

The God-Fearing Life of Leonhard Euler

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The steps of a good man are ordered by the LORD, and He delights in his way. Ps. 37:23

For the past three centuries it has been fashionable among philosophers and academicians to deny that God and religious faith play a part in serious intellectual inquiry. The Enlightenment and Postmodernism teach that no scholar of highest repute regards God as anything more than a First Cause if, indeed, He exists at all. The belief that God is not to be taken seriously is expressed in the French philosopher Voltaire's witticism, "God is a comedian playing to an audience too afraid to laugh." (Wikipedia—Voltaire)

Into Voltaire's eighteenth-century Age of Reason stepped Leonhard Euler, an unpretentious native of Switzerland who rose to prominence in the royal academies of Russia and Germany and whose extraordinary mathematical prowess was rivaled only by his heartfelt devotion to God. The man acknowledged by Laplace to be "the master of us all," who according to Arago "calculated without apparent effort, as men breathe, or as eagles sustain themselves in the wind" (Eves, p. 435), was a deeply religious man who in his humility asserted that "the works of the Creator infinitely surpass the productions of human skill" (Euler, *Letters*, p. 357). That a God-fearing man would gain such stature and reputation in Europe during the man-centered days of the Enlightenment is indeed noteworthy.

What were the religious beliefs of this remarkable man? What were their origins and their effects upon him and how he related to others? What has been his influence? To answer these questions, we first present a brief account of his life as a whole; next we view elements of his character through the lens of his life's experiences; then we unveil tenets of his theology, as gleaned primarily from his *Letters to a German Princess on Different Subjects in Natural Philosophy* and his *Defense of the Divine Revelation against the Objections of the Freethinkers*; finally we reflect upon his legacy, how his life has impacted persons of his day and of today.

Biographical Sketch

Born the son of a Protestant minister near Basel, Switzerland, on April 15, 1707, Leonhard Euler grew up knowing that his father expected him to follow him into the ministry. He studied philosophy at the University of Basel, but his heart lay in mathematics, a subject whose fundamentals he had learned from his father. At the university Euler had the good fortune to meet the renowned Johann Bernoulli, perhaps the greatest of all active mathematicians of that time. Bernoulli graciously agreed to give Euler Saturday afternoon tutoring sessions, and quickly he discovered his pupil's incredible aptitude in and love for mathematics (Condorcet, p. 1).

Euler completed a Master of Arts degree in philosophy at Basel in 1723 and then dutifully began studying theology. At this point Bernoulli was able to persuade the elder Euler to permit his son to focus on mathematics exclusively—thus an illustrious career was born (Condorcet, p. 1). Looking back Euler recalled:

I had to register in the faculty of theology, and I was to apply myself ... to the Greek and Hebrew languages, but not much progress was made, for I turned most of my

time to mathematical studies, and by my happy fortune the Saturday visits to Johann Bernoulli continued (Truesdell, in *Elements*, p. xii).

During Euler's time at the university he had become fast friends with Bernoulli's sons, Daniel and Nicolas. The younger Bernoullis secured positions for themselves in mathematics at the St. Petersburg Academy in Russia, and in 1727 they found an opening there for Euler, albeit in physiology/medicine. After a brief stint in the Russian Navy, Euler became professor of physics in 1730, and upon the departure of Daniel Bernoulli in 1733, he assumed his friend's position as professor of mathematics. That same year he married Katharina Gsell, also a Swiss emigrant to Russia, and he became a father ultimately to thirteen children, only five of whom survived infancy. In 1735 a severe infection cost him the sight of his right eye (Fuss, pp. 3-4).

While in Russia Euler distinguished himself by solving the 91-year-old *Basel problem* in infinite series, namely, finding an exact sum of the infinite series $1 + 1/4 + 1/9 + 1/16 + \dots$. He also made valuable contributions to both classical and analytic number theory, built foundations for the theory of partitions, and produced a treatise in mechanics that has been hailed as "a landmark in the history of physics" (Calinger, *Historia Mathematica*, p. 143). A steady stream of first-rate papers poured forth from his intellectual springs, most of which were (or ultimately would be) published in the academy's journal. As an employee of the Russian state, he was called upon to solve a variety of practical problems in such areas as cartography, navigation and shipbuilding, the assessment of weights and measures, and the testing of scales. He also found time to explore acoustics and the theory of musical harmony (Dunham, pp. xxii-xxiii).

Political unrest in Russia led to a tense working environment at the St. Petersburg Academy, prompting Euler to accept an invitation from Frederick the Great of Prussia to join his Royal Academy at Berlin in 1741. When asked by Frederick's mother why he would barely speak to her, Euler replied "Madame, because I have come from a country where one can be hanged for what one says" (Condorcet, p. 2). Over the next quarter century in Germany he would make important discoveries in the Calculus of Variations, establish *Euler's Identity* in Complex Numbers, produce two treatises in analysis (*Introduction to Analysis of the Infinite* in 1748 and *Institutions of Differential Calculus* in 1755), explore key concepts in algebra such as solutions of polynomial equations and *the Fundamental Theorem of Algebra* (Dunham, p. xxiv), and continue to produce high-quality papers at an astonishing rate. Not limiting himself to mathematics while in Berlin, Euler made important contributions to various branches of physics as well, including mechanics, astronomy, magnetism, light and color, and dioptics. Euler's expertise was also brought to bear upon practical problems dealing with insurance, currency, navigation canals, water pumps, and naval science (Fuss, pp. 7-11).

The Princess of Anhalt Dessau, a niece of Frederick's, desired to learn elementary physical science from Euler, and he responded by writing over 200 letters to her which would eventually be published under the title *Letters of Euler to a German Princess On Different Subjects in Natural Philosophy*. In *Letters*, which would become an international bestseller, Euler discussed in layman's terms much of the physical science of his day as well as his views on philosophy and theology (Dunham, p. xxiv).

While in Prussia Euler witnessed the growth of various movements hostile to Christianity, such as deism, natural theology, and atheism. "Freethinking found its way, by way of the French language and of the French fashions, into the court life and from there into the circles of the educated" (Hagenbach, p. 5). In response Euler became an ardent apologist of the Christian faith, participating in many theological debates (Thiele, pp. 513-514) and authoring a number of essays, most notably *Defense of the Divine Revelation against the Objections of the*

Freethinkers. He also emphatically opposed Wolff's theory of the *corporeality of the soul* and Leibniz' notions of *monads* and *pre-established harmony* (Hagenbach, pp. 4-6).

During his tenure at the Berlin Academy, Euler continued in the employ of and remained on best terms with the St. Petersburg Academy, submitting a host of articles to enrich the pages of its journal and regularly providing it financial counsel (Fuss, p. 13). His relationship with Frederick was becoming increasingly strained, partly due to the latter's growing obsession with sophistication and anything French (especially as embodied by his court philosopher Voltaire) and his diminishing respect for the decidedly inelegant Euler. Also Euler's tendency to become embroiled in arguments with Voltaire and the other philosophers in subjects about which he knew little, didn't help matters with Frederick (Kline, p. 403). Frederick went so far as to cruelly dub Euler "my cyclops" because of his conspicuous visual impairment (Dunham, pp. xxv-xxvi).

Consequently upon the invitation of the Russian empress Catherine the Great in 1766, Euler gladly returned to his former post at the St. Petersburg Academy. Shortly thereafter a cataract cost him the sight of his remaining good eye and he was virtually blind for the last seventeen years of his life. Nevertheless, the productivity of his "powerful and active imagination" (Condorcet, p. 12) never declined, as he performed monstrous mental calculations, wrote with large characters on a slate, and dictated new results to loyal scribes, most notably his sons. During this second tenure in St. Petersburg he produced influential works in integral calculus, algebra, dioptics, navigation, and the theory of lunar motion (Dunham, p. xxvi).

A 1771 fire in St. Petersburg destroyed Euler's home and most of his property, and he himself escaped the flames only by the heroic actions of his Swiss servant Peter Grimm, who carried his master to safety at the risk of his own life (Condorcet, pp. 12-13). Euler suffered the loss of his wife of 40 years in 1773; he remarried three years later. His two adult daughters died in the years just prior to his own death, leaving only three of his thirteen children to survive him. On Sept. 18, 1783, after studying the motion of hot-air balloons and the orbit of the newly-discovered planet Uranus, and giving his grandson a mathematics lesson, he succumbed to a massive hemorrhage and "ceased to calculate and live" (Condorcet, p. 15).

Euler's Character

Though Euler chose mathematics as a profession rather than theology, his early religious training took root in his heart and bore much fruit over his lifetime. "His piety was rational and sincere; his devotion was fervent" (Horner, p. li). Practical demonstrations of his love for God include his unsurpassed industry and commitment to his vocation, as we have already seen; his genuine humility before God and men; his professional generosity; his uncompromising integrity and desire for justice; his heartfelt devotion to his family; and his equanimity and perseverance through multiple tragedies.

1) Humility

Despite the widespread success and acclaim he enjoyed, Euler was as unpretentious as he was accomplished. "He never boasted about any of his discoveries" (Condorcet, p. 13). He continually marveled at the perfections of God's works and willingly acknowledged the deficiencies of man's best efforts. Concerning vision and the structure of the eye, he admitted that

though we are very far short of a perfect knowledge of the subject, the little we do know of it is more than sufficient to convince us of the power and wisdom of the Creator.

... *We discover in the structure of the eye perfections which the most exalted genius could never have imagined*" (Letters, p. 187).

Also Euler wasn't afraid to lower his reputation—he would without hesitation write about elementary subjects or advanced subjects at a low level if it would benefit his intended audience. "Ennobled by the goal of improving public education" he wrote a treatise on basic school arithmetic; hoping to benefit seafarers lacking in technical background he produced an influential work on the principles of navigation (Fuss, pp. 5, 10); desiring to educate laymen in elementary science he authored the momentous *Letters to a German Princess*. "He much preferred the education of his students to the small satisfaction derived from astonishment" (Condorcet, p. 9).

2) Generosity

Euler was a model of professional magnanimity, habitually promoting the reputations and accomplishments of others, often at his own expense. According to Clifford Truesdell

He was exceptionally generous, never once making a claim of priority and in some cases actually giving away discoveries that were his own. He was the first to cite the work of others in what is now regarded as the just way, that is, so as to acknowledge their worth (Truesdell, *Elements*, p. xxvi).

When Euler's young friend and rival Joseph-Louis Lagrange made an important discovery in a calculus-of-variations problem that had consumed much of Euler's time and energy, he responded with admiration for his friend's accomplishment. He "busied himself to expose this new method" and to cast it in a most favorable light (Condorcet, p. 7); also he refused to publish his own work on the subject until after Lagrange's appeared in print, happy to enhance the latter's reputation (Cajori, p. 261).

His treatise on mechanics had been brutally attacked by a Mr. Robins from England, yet Euler in turn praised the latter's work on the principles of artillery and gave it a glowing acknowledgement in his own work on the subject (Fuss, p. 7).

3) Integrity

Euler was scrupulous, honest, and forthright and an indefatigable champion of justice:

He sparked easily, but his anger passed as quickly as it appeared and he never kept a grudge against anyone. He was righteous and his correctness was irreproachable. Sworn enemy to all injustice and if he noticed some infraction committed somewhere, he had the frankness to censure and the courage to attack openly irrespective of who it was. (Fuss, p. 19)

He was a "man to keep his promise" and a "good citizen and loyal in all of his relations to society" (Fuss, pp. 17, 19). He was respected worldwide as much for the "nobility of his character" (Kline, p. 403) as for the magnitude of his accomplishments.

4) Devotion to Family

Euler's affection for his family and concern for its welfare were readily apparent to all who knew him. He regularly prayed with and read the Bible to them (Condorcet, p. 13); he tutored both his children and his grandchildren, and "constructed scientific games for them" (Kline, p. 403); he performed mental calculations with children nestled on his lap or crawling about his feet. According to Fuss, his family members responded with gratitude:

I know of no greater heart-rending spectacles than the ones that I enjoyed so many times while watching this venerable old patriarch encircled by his numerous family, thrilled only to make his golden years happy and to comfort him in his last days with all sorts of cares and attentions. (Fuss, p. 2)

5) Perseverance

As alluded to earlier, Euler sustained the loss of his wife, eight infant and two adult children, his eyesight, and his home and property in a fire. Yet he bore all of these tragedies with composure and courage, buoyed up in spirit by his unwavering faith in God and His providence:

To [Scripture] belongs in particular the doctrine of both general as well as particular divine providence, through which we can recognize that we can never get into any circumstance where God did not expressly place us according to his infinite wisdom and goodness, and can come to the firm assurance that not a single hair may fall from our head without the will of our heavenly Father. Now if only we were to ponder this doctrine with the appropriate attention and apply it to ourselves, we would submit to the will of God under all circumstances without difficulty and even with pleasure, and in this way attain true happiness. (Euler, *Defense*, XXVIII)

The last seventeen years of Euler's life, spent in virtual blindness, saw no decrease in either the quality or the quantity of his work. (Eves, p. 433) That Euler never slackened his pace after the devastation caused by the fire was astonishing to Fuss:

I am not aware of any strength, of nothing that better represents the heroic self than this spiritual equanimity and unshakeable courage in the middle of such a reversal of fortune. (Fuss, p. 16)

Euler's fortitude and perseverance were awe-inspiring to Dunham:

That this blind and aging man forged ahead with such gusto is a remarkable lesson, a tale for the ages. Euler's courage, determination, and utter unwillingness to be beaten serves, in the truest sense of the word, as an inspiration for mathematician and non-mathematician alike. The long history of mathematics provides no finer example of the triumph of the human spirit. (Dunham, p. xxvii)

Such character was truly a testimony to the grace of God at work in his life.

Euler's Theology

Much of Euler's theology may be ascertained from his *Letters to a German Princess* (1760-1762) and his *Defense of the Divine Revelation against the Objections of the Freethinkers* (1747). Included below are excerpts of his understanding of God as Creator; the divine

inspiration of Scripture; the spirituality of the soul; man's responsibility before God; God's sovereignty and man's free will; man's depravity and helplessness; and Christ and salvation.

1) God as Creator

Euler proclaimed the God of the Bible to be *omnipotent*, designating Him "the Almighty" and "the Divine Omnipotence" (*Letters*, pp. 5, 353); *omniscient*, speaking of the "infinite wisdom of the Creator" and His "Most consummate wisdom" (*Letters*, pp. 395, 401); and *omnipresent*, declaring that "His power extends to the whole universe and to all the bodies which it contains... God is everywhere present" (*Letters*, p. 409). Euler declared that "the world is the work of his infinite might and wisdom" (*Defense*, II) and that "everything has been created in the highest perfection" (*Letters*, p. 390). He further asserted that "the immensity (of space and the heavenly bodies) is the work of the Almighty, who governs the greatest bodies and the smallest" (*Letters*, p. 5). In stark contrast to the deists, he argued that the universe is no "mere machine" but is

... infinitely more worthy of the almighty Creator, who formed it. The government of this universe will, likewise, ever inspire us with the most sublime idea of the sovereign wisdom and goodness of God. (Letters, p. 382)

Euler was particularly intrigued by vision and the structure of the eye:

... the eye alone being a masterpiece that far transcends the human understanding, what an exalted idea must we form of Him who has bestowed this wonderful gift, and that in the highest perfection, not on man only, but on the brute creation, nay, on the vilest of insects! (Letters, p. 198)

2) The divine Inspiration of Scripture

In his *Defense of the Divine Revelation against the Objections of the Freethinkers*, Euler vigorously opposed a number of arguments proffered against the divine authorship of Scripture. To the charge that the origins of such a revelation need to be unmistakable and its contents compelling to all men, he argued that

Such a revelation to men would contribute much more to their destruction than to their salvation, since such a greater knowledge of God would increase the duties which are our responsibilities, and the neglect of these duties would lead to the guilt of an even greater offense. (Defense, XXI)

He added that

The Holy Scripture not only provides those who are seriously concerned with the improvement of their hearts with the most powerful means to that end, but that it also leads them in time to a greater knowledge of God. (Defense, XXIII)

Concerning the contempt shown for the human authors of Scripture and their testimony, especially with respect to the miraculous, Euler vouches for their character and exposes the folly of not trusting their eyewitness accounts:

The apostles and many early Christians unanimously claimed that Christ not only had risen from the dead, but that they themselves had seen him and that they had even spoken with him. That they did not truly believe this themselves and that beneath it there was hidden

deceit on their part cannot be asserted by any man with the least light who would weigh their doctrine with some attention and take into consideration their attested consistency. That the apostles should have falsely imagined this through an insane understanding can even less be affirmed in any likelihood. Or else one would have to assert that God has miraculously blinded all these men and this only to spread a false doctrine. (Defense, XXXIV)

Because of apparent contradictions they found in Scripture, the freethinkers had denied its credibility entirely. Euler remonstrated that contradictions of equal or greater magnitude found in mathematics and in the sciences caused no such wholesale rejection of these disciplines:

They behave in the most unfair and irresponsible way toward this Book when they dare to absolutely deny any value to it because of some (apparent to them) irreconcilable difficulties. Most of these people will have to admit that they are not able to resolve the difficulties mentioned above against geometry, against the existence of bodies and against the possibility of motion, and yet it has not come to the mind of even one of them to reject the truth and the reality of these things... Now, since such great and important difficulties, yes, even apparent contradictions as it were, can be adduced against those things which can be recognized by reason alone; so there must be at least equally great difficulties in revealed doctrines, which cannot be arrived at by reason. Consequently one has even far less reason to take exception to them. (Defense, XLIV-XLV)

The freethinkers had contended that the biblical account of creation and prediction of the earth's ultimate destruction were contrary to reason, the much-revered god of the age. Flatly rejecting this contention, Euler argued that science and natural causes support the assertion that the earth had a definite beginning and that at some future time life on earth must come to an end.

Should one have brought the freethinkers to the point where they must acknowledge a creation and a future destruction of the world, then their whole undertaking, whereby they keep attacking religion, would be brought to nothing. (Defense, LII)

3) The spirituality of the Soul

Dr. K. R. Hagenbach, professor of theology at the University of Basel in the mid-nineteenth century, summarized Euler's view of the non-corporeality of the soul as follows:

In the consideration of the relationship between spirit and matter, soul and body, God and the world, [Euler] is definitely a dualist. Spiritualism and materialism are dissociated for him. Spirits, in his view, are free, independent beings which have nothing in common with the realm of the body and for which the category of space does not exist. The connection of the human soul to the body is, for him, a connection willed and ordained by God but transitory and dissolved by death, where the soul maintains its complete independence. (Hagenbach, p. 7)

Further, the soul is intimately connected to the mind and the will:

The powers of the soul are manifested in a twofold set of faculties, one called the mind, the other the will. Now since all blissful happiness consists in perfection, the blissful happiness of a soul cannot be promoted except through the perfection of the mind and the perfection of the will. Therefore a soul is to be reckoned the happier the further it has brought the mind as well as the will to perfection. (Defense, I)

4) Man's Responsibility before God

In his *Defense*, Euler asserted that all men are required to obey God's law and that transgression thereof must necessarily provoke divine retribution:

Now since all our happiness is directed toward God as our greatest good, it follows that the violation of the law must necessarily plunge us into the most extreme perdition. How could God conceivably prescribe laws to reasonable creatures without demanding their fulfillment in full earnest and emphatically punishing the transgressors?... Therefore man must strive with all his powers to bring his will to observe the whole law prescribed to him by God and to put himself in such a state of mind that he does it with joy and finds his greatest satisfaction therein. (Defense, VI-VII)

Embracing the so-called *natural law* but rejecting God's law was not an option, insisted Euler:

The natural law, by which our duties in our dealings are determined through the light of nature, can for good reasons be called a divine law which God has, so to speak, written on the hearts of men and has obligated men to conduct all their dealings according to its instructions. (Defense, V)

5) God's Sovereignty and Man's Free Will

The French philosopher and mathematician the Marquis de Condorcet declared in his eulogy to Euler read at the Paris Academy that he "conserved his country's religion which was a conservative Calvinism" (Condorcet, p. 13). God does sovereignly foreordain all events, insisted Euler, without violating man's free will:

We must acknowledge the government and providence of God, who having from all eternity (foreseen) all the counsels, the projects, and the voluntary actions of men, arranged the corporeal world in such a manner, that it brings about, at all times, circumstances which cause these enterprises to fail, or to succeed, according as His infinite wisdom judges to be most fit. God thus remains absolute sovereign of all events, notwithstanding the liberty of men, all whose actions, though free, are, from the beginning, part of the plan which God intended to execute, when He created this universe. (Letters, p. 383)

Euler was quick to note that

God does not force men to it, for this would be contrary to the liberty, which is essential to them; but He endeavors to engage men to the observance of this commandment, by proposing to them motives the most powerful; but it always depends on the will of man, whether he is to obey or not. In this sense we are to understand the will of God, when it refers to the free actions of spiritual beings. (Letters, pp. 387-388)

6) Man's Depravity and Helplessness

To Euler it was abundantly clear that man is fallen in nature, readily acknowledging "the great quantity of evil that prevails and is diffused over the surface of our globe, and which flows from the wickedness of man" (*Letters*, p. 264). He admitted that men's spirits have "abused

their liberty and transgressed [God's] commandments, [so] they are responsible for it, and worthy of punishment" (*Letters*, p. 392).

He further maintained that man is helpless in perfecting his will:

The will cannot be in a happier state than when it is in a state of absolute submission to the divine will... [The power of dissolute lusts and desires] is so strong that man cannot reach such a happy state of his mind or will, no matter how strongly he may try... All warnings offered to a perverted will given over to its lusts are usually in vain, and the most urgent exhortations, which are the only means by which a man can be moved, have very seldom the desired effect. Now since happiness is tightly bound up with such insurmountable difficulties, it follows that it is an established fact that men find themselves in a most depraved way. (Defense, X-XII)

According to Euler, man is utterly incapable of saving himself:

If we are liable to weaknesses and inconsistencies so humiliating, in our researches into the phenomena of this visible world, which lies open to the examination of our senses, how wretched must we have been, had God left us to ourselves with respect to things invisible, and which concern our eternal salvation? On this important article, a Revelation was absolutely necessary to us; and we ought to avail ourselves of it, with the most profound veneration. (Letters, p. 82)

7) Christ and Salvation

Euler saw God's sovereignty operating in man's salvation by "furnishing (him) with motives the most efficacious, and by the circumstances and opportunities which His providence supplies" (*Letters*, p. 400). As is true in His sovereign foreordination of all events, however, God's actions do not violate man's freedom of the will:

Liberty, from its very nature, can submit to no degree of constraint, even on the part of God. But without exercising any constraints over (men's) spirits, God has an infinite variety of means of presenting them with persuasive motives; and, I believe, that all possible cases are adapted by Providence to our condition, in such a manner, that the most abandoned wretches might derive from them the most powerful motives to conversion, if they would but listen to them... It is thus that God cooperates in our conversion. (Letters, pp. 399-400)

For Euler God is the architect of man's salvation in that

the aforementioned circumstances are directed of God, in conformity to the most consummate wisdom, in the view of conducting every intelligent being to happiness and salvation, unless he willfully rejects the means by which he might have attained true felicity. (Letters, pp. 400-401)

Concerning the role of Christ, Euler maintained that

It is therefore a settled truth that Christ is risen from the dead: since this is such a marvel, which could only be performed by God alone, it makes it impossible to cast any doubt on the divine sending of Christ into this world. Consequently, the doctrine of Christ and of his apostles is divine and since it is directed toward our true happiness, we can therefore

believe with the strongest confidence all the promises which have been made in the gospel regarding this life as well as the one to come, and view the Christian religion as a divine work aiming at our spirituality. But it is not necessary to elaborate further on all this, since each one who is convinced only once of the resurrection of Christ cannot doubt any further the divinity of Holy Scripture. (Defense, XXXVI)

Euler further argued that

The holy life of the apostles, and of the other primitive Christians, appears to me an irresistible proof of the truth of the Christian religion. If true happiness consists in union with the Supreme Being, which it is impossible for a moment to doubt, the enjoyment of this happiness necessarily requires, on our part, a certain disposition, founded on supreme love to God, and the most perfect charity toward our neighbor... It is only by motives, therefore, that (men's) spirits can be determined to that which is good: now what motives could be proposed to the apostles, and other disciples, of Jesus Christ, to embrace a virtuous life, more powerful than the instructions of their divine Master, his miracles, his sufferings, his death, and resurrection, of which they were witnesses. All these striking events, united to a doctrine most sublime, must have excited, in their hearts, the most fervent love, and the most profound veneration for God, whom they could not but consider, and adore, as at once their heavenly Father, and the absolute Lord of the whole universe... The mission, then, of Jesus Christ into the world, produced in the minds of the apostles, this disposition, so necessary to the attainment and the enjoyment of supreme happiness... I confine myself to the salutary effects of our Saviour's mission, without presuming to dive into the mysteries of the work of our redemption, which infinitely transcends the powers of human understanding. I only remark, that these effects, of the truth of which we are convinced, by experience, could not be produced by illusion, or human imposture; they are too salutary not to be divine. (Letters, pp. 507-509)

Euler's Legacy

The breadth and depth and impact of Euler's works establish him as one of the truly great mathematicians of all time—mathematics historian Morris Kline ranks him at the highest level with Archimedes, Newton, and Gauss (Kline, p. 401). Approximately one third of all publications in the fields of mathematics, theoretical physics, and engineering mechanics between the years 1725 and 1800 were authored by Euler (Truesdell, in *Elements*, pp. viii-ix). Currently 73 volumes of his works, many in excess of 500 pages, are in print in the colossal *Leonhardi Euleri Opera Omnia*, a project begun in 1912 and as of yet incomplete, as many of his professional correspondences and manuscripts remain to be published (Dunham, p. xv). “Posterity will be hard pressed to establish that the life of one man produced this body of work” (Fuss, p. 7)—he was “far and away the most prolific writer in the history of (mathematics)” (Eves, p. 433).

Euler's genius brought new and powerful results to nearly every branch of mathematics—analysis (calculus, differential equations, calculus of variations), algebra, classical and analytic number theory, complex variables, Euclidean and differential geometry, topology, graph theory, and combinatorics. In addition to the results and discoveries that have been cited, such original and diverse concepts as Euler's identity (complex and transcendental functions), the Euler-Descartes formula (graph theory), the Euler ϕ -function (number theory), Eulerian integrals (calculus), the Euler equation (differential equations), and the Euler line of a triangle (geometry),

have become embedded in modern mathematics. Especially noteworthy has been his enrichment of analysis: “There are few great ideas pursued by succeeding analysts which were not suggested by Euler, or of which he did not share the honor of invention” (Cajori, p. 247).

Euler also systematized many branches of mathematics, providing for them coherent structure as well as practical notation. So thorough, organized, and well-written were Euler’s treatises on analysis and algebra that his style more than any other has been emulated by modern college textbook writers (Eves, p. 435). And mathematics truly benefits from his efficient notations, e.g., $f(x)$ for function value of x ; π for the ratio of a circle’s circumference to its diameter; i for the square root of -1 ; e (Euler’s number) for the natural logarithmic base; a , b , c for the sides of triangle ABC ; and Σ for the sum of several terms (Lamont, p. 68).

Euler merited high praise from fellow mathematicians and scientists as well as mathematics historians like Kline, Truesdell, etc. In a letter to Euler, his mentor Johann Bernoulli exclaimed, “I present higher analysis as it was in its childhood but you are bringing it to a man’s estate” (Kline, p. 592). Condorcet declared in his eulogy to Euler that

of all the famous mathematicians who exist today, most are his students and there is not one who has not been formed by reading his works and who has not learned the formulas and methods that he now uses, which in his discoveries has not been guided by Euler’s genius... Neither Newton nor even Descartes, whose influence today is so strongly felt, has attained this glory among the mathematicians that Mr. Euler possesses alone. (Condorcet, p. 14)

Condorcet also noted that upon meeting Euler in Berlin, D’Alembert had been astonished at his remarkable memory and ability to do mental calculations (Condorcet, p. 12). Euler protégé Nicolas Fuss observed in his eulogy to Euler read at the St. Petersburg Academy, “Here are five of us, and is there a scientist who could boast of having united in the same assembly as many disciples?” (Fuss, p. 20) Fuss also asserted that Newton would be surprised at the lofty heights to which Euler elevated the calculus—indeed, he was dubbed “Analysis Incarnate” by French physicist and astronomer Francois Arago (Eves, p. 435). The respect and admiration accorded him by Europe’s scientific community was perhaps best expressed by the Marquis de Laplace’s famous entreaty: “Read Euler, read Euler. He is the master of us all.”

Fields other than mathematics have benefited from Euler’s superlative industry and insights, most notably physics but also engineering, navigation, and business. The discoveries and advances he made in several branches of physics, including mechanics, astronomy, electricity and magnetism, light and color, hydraulics, optics, acoustics, and elasticity, were considerable—Clifford Truesdell regarded him as the “dominating theoretical physicist of the eighteenth century” (Truesdell, *Essays*, p. 106). Also Euler impacts physicists of today—his publications continue to frequent the pages of the Science Citation Index and his masterful teaching continues to enlighten:

*Euler taught mathematics and physics to the whole world, and down to the present time his influence on instruction in the exact sciences has been second only to Euclid’s. (Truesdell, in *Elements*, p. xxi)*

Despite his exalted success and popularity, he forever remained God-fearing and humble, “sweet of disposition, moderate in the passions, and simple of manners” (Horner, in *Elements*, p. 1). He repeatedly expressed his awe of the Creator and was a staunch defender of

Christianity. He was industrious, honest, generous, and courageous; he was universally respected “as much for his rare virtues as for the astonishing force of his genius” (Fuss, p. 20). To scientist and layman alike he was “not only a great scientist but also a great man” (Condorcet, p. 14).

His devotion to home and family was paramount; he was perfectly content to expound to them the Scriptures or to calculate with children on his lap. That he could face heartbreak and tragedy with such equanimity and perseverance is a testimony to his deep and abiding faith in God and His providence. May his consummate example—professionally, personally, spiritually—inspire us to serve God through mathematics with renewed vitality and devotion.

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