SCIENCE

MATHEMATICIANS, AND POETRY AND DRAMA[1]

By Professor RAYMOND CLARE ARCHIBALD

BROWN UNIVERSITY

IN general reading for a number of years I have
been interested in accumulating information concern-
ing, firstly, those who had not only achieved something
noteworthy in mathematics but had also written verses
or dramas; secondly, poems about mathematicians;
and thirdly, the numerous incidental citations of
mathematicians in poetry by poets of more or less dis-
tinction. Such general reading has not been confined
to any one language, and translations of poetical or
dramatic work of mathematicians were within the
scope of my search. The large amount of material
collected is in more than a score of languages, from
the time of Pythagoras and his "Golden Verses"[2] down

to the present. It is my purpose to give you some idea
of the nature of this material. I am not aware that
any one else has previously discussed this general
theme.

The relations between poetry and mathematics have
been considered by a number of writers;[3] but this is

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[1] Address of the retiring vice-president and chairman
of Section L (Historical and Philological Sciences),
American Association for the Advancement of Science,
delivered at a joint meeting of Sections A and L, of the
American Mathematical Society and of the Mathematical
Association of America; illustrated by 22 lantern slides.
Richmond, Va., December 28, 1938.

[2] See, e.g., "The Life of Pythagoras, with his Symbols

and Golden Verses together with the Life of Hierocles, and
his Commentaries upon the Verses. Collected out of the
choicest manuscripts and translated into French, with
annotations. By M. Dacier. Now done into English.
The Golden Verses translated from the Greek," by N.
Rowe. London, 1707. Greek text and Rowe's transla-
tion, pp. 149–164 + i–xi. "Pythagoras," a play by Mar-
tin Slaughter, was first acted in London in 1596.

[3] E. J. Wilczynski, "Poetry and Mathematics," The
University Chronicle, 3: 191–204, 1900; read at the annual
meeting of the Science Association May 2, 1900. I.
Ionescu, "Matematica si poezia," Gazeta Matematica, 17:
"Suppliment," pp. 1–3, May 15, 1912. D. E. Smith, (a)
"Mathematics and Poetry," Florence, 1922, 8 pp.; (b)
"Poetry of Mathematics," Mathematics Teacher, 19:
291–296, 1926; (c) "The Poetry of Mathematics and
other Essays," New York, 1934, "The Poetry of Mathe-
matics," pp. 1–13; contains practically all of (a). S.

not really a part of my topic, and I shall dismiss it after quoting a single paragraph from "My Friend the Mathematician," written more than fifty years ago by Percival Lowell, in a book on Korea.[4] This paragraph thus treats one of many phases of the subject:

It has often been said that Poetry and Mathematics are own sisters. They differ in feature, but not in blood; and their common mother is Imagination. The saying will soon lose, if it has not already lost, the brilliant glitter of a seeming paradox, but only to be recognized with all the more distinctness as a truism. For art is to the senses what science is to thought, and both have their birth in the realms of fancy. To appreciate the one the senses must be acute, to understand the other the mind must be discerning; but to originate in either, this is truly dependent upon imagination in science as in art. The faculty has to do with thought pictures there, with sense creations here; but in both the creative idea comes from without the man himself. It comes suddenly upon him, as the flame, on relighting a candle that still is warm, appears to fall to the wick from the air above it. But the wick must be warm, the mind prepared or the spark never kindles.

Let us then consider some of those whose minds were prepared and on whom the flame descended. By way of illustration, I shall refer to at least a score of mathematicians who flourished during the past 2,200 years, in seven countries, and I shall try to suggest (to those of you who are not mathematicians) why most of them may be regarded as having achieved something of importance in mathematics, as well as what may be their connections with poetry or drama. Let us first of all turn to a group of Americans.

One of the leading research mathematicians of America at the present time, one who has been the recipient of more numerous international distinctions than any other, is George David Birkhoff (1884–   ), of Harvard University. After thirty years of meditation on the matter he published a book, in which he sought to bring the basic side of art, including music and poetry, within the purview of the simple mathematical formula defining "Aesthetic Measure," which is the title of his book.[5] There is a twenty-page chapter on "The musical quality of poetry," in which among other things the following topics are discussed: "The tripartite nature of verse" (that is significance,

musical quality and meter), "The musical quality in poetry," "rhyme," "assonance," "alliteration," "the musical vowel sounds," "Poe's concept of verse," "poetry in other languages" and "the rôle of musical quality in poetry." He gives also an excellent "experimental poem" with his aesthetic measure indicated. It is as follows:

VISION

Wind and wind the wisps of fire
Bits of knowledge, heart's desire;
Soon within the central ball
Fiery vision will enthrall.

Wind too long, or strip the sphere
See the vision disappear.

Let us now consider another Harvard man, Thomas Hill[6] (1818–1891), president of the university for the six years 1862–68, immediately preceding President Eliot's régime. Among his books were the following mathematical works (1848–1887): "Elementary Treatise on Arithmetic," "Puzzles to Teach Geometry," "Geometry and Faith" (three editions), "An Elementary Treatise on Curvature." Also "A Fragmentary Essay on Curves" and (in collaboration with G. A. Wentworth) "A Practical Arithmetic." He invented the "occultator," an instrument for calculating eclipses and occultations, and a mechanical apparatus for determining latitude and longitude at sea. Now as to poetical contributions. In his senior year at Harvard he published a 16-page pamphlet, "Christmas, and Poems on Slavery."[7] Forty-five years later 120 of his poems, translations and imitations were brought together in a volume entitled "In the Woods, and Elsewhere."[8] His poetry was a perfectly natural flow of speech, and the best-liked pieces were those on subjects of nature written in free verse form. Perhaps the favorite was "Bloodroot," which appeared in the *Atlantic Monthly* for 1859 and was thought highly of by Oliver Wendell Holmes. The first eight lines may be quoted:

Beech trees, stretching their arms, rugged yet beautiful
Here shade meadow and brook; here the gay bobolink,
High poised over his mate, pours out his melody.
Here too, under the hill, blooms the wild violet;
Damp nooks hide, near the brook, bellworts that modestly,
Pale-faced, hanging their heads, droop there in silence,
    while
South winds, noiseless and soft, bring us the odor of
Birch twigs mingled with fresh buds of the hickory.

Another of Hill's excellent nature poems, "The

Buchanan, "Poetry and Mathematics," New York, 1929, "Poetry and Mathematics," pp. 3–24. G. Usai, "Matematica e poesia," Catania, 1932, 19 p.; inaugural address, Nov. 12, 1931, R. Istituto Superiore de Scienze Economiche e Commerciali di Catania.

[4] P. Lowell, "Chosön, the Land of the Morning Calm; a Sketch of Korea," Boston, 1886 [1885]; chapter 24, "My Friend the Mathematician," pp. 250–261.

[5] Cambridge, Mass., 1933, xvi + 226 pp. 23 plates. For further details of Birkhoff's life and work see R. C. Archibald, "A Semicentennial History of the American Mathematical Society, 1888–1938," New York, 1938, pp. 212–218.

[6] See *Scripta Mathematica*, 2: 78–79, 1933, and "Dict. Am. Biog.," v. 9, 1932.

[7] Cambridge, 1843; published by the author for the Massachusetts anti-slavery fair, Christmas, 1843.

[8] Boston, 1888, 237 pp. The first edition of this volume was a privately printed pamphlet (Portland, Me., 1887, 48 pp.), containing twenty poems.

Bobolink," was chosen by William Cullen Bryant for his "A Library of Poetry and Song."[9] Four of Hill's poems are in Griffith's collection, "The Poets of Maine,"[10] and his "Birthday Reflections" was published in London, as early as 1845, in a collection called "Flowers of Poetry."[11] These brief references to Hill's poetry must suffice.

During the first three quarters of the nineteenth century the most inspiring mathematician in the classroom of any American university was Benjamin Peirce (1809–1880), mathematician and astronomer, who taught at Harvard for half a century.[12] Not long ago President Emeritus Lowell recorded that he "still impresses me as having the most massive intellect with which I have ever come into close contact, and as being the most profoundly inspiring teacher that I ever had."[12] Peirce wrote a notable work on "Analytical Mechanics," and achieved remarkable pioneer results in linear associative algebra. At least three separate poems about him appeared in print.[13] Their general style can only be fully appreciated by those familiar with the life of Peirce and his modes of thought. The first, fourth and fifth stanzas of a ten-stanza poem published in the *Atlantic Monthly*,[14] by Oliver Wendell Holmes, Peirce's classmate at Harvard, were as follows:

> For him the Architect of all
> Unroofed our planet's starlit hall;
> Through voids unknown to worlds unseen
> His clearer vision rose serene.
>
> How vast the workroom where he brought
> The viewless implements of thought!
> The wit how subtle, how profound,
> That Nature's tangled web unwound;
>
> That through the clouded matrix saw
> The crystal planes of shaping law,
> Through these the sovereign skill that planned,—
> The Father's care, the Master's Hand!

In very recent days there has been another creative poet, a member of the present mathematical group in the National Academy of Sciences, who was a lecturer at Harvard in 1925–26. I refer to Eric Temple Bell[15]

(1883–), a native of Aberdeen, Scotland, who came to America in his youth and was later greatly to enrich its cultural life. He has been a professor of mathematics at the California Institute of Technology for the past twelve years. Among his nineteen books are nine novels (written under the *nom de plume* of John Taine), and the remarkable "Men of Mathematics." But his first two books were volumes of verse "By J. T."[16] There is much to interest the mathematician in the manner of Bell's treatment of a wide range of themes, and of a variety of verse forms. The first volume contains sonnets on "Newton," "James Clerk Maxwell" and "William Thomson—Lord Kelvin," and a poem on "Johann Sebastian Bach." There are over seventy poems in the first volume and about a dozen in the second. In the latter, the first poem, "The Singer," fills over 120 pages. Bell's novel "Green Fire"[17] was dramatized into a three-act play by Glenn Hughes, and the Pasadena Community Playhouse Association gave several performances of it in 1931.

Turning next to another important scientific center in the state, the University of California at Berkeley, we find that only a few months ago death claimed one of her rarely gifted members of the mathematics department, who, for many years, had there achieved notably in the fields of mathematics, poetry and music. I refer to the beloved Derrick Norman Lehmer[18] (1867–1938), author of mathematical papers and of great mathematical tables, published by the Carnegie Institution and used by scholars throughout the world. For a decade before its recent demise he was the editor of the literary magazine, called the *University of California Chronicle*. He published scores of poems, some of them very extensive, in such periodicals as *Overland Monthly, Poetry, Silhouettes, Step Ladder, Lyric West, University of California Chronicle, Poetry Review* (London), *Poetry of To-day* (London) and *Atlantic Monthly;* and in "West Winds. An Anthology of Verse,"[19] in various volumes of "California Writers Club Poems"[20] and in other poetical anthologies.[21]

[9] New York, 1871, p. 345.

[10] G. B. Griffith, Portland, Me., 1888, pp. 211–214.

[11] Pp. 271–273. There is also Hill's "Prosing in Rhyme," in "The Centenary of Leicester Academy" . . ., Worcester, Mass., 1884, pp. 63–67.

[12] "Benjamin Peirce, 1809–1880, Biographical Sketch and Bibliography," by R. C. Archibald, and "Reminiscences," by C. W. Eliot, A. L. Lowell, W. E. Byerly and A. B. Chace, Oberlin, O., 1925. Reprinted with new material and portraits from *Am. Math. Mo.*, v. 32, 1925. See also "Dict. Am. Biog.," v. 14, 1934, pp. 393–397.

[13] By T. W. Parsons, T. Thwing and O. W. Holmes; see M. King, "Benjamin Peirce . . . A Memorial Collection," Cambridge, 1881.

[14] Vol. 46, 1880, pp. 823–824.

[15] See "Who's Who in America," v. 20, 1938; "American Men of Science," sixth ed., 1938; *Scripta Mathematica*, 2: 375–376, 1934.

[16] "Recreations," Boston, The Gorham Press, 1915, 151 pp.; "The Singer," *idem.*, 1916, 166 pp.

[17] "Green Fire, the Story of the Terrible Days in the Summer of 1890. Now told in full for the first Time," New York, Dutton, 1928.

[18] See "Who's Who in America," v. 20, New York, 1938; "American Men of Science," sixth ed., New York, 1938.

[19] By members of the California Writers Club, San Francisco, 1925, pp. 98–99, 103–104.

[20] San Francisco, 1930, pp. 21–24, group of children's poems ("That Strange Land," "Dandelion Faeries," "Rumpelstiltskin," "Old Daddy Red-Cap," "Giant Blunderbore"); 1932, "Spring Gossip"; 1933, "The New Thanatopsis" and "I?"

[21] A. H. Bartlett, comp., "Sea Anthology," London, 1924, "The Limpet"; E. Markham, comp., "The Book of Poetry," New York, 1926, "Riches"; E. Markham, comp., "Songs and Stories" (California Series), Los Angeles,

Lehmer was a virile master in the writing of ballads, where the tale is always forcefully told and the interest finely sustained. He collected ten of his best ballads in the recent volume, "Fightery Dick and Other Poems."[22] For twenty years he traveled among Indians of the West, and made hundreds of valuable phonograph records of their songs. To melodies and words, or vocables, thus obtained he has added suitable simple harmonies with flute obbligato and, in some cases, wrote English poetry in keeping with the music. He published a number of collections of such songs.[23] Furthermore, two Indian operas, "The Harvest" and "The Necklace of the Sun," for which he wrote both libretti and music, were performed with success in Oakland, San José and San Francisco, California, in 1933 and 1935.

In referring to Indians our thought naturally turns to Dartmouth College, which originated in Connecticut, as a charity school for Indians. At this college during 1911–1932 the head of the department of mathematics was a man of culture and of outstanding abilities as teacher, organizer, committee man and editor, John Wesley Young[24] (1879–1932). He also achieved noteworthy mathematical research publication. On his death the following poem,[25] which struck a responsive chord in the heart of every friend, was written by Alexander K. Laing, the prominent American poet and author:

VALE: CY YOUNG

A week ago: your hand, in my hand resting—
The shy, queer smile that never went away.
A week ago: your jest, to crown my jesting—
Sunlight at nightfall on a gloomy day.

Long I shall cherish that last careless meeting,
That picture, stamped unfading on the brain:
Symbol of you, who offered life a greeting
Of banter, for its surly gift of pain.

Great heart, grown quiet, merely to have seen you
Wear, as an honored garment, such great ruth,
Made us your debtors. Death cannot demean you
Who taught us manhood in our stumbling youth.

Arthur Sherburne Hardy[26] (1847–1930) was another professor of mathematics at Dartmouth College, namely, for the fifteen years 1878–93, and during that time he wrote not only volumes of mathematical texts such as: "Elements of Quaternions" (1881), "New Methods in Topographical Surveying" (1884), "Elements of Analytic Geometry" (1889) and "Elements of the Calculus" (1890), but also three novels, "But Yet a Woman" (1883), "Wind of Destiny" (1886), "Passe Rose" (1889) and a small volume, "Francesca of Rimini. A Poem."[27] This last volume was his first book, and it is written in Chaucerian rhyme royal. On leaving Dartmouth, Professor Hardy was for two years editor of the *Cosmopolitan Magazine*. Shortly thereafter followed eight years (1897–1905) as the United States minister to Persia, Greece, Roumania, Servia, Switzerland and Spain. Then, and later, six other novels and another volume of poetry flowed from his pen. This second volume of poetry, a product of the Merrymount Press, was given the title of its first part, "Songs of Two,"[28] and its second part, called "Verses," includes the poem "Duality," which had first appeared several years before.[29] Yet other poems of Hardy, written to a little child, are to be found in his "A May and November Correspondence,"[30] published shortly before he died.

Since Hardy was our ambassador to Persia and also to Spain, we may next appropriately visit these countries. Few there are who do not know of the Rubaiyat of the eleventh-century Persian poet, popularly known as Omar Khayyám,[31] and of Edward

1930, "The Stroller," "Riches"; H. Harrison, comp., "California Poets," New York (?), 1932, "The Feud," "Eviction"; "World's Fair Anthology," Exposition Press, New York, 1939, "Edgar Allan Poe"; "Golden Gate Anthology," Tudor House, New York, 1939, "Prophecy."

[22] New York, 1936, x + 138 pp.

[23] (a) "Seven Indian Songs from the Yosemite Valley," published under the auspices of The National Society of Colonial Dames resident in California, Berkeley, 1924, 19 + 4 pp., 4to, 8 songs with flute obbligato; (b) "Down the Stream and Other Indian Songs," Berkeley, 1927, 11 + 1 pp., 5 songs with flute obbligato; (c) "Two Indian Choruses" "Buffalo Song" and "Invocation to the Sun," Berkeley, 1927, 7 pp.; (d) "Indian Camp-Fire Songs. Easy four-part arrangements of Indian Songs for Junior and Senior High Schools," Berkeley, 1930, 15 pp., 8 songs; (e) "Indian Songs from the Northland," Berkeley, 1931, 13 pp., 5 songs; (f) "Fingers of the Sun and other Indian Songs from the Sierra Slopes," Berkeley, 1931, 13 pp., 6 songs; (g) "Indian Songs from the Mesas," Berkeley, 1932, 13 pp., 5 songs. He published also "Five Songs from the Tundras, an Eskimo Song Cycle," Berkeley, 1932, 9 pp.

[24] See *Am. Math. Mo.*, 39: pp. 309–314, 1932; "American Men of Science," fourth ed., 1927; R. C. Archibald, "A Semicentennial History of the American Mathematical Society," 1938.

[25] *The Dartmouth*, 93: 2, February 20, 1932.

[26] "Dict. Am. Biog.," vol. 8, 1932. A. S. Hardy, "Things Remembered," Boston and New York, 1923.

[27] Philadelphia, 1878, 46 pp.

[28] New York, 1900, 36 pp.

[29] "The First Book of the Authors Club; Liber Scriptorum," New York, 1893, p. 272.

[30] Boston, Mass., 1928, 24 pp. and portrait and facsimile plates.

[31] W. E. Story, "Omar Khayyám as a Mathematician" [Needham, Mass.], 1919, 17 pp. and portrait of Story (also in "Twenty Years of the Omar Khayyám Club of America," 1921, privately printed by the Rosemary Press; "Omar as a Mathematician," pp. 70–81; Poems, "Omar Khayyám," by N. H. Dole, pp. 28–30, by G. Roe, pp. 34–36). A. G. Potter, "A Bibliography of Printed Editions of the Quatrains of Omar Khayyám in Foreign Languages," privately printed for members of the Omar Khayyám Club of America, 1923. There is also a bibliography in E. Heron-Allen's edition and translation of the Rubaiyat, Boston, 1898, pp. 279–286. D. S. Kasir, "The Algebra of Omar Khayyám," New York, Columbia University, 1931, especially pp. 1–39. J. Hay, "In Praise of Omar," T. B. Mosher, Portland, Me., 1898; address be-

Fitzgerald's beautiful, though not wholly literal, translation of the Rubaiyat[32] into English in 1859. To this are largely due its popularity, the establishment of numerous Omar Khayyám clubs and a long series of special publications. It is not so generally known that Omar Khayyám was the originator of a notable calendar, and wrote an important work on algebra, as well as a commentary on difficulties in Euclid's "Elements," very much like early discussions of non-Euclidean geometry.[33]

Fitzgerald's work in connection with 101 quatrains was sufficient to impel various other people to rush into print with translations of other quatrains of more or less doubtful authenticity; thus Whinfield gave 500 quatrains.[34] Another, innocent of knowledge of Persian, conceived the idea of eliminating the more doubtful of this number and having a Persian scholar make a literal translation into English of 289 quatrains, so as to give, as he conceived it, a truer picture of the original text. Having this literal translation before him he put it into metrical form and had it published in a most beautiful volume adorned with twelve remarkable illustrations in colors by an eminent Persian artist.[35] The author of this metrical translation, David Eugene Smith[36] (1860-), is one of the best loved among American mathematicians, and great is the debt which the United States owes to him for inspiring so many of the teaching fraternity. The popularity of his text-books and historical writings may be inferred from the fact that during each of the three years 1927–29, more than a million copies of his books were sold by his publisher. These included Spanish editions of several of his works used in Cuba and South America.

Omar's quatrains have been translated into many languages, and in some of these languages many trans-

lations have been made, in part antedating the translation of Fitzgerald. Danish, French, German and Italian translations are well known; but there have also been Basque, Catalanese, Czech, Dutch, Esperanto, Gaelic, Hebrew, Hungarian, Japanese, Latin, Welsh, Welsh Romany and Yiddish. There are many musical settings for the quatrains, of which the beautiful ones of Liza Lehmann, finely recorded on gramophone records, are the most notable.

Many poems about Omar have been brought together in a little volume edited by E. M. Moore.[37] Among the authors of these are the following: T. B. Aldrich, Austin Dobson, Edmund Gosse, Andrew Lang, R. Le Gallienne, J. R. Lowell, J. H. McCarthy and Stephen Phillips.

And now to Spain! The mathematician of all time to attain the greatest financial reward for his poetic and dramatic efforts was the very gifted and versatile Spaniard, José Echegaray,[38] who was born in 1832 and died in 1916. He ruled the Spanish stage unchallenged for the twenty years 1874–1894, and was a Nobel prize winner in literature in 1904, when 72 years of age, "in appreciation," to use the words of the award, "of his comprehensive and intellectual authorship which, in an independent and original way, has brought to life again the great traditions of Spanish drama."[39] Of the 65 dramatic pieces which he wrote many were translated into foreign languages such as Dutch, English, French, German, Greek, Italian, Portuguese and Russian. English translations[39] of "The Madman Divine," "Madman or Saint" and "Always Ridiculous" were published in Boston, in *Poet Lore*. But these are said to be trivial in literary value beside two of later years, "The Great Galeoto" and "The Son of Don Juan."

Echegaray's writing of plays began about 1868, when he was appointed professor of mathematical physics at the University of Madrid, and became a member of the Cortes. For five years he was minister of public works and finance. He is the author of

fore the Omar Khayyám Club, London, Dec., 1897. G. Sarton, "Introduction to the History of Science," vol. 1, Washington, 1927, pp. 759–761; H. Lamb, "Omar Khayyám, A Life," Garden City, N. Y., 1934, viii + 316 pp. Romances: (a) N. H. Dole, "Omar, the Tentmaker; a Romance of Old Persia," Boston, 1899, viii + 365 pp.; (b) H. Macfall, "The Three Students," London, 1926, viii + 351 pp., attractively written. G. Sarton, "The Tomb of Omar Khayyám," *Isis*, 29: 15–19, 1938, with plate illustration of the magnificent tomb at Nishâpûr. See also J. Fleming, "A Pilgrim to Omar's Forgotten Tomb," *Travel*, 58: 9–14, April, 1932.

32 The four Fitzgerald editions of the Rubaiyat (1859–79) were brought together in a single volume of the Golden Treasury Series, London, 1899. See also the beautiful edition of Thomas B. Mosher, Portland, Me., 1902.

33 D. E. Smith, "Euclid, Omar Khayyám, and Saccheri," *Scripta Mathematica*, 3: 5–10, 1935.

34 E. H. Whinfield, London, 1883.

35 New York, 1933.

36 *Scripta Mathematica*, 4: 182–184, 1936, and *Osiris*, 1: 9–84, 1936, with portrait. While traveling in Persia shortly after his Omar was published, Professor Smith was presented to the Shah, decorated with the Gold Star of the Order of Elim, of the first rank, and presented with an autographed portrait of the Shah.

37 "To Omar. Spoil of the North Wind," Blue Sky Press, Chicago, 1900, 93 pp.

38 J. Cejador y Frauca, "Historia de la Lengua y Literatura Castellana," Madrid, v. 9, pp. 111–128, 1918, with portrait; G. B. Shaw, "Dramatic Opinions and Essays," New York, 1907, v. 1, pp. 81–89; v. 2, pp. 186–194; N. A. Smith, "José Echegaray," *Poet Lore*, 20: 218–228, 1909; S. G. Morley, "José Echegaray," *Univ. California Chronicle*, 27: 368–379, 1925; F. W. Chandler, "Modern Continental Playwrights," New York, 1931, "Peninsular Tradition: Echegaray, Pérez Galdós Guimerá," pp. 465–486; *Scripta Mathematica*, 1: 265–266, 1933.

39 A. R. Marble, "The Nobel Prize Winners in Literature," New York, 1925, pp. 239–246, 282–283 (bibliography). For further bibliography of Echegaray see A. Flores, "Spanish Literature in English Translation, a Bibliographical Syllabus," New York, 1926, pp. 46–48; various editions of ten plays in English translation are listed.

many mathematical and scientific works on such subjects as calculus of variations (1858), theory of determinants (1868), elementary theory of thermodynamics (1868), mathematical theory of light (1871), modern theories of physics (5 v., 1883–89), and popular science (2 v., 1905). At the time of his death in 1916 he was the president of the Spanish Mathematical Society.[40]

In listing Omar's mathematical work I referred to his commentary on one of the works of Euclid. The magnificently endowed University of Alexandria opened about 300 B.C., and Euclid was there a professor of mathematics. Not less than ten mathematical treatises are to be attributed to him as author, and of these approximately complete texts of five are available. But by far the most famous one was his monumental work on geometry, containing 465 propositions, called "The Elements." More than a thousand editions have appeared since the first one[41] printed in 1482, and for 1,800 years before that, manuscript copies dominated all teaching of geometry. The following old English verses, which Halliwell has printed in one of his books,[42] show, if his ms. source is reliable, that Euclid's work was used in England as far back as King Adelstone, early in the tenth century.

> The clerk Euclide on this wyse hit fonde
> Thys craft of geometry, yn Egypte londe
> Yn Egypte he tawghte hyt ful wyde,
> In dyvers londe on every syde.
> Mony yerys afterwarde y understonde
> Yer that the craft com ynto thys londe.
> Thys craft com into England, as y yow say,
> Yn tyme of good Kyng Adelstone's Day.

There are many incidental references to Euclid in poetry. For example, in the fifth book of Wordsworth's "Prelude" the following lines may be recalled in the dream, which, according to De Quincey, "reaches the very *ne plus ultra* of sublimity":

> I looked and looked, self-questioned what this freight
> Which the new-comer carried through the waste
> Could mean, the Arab told me that the stone
> (To give it in the language of the dream)
> Was "Euclid's Elements."

During the past fifteen years two poems on Euclid have been published in this country—the one by Vachel Lindsay[43] and the other by Edna St. Vincent Millay.[44]

The latter's sonnet is as follows[44a]:

> Euclid alone has looked on Beauty bare.
> Let all who prate of Beauty hold their peace,
> And lay them prone upon the earth and cease
> To ponder on themselves, the while they stare
> At nothing, intrically drawn nowhere
> In shapes of shifting lineage; let geese
> Gabble and hiss, but heroes seek release
> From dusty bondage into luminous air.
> O blinding hour, O holy, terrible day,
> When first the shaft into his vision shone
> Of light anatomized! Euclid alone
> Has looked on Beauty bare. Fortunate they
> Who, though once only and then but far away,
> Have heard her massive sandal set on stone.

And now for another Greek of slightly later day. Should mathematicians be asked, who were the five greatest mathematicians who ever lived, their responses would probably agree, and the list begin with the names of Archimedes[45] and Newton. Archimedes, who flourished about 225 B.C., made most extraordinary discoveries, some of which called for use of what is equivalent to the solution of problems by the integral calculus, first later developed in more detail by Newton. Two of these results are that the volume of a sphere is exactly equal to two thirds that of its circumscribed cylinder, and that the area of the sphere was exactly equal to that of the cylinder. Archimedes was so proud of proving these results, he requested that the figure of a sphere in a cylinder be engraved on his tomb; Cicero found it there, as he tells us in his "Tusculan Disputations."

In this mechanistic age one may well recall Wordsworth's lines on Archimedes in book 8 of "The Excursion":[46]

> Call Archimedes from his buried tomb
> Upon the plain of vanished Syracuse,
> And feelingly the sage shall make report
> How insecure, how baseless in itself
> Is the philosophy, whose sway depends
> On mere material instruments; how weak
> Those arts, and high inventions, if unpropped
> By virtue.—

Somewhat the same underlying thought is suggested

[40] J. A. Sánchez Pérez, *Revista Matemática Hispano-Americana*, ser. 2, 7: 49–58, 1932, with portrait frontispiece of Echegaray; see also *Revista de la Sociedad Matemática Española*, 5: 281–282, 1916, and 6: 1–6 (by P. Carrasco), 1917.

[41] P. Riccardi, "Saggio di una Bibliografia Euclidea," Bologna, 1887–93; C. Thomas-Stanford, "Early Editions of Euclid's Elements," London, Bibliographical Society, 1926.

[42] J. O. Halliwell, "Rara Mathematica," second ed., London, 1841, p. 56, reproduced from Ms. Bib. Reg. Mus. Brit. 17A.1.f2ᵇ – 3, which dates from the fifteenth century.

[43] V. Lindsay, (a) "Collected Poems," rev. and

illustr. ed., New York, 1926, p. 231 in "Moon-Poems"; (b) "Golden Book," v. 13, 1931, p. 31.

[44] E. Millay, "The Harp-Weaver and Other Poems," New York, 1923, p. 74. See also "The Home Book of Modern Verse," ed. by R. E. Stevenson, New York, 1925, p. 822; and "The Riverside Book of Verse 1250–1925," ed. by R. M. Gay, Boston and New York, 1927, p. 610.

[44a] I am indebted to Miss Millay (Mrs. Boissevain) for kind permission to reprint this sonnet.

[45] T. L. Heath, (a) "Archimedes" (Pioneers of Progress) London, 1920; (b) "Manual of Greek Mathematics," Oxford, 1931. *Scripta Mathematica*, 2: 75–76, 363, 1933; 4: 82, 273–274, 1936.

[46] "The Complete Poetical Works of William Wordsworth," Cambridge ed., Boston, 1904, bk. 8, 11. 220–227.

by Schiller's poem, "Archimedes und der Schüler,"[47] which may be roughly translated as follows:[48]

To Archimedes once came a youth intent upon knowledge.
Said he "Initiate me into the science divine,
Which to our country has borne glorious fruits in abun-
    dance,
And which the walls of the town 'gainst the Sambuca
    protects'';
"Callst thou the science divine? It is so,'' the wise man
    responded;
"But so it was, my son, ere the state by her service was
    blest.
Would'st thou have fruit of her only? Mortals with that
    can provide thee,
He who the *goddess* would woo, seek not the woman in
    her.''

There are many other allusions to Archimedes and his work in poetry of different languages, but I shall not touch upon these except to draw attention to Stephen Vincent Benet's 120-line poem, "Archimedes' last foray,"[49] published about thirteen years ago with the motto, "And . . . having sought for a lever wherewith to move the world . . . he was slain . . . ."

The reference to Wordsworth leads next to consideration of one of his intimate friends. In Great Britain in the first half of the nineteenth century there were two great scholars of similar names. The older was Sir William Hamilton, baronet, one of the most eminent of Scottish metaphysicians, and the other Sir William Rowan Hamilton, knight (1805–1865), outstanding Irish mathematician.[50] The latter was a child prodigy, like John Stuart Mill. At three years of age he was a superior reader of English and considerably advanced in arithmetic; at four a good geographer; at five able to read and translate Latin, Greek and Hebrew, and liked to recite Dryden, Collins, Milton and Homer; at eight a reader of Italian and French and giving vent to his feelings in extemporized Latin; at ten a student of Arabic and Sanscrit. When twelve years old he met Zerah Colburn, the American calculating boy,[50a] and engaged with him in trials of arithmetical skill in which Hamilton came off with honor. His career at Trinity College, Dublin, was extraordi-

[47] For example, Schiller, "Sämmtliche Schriften,'' hist.-krit, Ausg. v. K. Goedeke, 11: 92, 1871. Compare "Archimedes und der Jüngling,'' a parody by C. G. J. Jacobi, Crelle's *Jour. f. Math.*, 101: 338, 1887, or Kronecker, "Werke,'' Leipzig, v. 3, 1899, p. 252.

[48] R. E. Moritz, "Memorabilia Mathematica,'' New York, 1914, p. 138.

[49] See, for example, W. S. Braithwaite, ed., "Anthology of Magazine Verse for 1926,'' Boston, 1926, pp. 36–40; *Saturday Rev. Lit.*, 2: 871, June 19, 1926.

[50] A. Macfarlane, "Lectures on Ten British Mathematicians of the Nineteenth Century,'' New York, 1916, pp. 34–49. E. T. Bell, "Men of Mathematics,'' New York, 1937, pp. 340–361.

[50a] "A Memoir of Zerah Colburn written by Himself,'' Springfield, Mass., 1833; F. D. Mitchell, "Mathematical Prodigies,'' *Amer. Jour. Psychology*, 18, 1907.

nary in that he achieved the previously unheard-of distinction of winning the highest possible marks both in mathematical physics and in Greek. Before entering college he was accustomed to translate Homer into blank verse, comparing his result with translations of Pope and Cowper, and he had already produced a number of original poems. These poems and about 100 others have been preserved in Hamilton's monumental biography.[51] While still an undergraduate Hamilton was appointed professor of astronomy. Before assuming the duties of his chair he made a tour through England and Scotland and thus met the poet Wordsworth for the first time, in 1827. The two men took to each other at once, and they remained close friends up to the day of the poet's death 23 years later. Wordsworth greatly loved and admired the young mathematician, declaring that Coleridge and Hamilton were the two most wonderful men, taking all their endowments together, that he had ever met. Here is Hamilton's account of their first meeting:

"Wordsworth with whom I spent the evening—I might almost say the night—of yesterday, for he and I were taking a midnight walk together for a long, long time, without any companion except the stars and our own burning thoughts and words." He goes on to record how Wordsworth walked back with him to his lodging about a mile distant. Hamilton then offered to return with Wordsworth, and their conversation was so interesting that, arrived at his house, Wordsworth turned back once more, when Hamilton again accompanied him home. From then on he sent Wordsworth the verses which he wrote in great quantity and with great facility. In 1831 Wordsworth wrote[52]: "You send me showers of verses which I receive with much pleasure, as do we all: yet have we fears that this employment may seduce you from the path of science which you seem destined to tread with so much honor to yourself and profit to others. Again and again I must repeat that the composition of verse is infinitely more of an art than men are prepared to believe, and absolute success in it depends upon innumerable *minutiae* which it grieves me you should stoop to acquire a knowledge of. . . . Again I do submit to your consideration, whether the poetical parts of your nature would not find a field more favorable to their exercise in the regions of prose; not because those regions are humbler, but because they may be gracefully and profitably trod, with footsteps less careful and in measures less elaborate." While Hamilton continued to indulge in poetical effusions with no little copiousness, Wordsworth's counsels were sufficient to decide him to dedicate his life to

[51] R. P. Graves, "Life of Sir William Rowan Hamilton, knt.,'' 3 v., Dublin, 1882–89.

[52] Graves, "Life,'' v. 1, pp. 491–492.

scientific research. In this direction three achievements may be mentioned: his notable discoveries in geometrical optics; "Hamiltonian equations," which are fundamental in discussions of dynamical problems; and his great works on quaternions, a subject of which he was the creator.

I wonder if it may not have been mainly due to association with Hamilton that Wordsworth's poems contain at least a dozen references, more, I believe, than made by any other poet, to mathematics and mathematicians. Most of these references are in "The Prelude," but there are others in "The Excursion" and in "Epitaphs translated from Chiabrera."

(To be concluded)

OBITUARY

CHARLES EDWARD MUNROE

THE death of Professor Charles Edward Munroe in his ninetieth year at his home in Forest Glen, Maryland, on the afternoon of December 7, 1938, marked the passing of a distinguished and most beloved American man of science. He was born in Cambridge, Massachusetts, on May 24, 1849, and his long career as student, teacher, consulting expert and investigator of chemistry spanned the entire period of modern industrial development.

Munroe's love of chemistry began early, and from first to last it was joyful, compelling and infectious. As a young boy he equipped a small chemical laboratory in an attic room, over the entrance of which, in the merry spirit that always stayed with him, he inscribed the words, "All hope abandon ye who enter here." Desirous of increasing his stock of chemicals, he went one day to the neighboring drug store of Dr. Abner Ham to buy an ounce of potassium cyanide. The venerable doctor peered down at the lad through his glasses and asked with surprise what he wished to do with so poisonous a substance. "To make experiments," replied the boy. Dr. Ham then questioned him and, finding that he had picked up an amount of chemical knowledge unusual for one so young, decided that what he needed most was not potassium cyanide but direction. He offered him therefore a position as helper and errand boy, together with the opportunity of making such chemical experiments as discretion and the resources of his store permitted. The proposal was eagerly accepted.

The zeal for chemistry, thus early aroused, accompanied Munroe into the Cambridge High School and then through the Lawrence Scientific School of Harvard, from which he graduated in the class of 1871 with the mark of *summa cum laude*. For the next three years he taught chemistry at Harvard in the courses of Professors O. Wolcott Gibbs and Josiah P. Cooke, of both of whom Munroe always spoke with admiring affection. Although there was a certain professional coolness between Gibbs and Cooke, Munroe was successful in maintaining cordial relations with both. In fact a cardinal trait of his character was a conciliatory spirit which made it impossible for him to become a partisan in the quarrels of his friends.

Among Munroe's chemistry pupils at Harvard was Harvey W. Wiley, of the class of '73, and between those two arose a deep and lasting friendship. Wiley, who was Munroe's senior by five years, was then pursuing a year of postgraduate study and being a B.A. of Hanover College had no intention of taking another degree. Munroe, however, persuaded him to try for a B.S. at Harvard, but the regulations required that he must first pass the examinations for each of the four college years. Wiley, after being duly coached by Munroe, had no difficulty in fulfilling this requirement, and he thereby attained the unique distinction of being promoted from freshman to senior year in the brief space of seventeen days. Helping Wiley to run this gauntlet of tests was jokingly referred to by Munroe as his greatest pedagogical achievement.

Munroe left Harvard in 1874 to accept the professorship of chemistry at the United States Naval Academy, where he remained until 1886. He then transferred his residence to Newport, where he served as chemist of the United States Naval Torpedo Station and War College until 1892. It was during this period that he conducted his famous researches on explosives. His fearless experiments in this field led to the invention of the smokeless powder called "Indurite" (U.S. Patent 489684) and to the discovery of the remarkable Munroe effect by which the outlines of a fragile leaf or photograph can be impressed upon a plate of the hardest steel by means of a powerful explosive. In 1892 he moved to Washington, where he served as professor of chemistry and dean of the Graduate School of George Washington University until his retirement as professor emeritus in 1918. He continued, however, to serve as consulting expert and chief explosives chemist of the U. S. Bureau of Mines until 1934, when failing health obliged him to resign the position.

Coincident with these main activities, Munroe discharged various miscellaneous public services which are too numerous to mention in detail. He was a member of the U. S. Assay Commission for 1885, 1890 and 1893 and consulting expert of the engineering board for the defense of Washington during the Spanish American War. His copious reports for the censuses of 1900, 1905 and 1910, as expert agent in charge of chemical