering its manner of action, and its results, I will briefly relate how the scientific principle found an introduction into Europe.

INTRODUCTION OF SCIENCE INTO EUROPE.

Not only had the Crusades, for many years, brought vast sums to Rome, extorted from the fears or the piety of every Christian nation; they had also increased the papal power to a most dangerous extent. In the dual governments everywhere prevailing in Europe, the spiritual had obtained the mastery; the temporal was little better than its servant.

From all quarters, and under all kinds of pretenses, streams of money were steadily flowing into Italy. The temporal princes found that there were left for them inadequate and impoverished revenues. Philip the Fair, King of France (A. D. 1300), not only determined to check this drain from his dominions, by prohibiting the export of gold and silver without his license; he also resolved that the clergy and the ecclesiastical estates should pay their share of taxes to him. This brought on a mortal contest with the papacy. The king was excommunicated, and, in retaliation, he accused the pope, Boniface VIII., of atheism; demanding that he should be tried by a general council. He sent some trusty persons into Italy, who seized Boniface in his palace at Anagni, and treated him with so much severity, that in a few days he died. The succeeding pontiff, Benedict XI., was poisoned.

The French king was determined that the papacy should be purified and reformed; that it should no longer be the appanage of a few Italian families, who were dexterously transmuting the credulity of Europe into coin —that French influence should prevail in it. He

therefore came to an understanding with the cardinals; a French archbishop was elevated to the pontificate; he took the name of Clement V. The papal court was removed to Avignon, in France, and Rome was abandoned as the metropolis of Christianity.

Seventy years elapsed before the papacy was restored to the Eternal City (A. D. 1376). The diminution of its influence in the peninsula, that had thus occurred, gave opportunity for the memorable intellectual movement which soon manifested itself in the great commercial cities of Upper Italy. Contemporaneously, also, there were other propitious events. The result of the Crusades had shaken the faith of all Christendom. In an age when the test of the ordeal of battle was universally accepted, those wars had ended in leaving the Holy Land in the hands of the Saracens; the many thousand Christian warriors who had returned from them did not hesitate to declare that they had found their antagonists not such as had been pictured by the Church, but valiant, courteous, just. Through the gay cities of the south of France a love of romantic literature had been spreading; the wandering troubadours had been singing their songs—songs far from being restricted to ladye-love and feats of war; often their burden was the awful atrocities that had been perpetrated by papal authority—the religious massacres of Languedoc; often their burden was the illicit amours of the clergy. From Moorish Spain the gentle and gallant idea of chivalry had been brought, and with it the noble sentiment of "personal honor," destined in the course of time to give a code of its own to Europe.

The return of the papacy to Rome was far from restoring the influence of the popes over the Italian Peninsula. More than two generations had passed away

since their departure, and, had they come back even in their original strength, they could not have resisted the intellectual progress that had been made during their absence. The papacy, however, came back not to rule, but to be divided against itself, to encounter the Great Schism. Out of its dissensions emerged two rival popes; eventually there were three, each pressing his claims upon the religious, each cursing his rival. A sentiment of indignation soon spread all over Europe, a determination that the shameful scenes which were then enacting should be ended. How could the dogma of a Vicar of God upon earth, the dogma of an infallible pope, be sustained in presence of such scandals? Herein lay the cause of that resolution of the ablest ecclesiastics of those times (which, alas for Europe! could not be carried into effect), that a general council should be made the permanent religious parliament of the whole continent, with the pope as its chief executive officer. Had that intention been accomplished, there would have been at this day no conflict between science and religion; the convulsion of the Reformation would have been avoided; there would have been no jarring Protestant sects. But the Councils of Constance and Basle failed to shake off the Italian yoke, failed to attain that noble result.

Catholicism was thus weakening; as its leaden pressure lifted, the intellect of man expanded. The Saracens had invented the method of making paper from linen rags and from cotton. The Venetians had brought from China to Europe the art of printing. The former of these inventions was essential to the latter. Henceforth, without the possibility of a check, there was intellectual intercommunication among all men.

The invention of printing was a severe blow to

Catholicism, which had, previously, enjoyed the inappreciable advantage of a monopoly of intercommunication. From its central seat, orders could be disseminated through all the ecclesiastical ranks, and fulminated through the pulpits. This monopoly and the amazing power it conferred were destroyed by the press. In modern times, the influence of the pulpit has become insignificant. The pulpit has been thoroughly supplanted by the newspaper.

Yet, Catholicism did not yield its ancient advantage without a struggle. As soon as the inevitable tendency of the new art was detected, a restraint upon it, under the form of a censorship, was attempted. It was made necessary to have a permit, in order to print a book. For this, it was needful that the work should have been read, examined, and approved by the clergy. There must be a certificate that it was a godly and orthodox book. A bull of excommunication was issued in 1501, by Alexander VI., against printers who should publish pernicious doctrines. In 1515 the Lateran Council ordered that no books should be printed but such as had been inspected by the ecclesiastical censors, under pain of excommunication and fine; the censors being directed "to take the utmost care that nothing should be printed contrary to the orthodox faith." There was thus a dread of religious discussion; a terror lest truth should emerge.

But these frantic struggles of the powers of ignorance were unavailing. Intellectual intercommunication among men was secured. It culminated in the modern newspaper, which daily gives its contemporaneous intelligence from all parts of the world. Reading became a common occupation. In ancient society that art was possessed by comparatively few persons. Mod-

ern society owes some of its most striking characteristics to this change.

Such was the result of bringing into Europe the manufacture of paper and the printing-press. In like manner the introduction of the mariner's compass was followed by imposing material and moral effects. These were—the discovery of America in consequence of the rivalry of the Venetians and Genoese about the India trade; the doubling of Africa by De Gama; and the circumnavigation of the earth by Magellan. With respect to the last, the grandest of all human undertakings, it is to be remembered that Catholicism had irrevocably committed itself to the dogma of a flat earth, with the sky as the floor of heaven, and hell in the under-world. Some of the Fathers, whose authority was held to be paramount, had, as we have previously said, furnished philosophical and religious arguments against the globular form. The controversy had now suddenly come to an end—the Church was found to be in error.

The correction of that geographical error was by no means the only important result that followed the three great voyages. The spirit of Columbus, De Gama, Magellan, diffused itself among all the enterprising men of Western Europe. Society had been hitherto living under the dogma of "loyalty to the king, obedience to the Church." It had therefore been living for others, not for itself. The political effect of that dogma had culminated in the Crusades. Countless thousands had perished in wars that could bring them no reward, and of which the result had been conspicuous failure. Experience had revealed the fact that the only gainers were the pontiffs, cardinals, and other ecclesiastics in Rome, and the shipmasters of Venice. But, when it became known that the wealth of Mexico, Peru, and

India, might be shared by any one who had enterprise and courage, the motives that had animated the restless populations of Europe suddenly changed. The story of Cortez and Pizarro found enthusiastic listeners everywhere. Maritime adventure supplanted religious enthusiasm.

If we attempt to isolate the principle that lay at the basis of the wonderful social changes that now took place, we may recognize it without difficulty. Heretofore each man had dedicated his services to his superior—feudal or ecclesiastical; now he had resolved to gather the fruits of his exertions himself. Individualism was becoming predominant, loyalty was declining into a sentiment. We shall now see how it was with the Church.

Individualism rests on the principle that a man shall be his own master, that he shall have liberty to form his own opinions, freedom to carry into effect his resolves. He is, therefore, ever brought into competition with his fellow-men. His life is a display of energy.

To remove the stagnation of centuries from European life, to vivify suddenly what had hitherto been an inert mass, to impart to it individualism, was to bring it into conflict with the influences that had been oppressing it. All through the fourteenth and fifteenth centuries uneasy strugglings gave a premonition of what was coming. In the early part of the sixteenth (1517), the battle was joined. Individualism found its embodiment in a sturdy German monk, and therefore, perhaps necessarily, asserted its rights under theological forms. There were some preliminary skirmishes about indulgences and other minor matters, but very soon the real cause of dispute came plainly into view. Martin Luther refused to think as he was ordered to do by his ec-

clesiastical superiors at Rome; he asserted that he had an inalienable right to interpret the Bible for himself.

At her first glance, Rome saw nothing in Martin Luther but a vulgar, insubordinate, quarrelsome monk. Could the Inquisition have laid hold of him, it would have speedily disposed of his affair; but, as the conflict went on, it was discovered that Martin was not standing alone. Many thousands of men, as resolute as himself, were coming up to his support; and, while he carried on the combat with writings and words, they made good his propositions with the sword.

The vilification which was poured on Luther and his doings was so bitter as to be ludicrous. It was declared that his father was not his mother's husband, but an impish incubus, who had deluded her; that, after ten years' struggling with his conscience, he had become an atheist; that he denied the immortality of the soul; that he had composed hymns in honor of drunkenness, a vice to which he was unceasingly addicted; that he blasphemed the Holy Scriptures, and particularly Moses; that he did not believe a word of what he preached; that he had called the Epistle of St. James a thing of straw; and, above all, that the Reformation was no work of his, but, in reality, was due to a certain astrological position of the stars. It was, however, a vulgar saying among the Roman ecclesiastics that Erasmus laid the egg of the Reformation, and Luther hatched it.

Rome at first made the mistake of supposing that this was nothing more than a casual outbreak; she failed to discern that it was, in fact, the culmination of an internal movement which for two centuries had been going on in Europe, and which had been hourly gathering force; that, had there been nothing else, the existence of three popes—three obediences—would have compelled men to

think, to deliberate, to conclude for themselves. The Councils of Constance and Basle taught them that there was a higher power than the popes. The long and bloody wars that ensued were closed by the Peace of Westphalia; and then it was found that Central and Northern Europe had cast off the intellectual tyranny of Rome, that individualism had carried its point, and had established the right of every man to think for himself.

But it was impossible that the establishment of this right of private judgment should end with the rejection of Catholicism. Early in the movement some of the most distinguished men, such as Erasmus, who had been among its first promoters, abandoned it. They perceived that many of the Reformers entertained a bitter dislike of learning, and they were afraid of being brought under bigoted caprice. The Protestant party, having thus established its existence by dissent and separation, must, in its turn, submit to the operation of the same principles. A decomposition into many subordinate sects was inevitable. And these, now that they had no longer any thing to fear from their great Italian adversary, commenced partisan warfares on each other. As, in different countries, first one and then another sect rose to power, it stained itself with cruelties perpetrated upon its competitors. The mortal retaliations that had ensued, when, in the chances of the times, the oppressed got the better of their oppressors, convinced the contending sectarians that they must concede to their competitors what they claimed for themselves; and thus, from their broils and their crimes, the great principle of toleration extricated itself. But toleration is only an intermediate stage; and, as the intellectual decomposition of Protestantism keeps going on, that tran-

sitional condition will lead to a higher and nobler state —the hope of philosophy in all past ages of the world— a social state in which there shall be unfettered freedom for thought. Toleration, except when extorted by fear, can only come from those who are capable of entertaining and respecting other opinions than their own. It can therefore only come from philosophy. History teaches us only too plainly that fanaticism is stimulated by religion, and neutralized or eradicated by philosophy.

The avowed object of the Reformation was, to remove from Christianity the pagan ideas and pagan rites engrafted upon it by Constantine and his successors, in their attempt to reconcile the Roman Empire to it. The Protestants designed to bring it back to its primitive purity; and hence, while restoring the ancient doctrines, they cast out of it all such practices as the adoration of the Virgin Mary and the invocation of saints. The Virgin Mary, we are assured by the Evangelists, had accepted the duties of married life, and borne to her husband several children. In the prevailing idolatry, she had ceased to be regarded as the carpenter's wife; she had become the queen of heaven, and the mother of God.

The science of the Arabians followed the invading track of their literature, which had come into Christendom by two routes—the south of France, and Sicily. Favored by the exile of the popes to Avignon, and by the Great Schism, it made good its foothold in Upper Italy. The Aristotelian or Inductive philosophy, clad in the Saracenic costume that Averroes had given it, made many secret and not a few open friends. It found many minds eager to receive and able to appreciate it. Among these were Leonardo da Vinci, who proclaimed

the fundamental principle that experiment and observation are the only reliable foundations of reasoning in science, that experiment is the only trustworthy interpreter of Nature, and is essential to the ascertainment of laws. He showed that the action of two perpendicular forces upon a point is the same as that denoted by the diagonal of a rectangle, of which they represent the sides. From this the passage to the proposition of oblique forces was very easy. This proposition was rediscovered by Stevinus, a century later, and applied by him to the explanation of the mechanical powers. Da Vinci gave a clear exposition of the theory of forces applied obliquely on a lever, discovered the laws of friction subsequently demonstrated by Amontons, and understood the principle of virtual velocities. He treated of the conditions of descent of bodies along inclined planes and circular arcs, invented the camera-obscura, discussed correctly several physiological problems, and foreshadowed some of the great conclusions of modern geology, such as the nature of fossil remains, and the elevation of continents. He explained the earth-light reflected by the moon. With surprising versatility of genius he excelled as a sculptor, architect, engineer; was thoroughly versed in the astronomy, anatomy, and chemistry of his times. In painting, he was the rival of Michel Angelo; in a competition between them, he was considered to have established his superiority. His "Last Supper," on the wall of the refectory of the Dominican convent of Sta. Maria delle Grazie, is well known, from the numerous engravings and copies that have been made of it.

Once firmly established in the north of Italy, Science soon extended her sway over the entire peninsula. The increasing number of her devotees is indicated by the rise and rapid multiplication of learned

societies. These were reproductions of the Moorish ones that had formerly existed in Granada and Cordova. As if to mark by a monument the track through which civilizing influences had come, the Academy of Toulouse, founded in 1345, has survived to our own times. It represented, however, the gay literature of the south of France, and was known under the fanciful title of "the Academy of Floral Games." The first society for the promotion of physical science, the Academia Secretorum Naturæ, was founded at Naples, by Baptista Porta. It was, as Tiraboschi relates, dissolved by the ecclesiastical authorities. The Lyncean was founded by Prince Frederic Cesi at Rome; its device plainly indicated its intention: a lynx, with its eyes turned upward toward heaven, tearing a triple-headed Cerberus with its claws. The Accademia del Cimento, established at Florence, 1657, held its meetings in the ducal palace. It lasted ten years, and was then suppressed at the instance of the papal government; as an equivalent, the brother of the grand-duke was made a cardinal. It numbered many great men, such as Torricelli and Castelli, among its members. The condition of admission into it was an abjuration of all faith, and a resolution to inquire into the truth. These societies extricated the cultivators of science from the isolation in which they had hitherto lived, and, by promoting their intercommunication and union, imparted activity and strength to them all.

INTELLECTUAL INFLUENCE OF SCIENCE.

Returning now from this digression, this historical sketch of the circumstances under which science was introduced into Europe, I pass to the consideration of its manner of action and its results.

The influence of science on modern civilization has been twofold: 1. Intellectual; 2. Economical. Under these titles we may conveniently consider it.

Intellectually it overthrew the authority of tradition. It refused to accept, unless accompanied by proof, the dicta of any master, no matter how eminent or honored his name. The conditions of admission into the Italian Accademia del Cimento, and the motto adopted by the Royal Society of London, illustrate the position it took in this respect.

It rejected the supernatural and miraculous as evidence in physical discussions. It abandoned sign-proof such as the Jews in old days required, and denied that a demonstration can be given through an illustration of something else, thus casting aside the logic that had been in vogue for many centuries.

In physical inquiries, its mode of procedure was, to test the value of any proposed hypothesis, by executing computations in any special case on the basis or principle of that hypothesis, and then, by performing an experiment or making an observation, to ascertain whether the result of these agreed with the result of the computation. If it did not, the hypothesis was to be rejected.

We may here introduce an illustration or two of this mode of procedure:

Newton, suspecting that the influence of the earth's attraction, gravity, may extend as far as the moon, and be the force that causes her to revolve in her orbit round the earth, calculated that, by her motion in her orbit, she was deflected from the tangent thirteen feet every minute; but, by ascertaining the space through which bodies would fall in one minute at the earth's surface, and supposing it to be diminished in the ratic

of the inverse square, it appeared that the attraction at the moon's orbit would draw a body through more than fifteen feet. He, therefore, for the time, considered his hypothesis as unsustained. But it so happened that Picard shortly afterward executed more correctly a new measurement of a degree; this changed the estimated magnitude of the earth, and the distance of the moon, which was measured in earth-semidiameters. Newton now renewed his computation, and, as I have related on a previous page, as it drew to a close, foreseeing that a coincidence was about to be established, was so much agitated that he was obliged to ask a friend to complete it. The hypothesis was sustained.

A second instance will sufficiently illustrate the method under consideration. It is presented by the chemical theory of phlogiston. Stahl, the author of this theory, asserted that there is a principle of inflammability, to which he gave the name phlogiston, having the quality of uniting with substances. Thus, when what we now term a metallic oxide was united to it, a metal was produced; and, if the phlogiston were withdrawn, the metal passed back into its earthy or oxidized state. On this principle, then, the metals were compound bodies, earths combined with phlogiston.

But during the eighteenth century the balance was introduced as an instrument of chemical research. Now, if the phlogistic hypothesis be true, it would follow that a metal should be the heavier, its oxide the lighter body, for the former contains something—phlogiston—that has been added to the latter. But, on weighing a portion of any metal, and also the oxide producible from it, the latter proves to be the heavier, and here the phlogistic hypothesis fails. Still further, on continuing the investigation, it may be shown that the oxide or calx, as

it used to be called, has become heavier by combining with one of the ingredients of the air.

To Lavoisier is usually attributed this test experiment; but the fact that the weight of a metal increases by calcination was established by earlier European experimenters, and, indeed, was well known to the Arabian chemists. Lavoisier, however, was the first to recognize its great importance. In his hands it produced a revolution in chemistry.

The abandonment of the phlogistic theory is an illustration of the readiness with which scientific hypotheses are surrendered, when found to be wanting in accordance with facts. Authority and tradition pass for nothing. Every thing is settled by an appeal to Nature. It is assumed that the answers she gives to a practical interrogation will ever be true.

Comparing now the philosophical principles on which science was proceeding, with the principles on which ecclesiasticism rested, we see that, while the former repudiated tradition, to the latter it was the main support; while the former insisted on the agreement of calculation and observation, or the correspondence of reasoning and fact, the latter leaned upon mysteries; while the former summarily rejected its own theories, if it saw that they could not be coördinated with Nature, the latter found merit in a faith that blindly accepted the inexplicable, a satisfied contemplation of "things above reason." The alienation between the two continually increased. On one side there was a sentiment of disdain, on the other a sentiment of hatred. Impartial witnesses on all hands perceived that science was rapid ly undermining ecclesiasticism.

Mathematics had thus become the great instrument