Journal of Humanistic Mathematics

Volume 9 | Issue 2 July 2019

Public Recognition and Media Coverage of Mathematical Achievements

Juan Matías Sepulcre
University of Alicante

Public Recognition and Media Coverage of Mathematical Achievements

Juan Matías Sepulcre

Department of Mathematics, University of Alicante, Alicante, SPAIN
JM.Sepulcre@ua.es

Synopsis

This report aims to convince readers that there are clear indications that society is increasingly taking a greater interest in science and particularly in mathematics, and thus society in general has come to recognise, through different awards, privileges, and distinctions, the work of many mathematicians. We provide examples of recognition accorded by institutions, societies, schools, communities, academies, and the public in general to these mathematicians.

In this paper we provide examples of recognition accorded by institutions, societies, schools, communities, academies, and the public in general to mathematicians. Several major prizes in mathematics are reported with the aim to convince readers that there are clear indications that the public is increasingly taking a greater interest in science and particularly in mathematics, and thus society in general has come to recognise, through different awards, privileges, and distinctions, the work of many mathematicians.

1. The Nobel Prize

It is common knowledge that there is no *Nobel Prize* for mathematics. In fact, several fields of human cultural and scientific development are not included in the list of Nobel Prizes, because they were not among the prizes established as part of Alfred Nobel's will, in which he claimed that "[. . .] the interest on which shall be annually distributed in the form of prizes to whose who, during the preceding year, shall have conferred the greatest benefit on mankind".

These benefits were to be found in work on physics, chemistry, physiology or medicine, literature, and peace. As such mathematics did not make Nobel's list. One popular explanation for this, albeit probably apocryphal, holds that one of Alfred Nobel's lovers left him for a famous mathematician of the day, and that he avenged himself on the mathematical community by leaving out mathematics from the scope of awards. However, other explanations also abound, such as the fact that an important award for mathematics already existed, the Scandinavian Mathematics Prize, and Alfred Nobel (Stockholm, 1833-1896) did not want to set himself up as a rival to the prize, and yet another reason given is that he was simply not interested in mathematics (see [5]).

Nevertheless, the Nobel Prize has frequently been awarded to mathematicians, more often for their contributions to physics and economics, but also occasionally to literature and chemistry (for more information, see [18] and [20]). There are also Nobel Prize winners who were trained in mathematics but whose work did not encompass this science.

2. The Abel Prize and the Fields Medal

The *Fields Medal* and the *Abel Prize* are the highest honour a mathematician can receive and they have often been described as the mathematician's "Nobel Prize". The status of a mathematician who receives such an award changes from highly respected researcher in a concrete area to celebrity in the mathematics community.

The *Abel Prize* is presented annually by the King of Norway to prominent mathematicians. Named after Norwegian mathematician Niels Henrik Abel (Nedstrand, 1802-1829), this award was established by the Government of Norway in 2002 on the occasion of the 200th anniversary of Niels Henrik Abel's birth and it was specifically intended to give the mathematicians their own equivalent of a Nobel Prize (see [8]).

The establishment of the Abel Prize was proposed almost a century before, but the dissolution of the union between the kingdoms of Sweden and Norway in 1905 ended the first attempt to create an Abel Prize. The Norwegian Academy of Science and Letters declares the winner of the Abel Prize each March after recommendation by the Abel Committee, which consists of five leading mathematicians. The first prize was awarded in 2003, and it went to

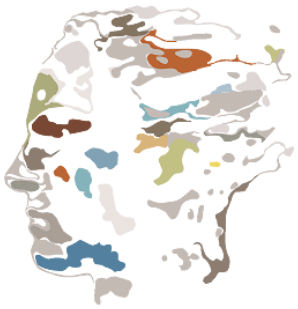

Figure 1: The Abel prize logo. Extracted from: https://commons.wikimedia.org/wiki/File:PREMIO_ABEL.gif, last accessed on July 18, 2019.

French mathematician Jean-Pierre Serre (Bages, 1926) for his role in shaping algebraic geometry and number theory. For more information see [34].

Another prestigious prize for mathematics is the *Fields medal,* which was fixed in the will of the mathematician John Charles Fields (Hamilton, 1863-1932). It was first awarded in 1936 to the mathematicians Lars Ahlfors (Helsinki, 1907-1996) and Jesse Douglas (New York, 1897-1965), and it is sometimes viewed as the most prestigious honour in existence for the discipline. It has been awarded every four years since 1950 at the International Congress of Mathematicians to researchers under 40. Hence the Fields Medal differs from the Nobel one in view of the age restriction mentioned above and the fact that it is awarded every four years. The medal bears Archimedes's profile on its reverse side (see Figure 2).

Figure 2: The Fields medal. Extracted from https://commons.wikimedia.org/w/index.php?curid=2277414, last accessed on July 18, 2019.

The youngest winner of the Fields Medal, at 27, was Jean-Pierre Serre in 1954. In 2006, Grigori Perelman (Saint Petersburg, 1966), who proved the Poincaré conjecture, refused his Fields Medal and did not attend the Congress held in Madrid [23]. The 2018 recipients, honoured for major contributions to their respective areas in mathematics, were Caucher Birkar, Alessio Figalli, Akshay Venkatesh, and Peter Scholze. It is worth mentioning that, in 2014, Maryam Mirzakhani (Tehran, 1977-2017), who died last year at the age of 40 years old, became the first woman as well as the first Iranian to win the Fields Medal. In the list of countries by number of Fields Medallists, United States, France, and Russia have the top three positions. For more information see [29].

3. Hilbert's Problems and the Millennium Problems

From time to time, mathematics has also made a splash in the press. When Andrew Wiles (Cambridge, 1923) announced that he had proved Fermat's Last Theorem, there was wide coverage of the event. Many journals and magazines in the world reported about the *Wolfskehl Prize*, an award offered by Paul Wolfskehl (Darmstadt, 1856-1906), a wealthy, charitable Jewish banker interested in mathematics who died in 1906. According to the terms of his will, 100,000 marks were set aside to the first person to prove Fermat's Last Theorem. Conditions for the prize were established and published in 1908, and there was a closing date of almost a century [2].

Fermat's Last Problem was not one of Hilbert's famous twenty-three problems but it was definitely related to at least one of them. The German mathematician David Hilbert (Königsberg, 1862-1943) established in 1900 a remarkably well rounded list of twenty-three unresolved problems, some of which came in families that spanned many areas. Hilbert presented ten of the problems at a speech at the Paris conference of the International Congress of Mathematicians in 1900, but the complete list of twenty-three problems was published later; the English translation appeared in 1902 in the Bulletin of the American Mathematical Society [9]. These became the focus of attention of many mathematicians for much of the twentieth century. As of today, most of the well-formulated problems are solved or partially resolved, although some of them (at least two of them) are still open; see [6] for more on Hilbert's problems.

The Riemann hypothesis, proposed by Bernhard Riemann (Breselenz, 1826-1866) is one of Hilbert's twenty-three problems that has not yet been resolved. This problem found new life in 2000 when a new set of problems appeared. The seven *Millennium Problems*, established in 2000 by a group of eminent mathematicians, with the promise of a million dollars to be awarded by the Clay Mathematics Institute, have been widely reported, and they constitute a strong stimulus for mathematical research (see [3]).[1] At the present time, only one of these problems has been resolved. This is the Poincaré hypothesis, which was proven in 2003 by the mathematician Grigori Perelman (Leningrad, 1966) who, incidentally, rejected the cash prize.[2]

It is worth mentioning that the Clay Mathematics Institute, founded in 1998, is a private, non-profit foundation dedicated to increasing and disseminating mathematical knowledge. For each one of the Millennium Problems, the institute had professional mathematicians in charge of it. Besides the Millennium Prize Problems, the Clay Mathematics Institute gives out various awards and sponsorships to promising mathematicians. In particular, the *Clay Research Award*, first awarded 1999, is an annual award in recognition of major breakthroughs in mathematical research.

In this line of soliciting innovative research via problem lists, we can also mention that in 2007 the Defense Advanced Research Projects Agency (DARPA) released a list of twenty-three challenging mathematical problems (alluding to Hilbert's famous list) with the goal of dramatically revolutionizing mathematics and thereby strengthening the United States Department of Defense's scientific and technological capabilities.[3] Some problems on the DARPA list have a crisp statement, but most are very broad and applied (Hilbert's problems mostly belonged to what we might call pure mathematics).

[1] 2000 was an exciting year for mathematics. Apart from the symbolic value of the year when these problems were proposed (exactly one hundred years after Hilbert posed his list), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Mathematical Union (IMU) declared it the World Year of Mathematics.

[2] This situation is not the only one in the mathematical community. Indeed, another example is Peter Scholze, one of the 2018 Fields Medalists. When he was 27, Scholze was awarded and chose to decline the *2016 New Horizons prize* for promising junior researchers, an award endowed with $100,000. It seems that many eminent mathematicians do not want money or fame and they think just solving a problem is a prize in itself.

[3] A copy of the original solicitation is available at `http://www.math.utk.edu/~vasili/refs/darpa07.MathChallenges.html`, last accessed on July 18, 2019. Also see [4].

4. Prominent Institutions and Worldwide Organisations

In the nineteenth century, during which extremely important advances occurred in mathematics, several prominent societies were formed. These include the *London Mathematical Society* (1865), the *Société Mathématique de France* (1872), and the *American Mathematical Society* (1888). These developments led to the implicit social legitimacy of a mathematical job [19]. Little by little, more and more mathematical institutions (and, in general, scientific ones) were emerging, which helped to recognize the relevant work of mathematicians in our society. These institutions have instituted several prizes that have been named after some eminent mathematicians.

In this context, we must mention the *International Mathematical Union* (IMU), formed in 1920, whose members are national mathematics organizations from more than eighty countries. IMU is devoted to international cooperation in the field of mathematics across the world and supports the International Congress of Mathematicians (ICM), held every four years. In addition to the Fields Medal, the IMU awards during the ICM: the *Gauss Prize,* which rewards mathematical results that have had the greatest impact on technology and daily life (first awarded in 2006, it is granted jointly by the International Mathematical Union (IMU) and the German Mathematical Society); the *Nevanlinna prize*, which celebrates progress in mathematical aspects of the information society (first awarded in 1982); the *Chern Medal*, which recognizes outstanding lifelong achievement of the highest level in the field of mathematics (first awarded in 2010, it is a joint effort of the IMU and the Chern Medal Foundation); the *Leelavati prize*, sponsored by Infosys, which is awarded for contributions towards increasing public awareness of mathematics (first awarded in 2010) [30], see Figure 3.

Figure 3: Gauss, Nevanlinna, and Chern medals. Retrieved from http://www.icm2018.org, last accessed on July 18, 2019.

In the context of applied mathematics, the *International Council for Industrial and Applied Mathematics* (ICIAM), formed in 1987, is a worldwide organisation for professional applied mathematics societies, and for other societies with a significant interest in industrial or applied mathematics. The Council works to advance the applications of mathematics in all parts of the world. ICIAM awards five major scientific prizes at the opening of the ICIAM Congresses: the *ICIAM Collatz Prize* for scientists under the age of 42; the *ICIAM Lagrange Prize* for exceptional career contributions; the *ICIAM Maxwell Prize* for originality in applied mathematics; the *ICIAM Pioneer Prize* for applied mathematical work in a new field; and the *ICIAM Su Buchin Prize* for contributions to emerging economies and human development [28]. Incidentally the last edition of the ICIAM Congress was held in Valencia, Spain, from 15th to 19th July 2019.

5. Awards from National and Regional Mathematical Societies

Several prizes for outstanding contributions to mathematics are awarded to mathematicians by a range of relevant national, regional, and international societies. The list of notable prizes, medals and awards in connection with mathematics is extensive, and it would be impossible to list them exhaustively for every country. We still make an effort below to provide a representative sample. Also see [7, 14, 37].

The *European Mathematical Society* (EMS) has as its members around sixty national mathematical societies in Europe. It is a learned society representing mathematicians throughout Europe, and promotes the development of all aspects of mathematics in Europe, in particular mathematical research, relations of mathematics to society, relations to European institutions, and mathematical education. Every four years, the EMS awards ten *EMS prizes* to young researchers with European nationality or who work in Europe and who are under 35, in recognition of their excellent contributions to mathematics [26]. In addition, the EMS awards the *Felix Klein prize* to outstanding mathematicians aged under 38 who have used sophisticated mathematical methods to solve an industrial problem, and the *Otto Neugebauer prize* which is awarded in recognition of highly original and influential work in the field of history of mathematics.

London Mathematical Society (LMS), the most prominent professional society for mathematics in the United Kingdom, awards several prizes as well [31].

The most prestigious award of this society is the *De Morgan Medal*, which has been given since 1884 (the first winner was Arthur Cayley) for outstanding contributions to mathematics every third year (in years divisible by 3) in memory of Augustus De Morgan, who was the first President of the society. Second only to the De Morgan Medal in prestige among the Society's awards, the *Pólya Prize*, first given in 1987, is awarded in the years in which the De Morgan Medal is not awarded. This prize, awarded in recognition of outstanding creativity in, imaginative exposition of, or distinguished contribution to mathematics, is named after famous Hungarian mathematician George Pólya, who was a member of the society for over sixty years. In the UK context, it is also worth mentioning the *Sylvester Medal,* a bronze medal awarded by the Royal Society for the encouragement of mathematical research. It was first awarded in 1901 and is named in honour of James Joseph Sylvester, the Savilian Professor of Geometry at the University of Oxford in the 1880s.

Mathematicians who reside in the United Kingdom (or have been educated there) can also be awarded by the LMS with the *Whitehead Prize* and the *Senior Whitehead Prize*, awarded yearly in memory of homotopy theory pioneer J. H. C. Whitehead. The *Naylor Prize and lectureship in Applied Mathematics* is awarded every two years in the context of, and influence on, the applications of mathematics, and lecturing gifts. The *Berwick Prize* and *Senior Berwick Prize* are two prizes awarded in alternating years in recognition of an outstanding piece of mathematical research published by the Society. The *Adams Prize* is one of the most prestigious prizes awarded by the University of Cambridge to a UK based mathematician for distinguished research in the Mathematical Sciences. Another prize of the LMS, which is awarded in even numbered years to a mathematician under 25 years of age, is the *Fröhlich Prize* for original and innovative work in any branch of mathematics. Finally, in collaboration with the Institute of Mathematics and its Applications, the LMS instituted in 2002 the David Crighton Medal, which is awarded triennially to a mathematician for services both to mathematics and to the mathematical community. Furthermore, the *Christopher Zeeman medal* was created in order to recognise and honour contributions made to engage the public with mathematics in Britain. The *Andreï Kolmogorov Medal* has been awarded annually since 2003 by the Royal Holloway College of the University of London to honour research building on the work of Andreï Kolmogorov in theoretical computer science and mathematics.

The *American Mathematical Society* (AMS), jointly with other American institutions, has established several prizes; see [24] for a complete list of prizes and awards from the AMS. The *Bôcher Memorial Prize* was founded in 1923 and it is awarded every three years for a notable research memoir in analysis that has appeared during the past six years in a recognized North American journal or was authored by a member of the Society. The *Frank Nelson Cole Prizes*, one for an outstanding contribution to algebra (the first awarded in 1928), and the other for an outstanding contribution to number theory (the first awarded in 1931), are named after Frank Nelson Cole, who served the Society for 25 years. The *Oswald Veblen Prize in Geometry*, founded in 1961, is an award granted by the AMS, every three years, for notable research in geometry or topology. The *David P. Robbins Prize* was endowed in 2005 for papers reporting novel and significant research in algebra, combinatorics or discrete mathematics, and it is awarded jointly by the AMS and the Mathematical Association of America (MAA). This prize recognizes papers with a significant experimental component on a topic that is broadly accessible and provide a simple statement of the problem and clear exposition of the work. The *Leonard Eisenbud Prize*, established in 2006, honours a single work or a series of works, published in the preceding six years, that brings mathematics and physics closer together. The *Chevalley Prize* was instituted in 2014 for notable work in Lie Theory published during the preceding six years. The *Fulkerson Prize* for outstanding papers in the area of discrete mathematics is sponsored jointly by the Mathematical Optimization Society (MOS) and the AMS. The *Ulf Grenander Prize*, founded in 2016, recognizes exceptional theoretical and applied contributions in stochastic theory and modeling. The *Leroy P. Steele Prizes* are awarded every year for distinguished research work and writing in the field of mathematics. Since 1993 there has been a formal division into three categories: for lifetime achievement, for mathematical exposition, and for seminal contribution to research. The *AMS Centennial Fellowship* was established by the AMS in 1973 and it is presented annually to outstanding mathematicians who have held the doctoral degree for between three and twelve years. The *Blumenthal Award*, founded by the AMS in 1993, was presented to the individual deemed to have made the most substantial contribution in research in the field of pure mathematics, and who was deemed to have the potential for future production of distinguished research in such field. The *Bertrand Russell Prize* of the AMS was established in 2016 to honour research or service contributions of mathematicians or related professionals to

promoting good in the world and recognizes the various ways that mathematics furthers human values. In addition, the *Stefan Bergman Prize* is a mathematical distinction that has been given since 1989. Finally the most recent prize of the AMS is the *AMS Mary P. Dolciani Prize for Excellence in Research*, funded by a grant from the Mary P. Dolciani Halloran Foundation. This prize recognizes a mathematician employed at an undergraduate institution who has an active research program in mathematics and a distinguished record of scholarship.

The *Society for Industrial and Applied Mathematics* (SIAM) exists to ensure the strongest interactions between mathematics and other scientific and technological communities through membership activities, publication of journals and books, and conferences. Toward these ends, the *Norbert Wiener Prize* and the *George David Birkhoff Prize in applied mathematics*, endowed in 1967 and provided jointly by the AMS and the SIAM, are awarded every three years for an outstanding contribution to applied mathematics in the highest and broadest sense. The SIAM also awards the *George Pólya Prize*, first given in 1969, which is named after Hungarian mathematician George Pólya. The prize is given every two years, alternately in two categories: for a notable application of combinatorial theory, and for a notable contribution in another area of interest to George Pólya such as approximation theory, complex analysis, number theory, orthogonal polynomials, probability theory, or mathematical discovery and learning. The *J.D. Crawford Prize* is a biennial award presented by the SIAM for achievements in the field of dynamical systems. The *Theodore von Kármán Prize,* founded in 1968, is awarded by the SIAM every fifth year to an individual in recognition of his or her notable application of mathematics to mechanics and/or the engineering sciences. The *SIAM/ACM Prize in Computational Science and Engineering* is awarded every two years by SIAM and the Association for Computing Machinery (ACM) in recognition of outstanding contributions to the development and use of mathematical and computational tools and methods for the solution of science and engineering problems. The *Josiah Willard Gibbs Lectureship* is an annually awarded prize that is intended not only for mathematicians, but also for physicists, chemists, biologists, physicians, and other scientists who have developed important applications of mathematics. The *James H. Wilkinson Award,* awarded since 1982, is connected with the numerical analysis and scientific computing. Other notable prizes awarded by the SIAM, including all the SIAM Activity Group prizes, can be seen in [35].

The *Mathematical Association of America* (MAA) also awards several prizes every year; see [32]. For example, the *Yueh-Gin Gung and Dr. Charles Y. Hu Award* for distinguished service to mathematics is a prestigious award made by the MAA that was first given in 1990 and is the successor to the Award for Distinguished Service to Mathematics, awarded since 1962. The *Chauvenet Prize*, the highest award for mathematical expository writing, is given by the MAA in recognition of an outstanding expository article on a mathematical topic. The *Carl B. Allendoerfer Award* is given by the MAA for expository excellence published in *Mathematics Magazine*. The *George Pólya Award*, established in 1976 and awarded since 1977, is given for quality articles published in the MAA-edited *College Mathematics Journal*.

Other awards for exposition and publishing exist. The *Joseph L. Doob Prize*, endowed in 2005 by the AMS, recognizes a single, relatively recent, outstanding research book that makes a seminal contribution to the research literature, reflects the highest standards of research exposition, and promises to have a deep and long-term impact in its area. The *Moore Prize*, established in 2002, is awarded by the AMS for an outstanding research article to have appeared in one of the AMS primary research journals. The *Levi L. Conant Prize* is a mathematics prize of the AMS which has been awarded since 2000 for outstanding expository papers published in the *Bulletin of the AMS* or the *Notices of the AMS* in the past five years. The *Frederick W. Lanchester Prize* is an Institute for Operations Research and the Management Sciences prize given for the best contribution to operations research and the management sciences published in English. Moreover, the *U.S. National Academy of Sciences Award in Mathematics* is awarded every four years (since 1988) for excellence of research in the mathematical sciences published within the past ten years.

The *French Academy of Sciences*, founded in 1666 by Louis XIV to encourage and protect the spirit of French scientific research, has also established several prizes [27]. The *Sophie Germain Prize* is a major annual mathematics prize that has been conferred since the year 2003. The *Leconte Prize* is a prize created in 1886 to recognize notable discoveries in mathematics, physics, chemistry, natural history or medicine. The *Émile Picard Medal*, which was established in 1946, is a medal awarded every 6 years to a mathematician. The *Servant Award*, created in 1952, is a prize awarded every two years alternately in the field of mathematical sciences and in the field of physical sciences.

The *Ampère de l'Électricité de France Prize* was founded in 1974 in honour of André-Marie Ampère to celebrate his 200th birthday in 1975; the award is granted to one or more French scientists for outstanding research work in mathematics or physics. The *Élie Cartan Prize* was created in 1980 and it is awarded every three years to a mathematician under 45 that developed a scientific research characterized by new ideas or resolved a difficult mathematical problem. The *Grande Médaille*, founded in 1997, is awarded annually to a researcher who has contributed decisively to the development of science. The *Jacques Herbrand Prize*, for mathematics and physics. The *Léonid Frank Award* is a distinction in mathematics created in 2006 for an European mathematician working in the field of pure or applied mathematics; the *Michel Montpetit Prize* for computer science and applied mathematics, awarded since 1977. The *Charles-Louis de Saulses De Freycinet Prize* is awarded every four years and it aims at encouraging researches in mathematics. The *Paul Doistau-Émile Blutet Prize* is a biennal prize awarded to a scientist doing research in mathematics. Moreover, we mention that in 19^{th} and 20^{th} centuries, the *Poncelet Prize,* created in 1868, was awarded for the advancement of the sciences, and mostly for the work in applied mathematics.

The *Société de Mathématiques Appliquées et Industrielles* (SMAI) is a French scientific society aiming to promote applied mathematics. SMAI was founded in 1983 to contribute to the development of applied mathematics for research, commercial applications, publications, teaching, and industrial training. This society, jointly with the Société Mathématique de France and the French Academy of Sciences, has established important prizes such as the *Blaise Pascal Prize* and the *Jacques-Louis-Lions Prize*, created in 1984 and 2003 respectively.

There are several other awards given in France. The *Thérèse Gautier Prize* is a four-year prize created in 2007. The *Mergier-Bourdeix Award* is given since 1987. The *Petit d'Ormoy, Carrière, Thébault Award* was established in 1943. The *Alexandre-Joannidès Prize* is given since 1958. The *Langevin Prize* is a prize awarded in mathematics, physics, chemistry, or biology as a tribute to the memory of French scholars assassinated by the Nazis in 1940-1945. The *Jaffé Prize* was created in 1930 to recognize works in pure or applied mathematics. The *Michel Monpetit Award* is a French scientific award created in 1977 to reward a researcher or engineer for his work in the field of applied mathematics or computer science. The Mathematical Sciences Foundation of Paris awards an annual prize for highlighting and

rewarding the excellence of a young researcher's career in France and abroad in fundamental and applied mathematics. The *Maurice-Audin Mathematics Prize,* created in 2004, is a French scientific prize awarded by the French Academy of Sciences to an Algerian mathematician practicing in Algeria and a French mathematician practicing in France.

Moreover, the *Institut de Mathématiques de Toulouse* created in 1989 the *Fermat prize of mathematical research* that rewards once every two years research works in fields where the contributions of Pierre de Fermat have been decisive. The *CNRS Gold medal*, presented annually by the French National Centre for Scientific Research and first awarded in 1954, is the highest scientific research award in France. Silver Medals are given to researchers for originality, quality, and importance, while Bronze Medals recognize initial fruitful results.

In Russia, the *Lobachevsky Prize*, awarded by the Russian Academy of Sciences, and the *Lobachevsky Medal*, awarded by the Kazan State University, are mathematical awards in honour of the famous mathematician Nikolai Ivanovich Lobachevsky, one of the discoverers of non-Euclidean geometry. The Lobachevsky Prize was endowed in 1896 and was to be awarded for the best recent book on a geometrical subject. Also the Russian Academy of Sciences awards the *Lomonosov Gold Medal*, the Academy's highest accolade, annually since 1959. Since 1962, the St Petersburg Mathematical Society awards the *Young Mathematician Prize* to a young mathematician for work of outstanding promise.

The German Mathematical Society has awarded the *Cantor medal* since 1990. It was named in honour of its first president, Georg Cantor, and it is awarded at most every second year during the yearly meetings of the society. The prize winners are German-speaking mathematicians who have made significant contributions. The *Gauss Lectureship*, established in 2001, is an annually awarded mathematical distinction, named in honour of Carl Friedrich Gauss.[4] Other distinguished prizes given in Germany include the *Gottfried Wilhelm Leibniz Prize*. Established in 1985, this is a program of the German Research Foundation which awards prizes to exceptional scientists and academics, working at a research institution in Germany or at a German research institution abroad, for their outstanding achievements in a field of research.

[4] https://www.mathematik.de/dmv/gauss-vorlesungen, accessed on July 19, 2019.

The *Humboldt Prize* is an award given by the Alexander von Humboldt Foundation of Germany to internationally renowned scientists and scholars who work outside of Germany. The *von Kaven Prize* is a mathematical distinction awarded each year, with the support of the German Foundation for Research, to a mathematician working in the European Union who has demonstrated scientific excellence. The *Karl Georg Prize Christian von Staudt* has been awarded every 3 to 6 years since 1991 to one or more mathematicians, and rewards outstanding mathematical work done in German organizations teaching or research in the field of mathematics (funds for the prize money are provided by the Otto-und-Edith-Haupt Foundation). The *Hausdorff Prize* is a German mathematical distinction which is awarded by the University of Bonn in recognition of the best thesis of the year. The *Oberwolfach Prize* is awarded approximately every three years, since 1991, to young European mathematicians under 35 years of age (it was founded by the Oberwolfach Foundation). The *Helmholtz Medal* and the *Leibniz Medal*, awarded biennially by the Berlin-Brandenburg Academy of Sciences and Humanities, honours outstanding lifetime achievements in the fields of humanities, social sciences, mathematics and natural sciences, biology, medicine and engineering sciences, and in the promotion of science, respectively.

The *Kyoto Prizes*, awarded annually since 1985, are Japan's highest private awards for global achievement, and they are regarded by many as the most prestigious award available in fields that are traditionally not honoured with a Nobel prize. The Kyoto Prize in Basic Sciences includes the field of mathematics. Three relevant prizes given in Japan are the *Algebra*, *Analysis*, and *Geometry Prizes*, established respectively in 1998, 2002, and 1987, which are awards granted by the Mathematical Society of Japan (MSJ), for the recognition of significant or long-time research works in the field of algebra, analysis, and geometry, respectively. Other prizes by the MSJ are the *Spring and Autumn Prizes*, the *Iyanaga Prize* (awarded from 1973 to 1987) and the *Seki-Takakazu Prize* (awarded from 1995 to 2007).[5]

The International Congress of Chinese Mathematicians is held annually and, on the occasion of the celebration of this congress, the *Chern Prize* has been awarded since 2001. Moreover, the *Morningside Medal of Mathematics* is awarded since 1998 to exceptional mathematicians of Chinese descent un-

[5] http://mathsoc.jp/en/list/winners-list.html, last accessed on July 19, 2019.

der the age of forty-five for their seminal achievements in mathematics and applied mathematics. The *Shaw Prize in Mathematical Sciences*, organized since 2002 by the Shaw Prize Foundation based in Hong Kong, is an international award to honour individuals who are currently active and who have recently achieved distinguished and significant advances.

The Indian National Science Academy awards for work in the mathematical sciences the *Srinivasa Ramanujan Medal*, named after the Indian mathematician Srinivasa Ramanujan. Young mathematicians judged to have done outstanding work in Ramanujan's fields of interest can be awarded with the *SASTRA Ramanujan Prize* founded by the Shanmugha Arts, Science, Technology & Research Academy, located near Srinivasa Ramanujan's hometown. The age limit for the prize has been set at 32 (the age at which Ramanujan died). The name of Ramanujan is also included in the *ICTP Ramanujan Prize for Young Mathematicians from Developing Countries*, a prize awarded annually since 2005 by the International Centre for Theoretical Physics.

The Australian Mathematical Society established in 1981 the *Australian Mathematical Society Medal* for distinguished mathematical sciences research by society members under the age of 40 years, a significant portion of whose research was carried out in Australia. This society also established in 2001 the *George Szekeres Medal* for outstanding research contributions over a fifteen-year period. The Australian Academy of Science also instituted several prizes. In 1932 the *Thomas Ranken Lyle Medal* is awarded at most every two years to a mathematician or physicist for his or her outstanding research accomplishments. The *Hannan Medal in the Mathematical Sciences* is awarded every two years to recognize achievements by Australians in the fields of pure mathematics, applied and computational mathematics, and statistical science. The *Moran Medal in Statistical Sciences* is awarded every two years by this academy to recognize outstanding research by Australian scientists under 40 years of age in the fields of applied probability, biometrics, mathematical genetics, psychometrics, and statistics.

The Canadian Mathematical Society has also founded several awards. It constituted in 1968 the *Jeffery-Williams Prize*, a mathematics award presented annually to individuals in recognition of outstanding contributions to mathematical research. It established in 1978 the *Coxeter-James Prize*, given annually to young mathematicians in recognition of outstanding contributions to mathematical research. The *Adrien Pouliot Award* was first awarded in 1995

and it is presented annually to individuals or teams in recognition of significant contributions to mathematics education in Canada. The *John L. Synge Award* is an award by the Royal Society of Canada, created in 1986, for outstanding research in any branch of the mathematical sciencesh. The *CRM-Fields-PIMS Prize* is a Canadian award in the mathematical sciences which is given annually by three Canadian mathematics institutes: the Centre de Recherches Mathématiques, the Fields Institute, and the Pacific Institute for the Mathematical Sciencesh. The *André Aisenstadt Prize*, awarded annually since 1992, recognizes a young Canadian mathematician's outstanding achievement in pure or applied mathematics. The *David-Borwein Award* is awarded since 2006 to Canadian mathematicians who have made an outstanding and sustained contribution to mathematics. The *G. de B. Robinson Award* is a mathematical award given by the Canadian Mathematical Society to recognize the best articles in the *Canadian Journal of Mathematics* and the *Canadian Mathematical Bulletin.*

The *Rolf Schock Prizes*, first awarded in Sweden in 1993, are awarded every three years in four categories. In particular, the international prize for mathematics is decided by the Royal Swedish Academy of Sciences. The Royal Swedish Academy of Sciences jointly with the Crafoord Foundation in Lund also awards the *Crafoord Prize,* established in 1980, to outstanding scientists in Mathematics and Astronomy, Biosciences, Geosciences or Polyarthritis.

A well-known prize is the *Wolf Prize in Mathematics, which is* given since 1978 by the Wolf Foundation in Israel and it is one of the six Wolf Prizes established by this foundation. Also in Israel, the *Anna and Lajos Erdős Prize in Mathematics*, founded in 1977 in honour of Paul Erdös's parents, is a prize given annually, or biannually, by the Israel Mathematical Union to an Israeli mathematician. The name was changed from *Erdős Prize* in 1996, after Erdős's death to reflect his original wishes.

In Hungary, the *Paul Erdős Prize* is given to Hungarian mathematicians no older than 40 by the Mathematics Department of the Hungarian Academy of Sciences. The Hungarian Academy of Sciences awards several other prizes. The *Alfréd Rényi Prize* is awarded biannually in recognition of outstanding performance in mathematics research in the previous five-year period. The *International János Bolyai Prize of Mathematics*, also by the Hungarian Academy of Sciences, is an international prize awarded every five years to mathematicians who have published a monograph in the last ten years.

In Poland, the *Stefan-Banach Prize,* handed over since the end of the Second World War, is a mathematical prize awarded by the Polish Mathematical Society to Polish mathematicians in memory of Stefan Banach. Another mathematics prize by the Polish Academy of Sciences is called the *Stefan Banach Medal* and rewards outstanding achievements in mathematical sciences.

Other countries have special awards for mathematical achievements. The *Hector Medal* is a science award given by the Royal Society of New Zealand to researchers working in New Zealand. It is awarded annually in rotation for different sciences, and currently there are three: chemical sciences; physical sciences; mathematical and information sciences. In 1991 it was overtaken by the *Rutherford Medal* as the highest award given by the Royal Society of New Zealand. In Colombia, the Colombian Mathematical Society awards the *National Mathematics Award* to those people who have excelled in their professional work and who, through it, have contributed in a fundamental way to the development of mathematics in the country.[6] Scientists in Pakistan, below 35 years of age, can be awarded with the prestigious *Abdus Salam Award* in the fields of chemistry, mathematics, physics or biology.[7]

Instituted in 1955, the *Prize of the Austrian Mathematical Society* is the highest mathematics award in Austria, awarded for outstanding achievements every year to a promising young mathematician, whose work was performed in Austria. In Scotland, the Edinburgh Mathematical Society established in 1961 the *Sir Edmund Whittaker Memorial Prize*, awarded every four years to an outstanding young mathematician with a connection to Scotland. The *Keith Medal* is a prize awarded since 1827 by the Royal Society of Edinburgh, Scotland's national academy, for a paper published in the society's scientific journals, preference given to a paper containing a discovery, either in mathematics or earth sciences. In Belgium, the *Eugène-Catalan prize*, founded in 1964 by the Royal Academy of Science of Belgium, is awarded every five years to a Belgian or French scientist (recently extended to include European Union nationals) for a significant advance in the pure mathematical sciences. The *Brouwer Medal,* the most prestigious mathematical prize in Netherlands, is awarded every three years by the Royal

[6] https://www-history.mcs.st-andrews.ac.uk/Societies/Colombian.html, last accessed on July 19, 2019.

[7] https://www.ictp.it/about-ictp/prizes-awards/spirit-of-abdus-salam-award.aspx, last accessed on July 19, 2019.

Mathematical Society of Netherlands. The *Van Wijngaarden Award,* created in 2006, is another distinction in Netherlands and is awarded every five years.

The Italian Mathematical Union awards the *Bartolozzi Prize* every two years to an Italian mathematician below the age of 34. The *Caccioppoli Prize* is awarded every four years on the occasion of the Italian Mathematical Union conference to an Italian mathematician no older than 38 who established a wide international reputation. The *Vinti Prize* is awarded since 1998 to an Italian mathematician no older than 40, in recognition of his/her contributions to the field of Mathematical Analysis. The *Stampacchia Medal* is an international prize awarded every three years together with the Ettore Majorana Foundation (Erice) to mathematicians no older than 35 in recognition of outstanding contributions to the field of Calculus of Variations and related applications. The *International Balzan Prize Foundation awards* since 1978 four annual monetary prizes to people or organizations who have made outstanding achievements in the fields of humanities, natural sciences, culture, as well as for endeavours for peace and the brotherhood of man. The *Pythagoras Award,* awarded for the first time in 2004, is made each year by the City of Crotone on behalf of the University of Calabria.

The Royal Spanish Mathematical Society (RSME), founded in 1911, awards several prizes.[8] The *José Luis Rubio de Francia Awards*, given annually since 2004, are the highest distinction awarded by the RSME to young Spanish researchers or scientists who have done their work in Spain. The *Vicent Caselles Prize*, first awarded in 2015, is an annual distinction to young Spanish researchers whose doctoral work is pioneering and influential in international research in mathematics (the BBVA Foundation also collaborates in this award). The *RSME Medals* are distinctions that express public recognition of the community to people highlighted by their relevant, exceptional and continuous contributions in any field of mathematics (they were first awarded in 2015). We must also mention the prestigious *Princess of Asturias Awards for Scientific and Technical Research* (called the *Prince of Asturias Awards for Scientific and Technical Research* until 2014) that are granted since 1981 to scientists whose discoveries or research contribute to the progress of humanity in the fields of mathematics, physics, chemistry, and biology, as well as techniques and technologies related to them.

[8] https://www.rsme.es/, last accessed on July 19, 2019.

Other prizes given in Spain include the *Julio Rey Pastor National Research Prize*. Instituted in 2001, this is an award for mathematics and information and communication technologies from the Spanish Ministry of Education and Science. The *Fronteras del Conocimiento Prize* from BBVA Foundation and CSIC, recognizes and encourages research and cultural creation of excellence, especially contributions of singular impact for their originality and meaning. The *Ferran Sunyer i Balaguer Prize* is awarded annually for a book on a current area of mathematics, to which the laureate has made crucial contributions. The *Antonio Valle Award* is given by the Spanish Society of Applied Mathematics to a young researcher who has shown excellence in original mathematical work in any branch of mathematics that has an applied component. The *prize for the best article in the SeMA Journal* was established in 2009 with the aim of promoting the publication of quality works, both scientific works and works disseminating mathematics.

6. Prizes in Specific Branches of Mathematics

Several prizes are awarded in the context of specific branches of mathematics by a range of awarding bodies. For example the Institute of Combinatorics and its Applications (ICA) awards the *Euler Medals* annually for distinguished career contributions to combinatorics by a member of the institute who is still active in research (the ICA also awards the *Hall Medal* in recognition of outstanding work by members under 40 years of age, and the *Kirkman Medal* in recognition of outstanding work by members within four years of graduation). The *Ostrowski Prize*, for outstanding achievements in pure mathematics and the foundations of numerical mathematics, is given every odd year since 1989 for outstanding mathematical achievement judged by an international jury from the universities of Basel, Jerusalem, Waterloo, and the academies of Denmark and the Netherlands. The *Heinz Hopf Prize* is awarded every two years at ETH Zurich for outstanding scientific work in the field of pure mathematics. The *Ribenboim Prize* is awarded by the Canadian Number Theory Association for distinguished research in number theory. The *Alfred Ackermann-Teubner Memorial Award for the Promotion of Mathematical Sciences* was established in 1912 to recognize work in mathematical analysis. There is also the *European Prize in Combinatorics* (a prize for research in combinatorics which is awarded biennially at Eurocomb, the European conference on combinatorics, graph theory, and applications).

The *Salem Prize* is awarded every year since 1968 to a young mathematician judged to have done outstanding work in primarily the theory of Fourier series. The *Michael Brin Prize in Dynamical Systems*, abbreviated as the *Brin Prize*, is awarded since 2008 to mathematicians who have made outstanding advances in the field of dynamical systems and are within 14 years of their PhD. The *Cor Baayen Award* is an annual award given to a researcher in computer science and applied mathematics. The *Leslie Fox Prize for Numerical Analysis* of the Institute of Mathematics and its Applications is a biennial prize established in 1985 which honours young numerical analysts worldwide. The *Louis Bachelier Prize* is a biennial prize in applied mathematics jointly awarded by the LMS, the Natixis Foundation for Quantitative Research, and the Société de Mathématiques Appliquées et Industrielles, in recognition for exceptional contributions to mathematical modelling in finance, insurance, risk management, and/or scientific computing applied to finance and insurance. The *Emil Artin Junior Prize in Mathematics*, established in 2001, is presented usually every year to a former student of an Armenian university, who is under the age of thirty-five, for outstanding contributions in algebra, geometry, topology, and number theory. The *Shewhart Medal* is awarded for outstanding technical leadership in the field of modern quality control, especially through the development to its theory, principles, and techniques. The *André Lichnerowicz Prize in Poisson Geometry* was endowed in 2008 for notable contributions to Poisson geometry. The *Popov Prize* is awarded every three years since 1995 by the Interdisciplinary Mathematics Institute of the University of South Carolina for contributions to the theory of approximation and related mathematical fields.

The *George B. Dantzig Prize* and the *Lagrange Prize in Continuous Optimization,* awarded every three years since 1982 and 2003, respectively, are distinctions by the SIAM and the Mathematical Optimization Society in the fields of operations research and computer science, and mathematical optimization, respectively. The *Stephen Smale Award* is awarded since 2011 by the Society for the Foundations of Computational Mathematics to recognize major contributions in improving the understanding of the connections between mathematics and computation, including the interfaces between pure and applied mathematics, numerical analysis and computer science.

The *Karp Prize* is awarded by the Association for Symbolic Logic in the United States every five years since 1978. The *Hausdorff Medal* is awarded every two years by the European Society of Theory of Sets for works that

have had the most influence in set theory among those published in the five years preceding the awarding of the medal. The *Turing Award,* generally recognized as the highest distinction in computer science and the Nobel Prize of computing, is an annual prize since 1966 given by the Association for Computing Machinery to an individual selected for contributions of lasting and major technical importance to computer science.

The *Lyapunov* Award, established in 2005, in recognition of lifelong contributions to the field of nonlinear dynamics. The *Henri Poincaré Prize*, sponsored by the Daniel Iagolnitzer Foundation, was created in 1997 to recognize and support young people of exceptional promise who have already made outstanding contributions to the field of mathematical physics. The *Peter Henrici Prize* is awarded by SIAM and ETH Zurich for contributions to applied analysis and numerical analysis and/or for exposition appropriate for applied mathematics and scientific computing.

In the branch of probability and statistics, important prizes include the *Michel Loève International Prize in Probability,* the *Line Prize in Probability,* the *Guy Medals* (awarded in three categories; Gold, Silver and Bronze), the *Henri Willem Methorst Medal*, the *Wilks Memorial Award*, the *COPSS Presidents' Award*, the *Rollo Davidson Prize*, the *Norwegian Statistics Sverdrup Prize,* the *Marc Yor Prize in Probability*, the *Snedecor Award*, the *Ethel Newbold Prize,* the *Wolfgang-Döblin Prize* in Probability, the *Ito Prize* in Probability, and the *George Box Medal*.

7. Recognizing Women in Mathematics

Most people think of a man when asked to think of a mathematician. However, as the general interest in mathematics is increasing, so is the visibility of the work of female mathematicians. Several organizations and institutions exert significant efforts to help with this development. As might be expected, prizes play a role in these efforts.

The Association for Women in Mathematics (AWM), founded in 1971, is a professional society whose mission is to encourage women and girls to study and to have active careers in the mathematical sciences, and to promote equal opportunity for and the equal treatment of women and girls in the mathematical sciences. AWM established several awards and prizes to honour the works of women mathematicians, see [25] for more details.

Most significantly AWM has established the *Emmy Noether Lectures* in 1980 to honour women who have made fundamental and sustained contributions to the mathematical sciences. In 2013 the lectureship was renamed the AWM-AMS Noether Lecture and since 2015 is sponsored jointly with the AMS.

Emmy Noether was an outstanding mathematician and it is not surprising that her name would be associated with a prize in mathematics. It is worth mentioning that several other relevant prizes are named after great women mathematicians. For example, the *Sophie Germain Prize* is an annual mathematics prize from the French Academy of Sciences conferred since the year 2003 in honour of Sophie Germain (Paris, 1776-1831), a famous French mathematician, physicist, and philosopher.

The *Sofia-Kovalevskaya Prize* is a scientific distinction awarded every two years since 2002 by the Alexander von Humboldt Foundation in Germany. This award is given to promising young university graduates to pursue their research in the sciences or the arts and humanities. Moreover, an homonymous award, the *Kovalevskaya Prize*, is intended to distinguish and promote scientific research among women scientists in developing countries: Vietnam, Peru, Mexico, Cuba, South Africa. It has been awarded since 1985. Also, the *AWM-SIAM Sonia Kovalevsky Lecture* is awarded annually since 2003 by the AWM and SIAM to highlight significant contributions of women to applied or computational mathematics.

The Committee of Presidents of Statistical Societies established the *Florence Nightingale David Award*, awarded in odd-numbered years only and first awarded in 2001, which recognizes a female statistician who exemplifies the contributions of Florence Nightingale David, an accomplished statistician in combinatorial probability theory; the *Elizabeth L. Scott Award*, which recognizes in even numbered years an individual who exemplifies the contributions of Elizabeth L. Scott's lifelong efforts to further the careers of women in academia. Also, the *Janet L. Norwood Award* is presented annually by the School of Public Health at Birmingham to recognize outstanding achievement by a woman in the statistical sciences.

Other important prizes established to honour women who have made distinguished contributions to mathematics include the *Ruth Lyttle Satter Prize* in Mathematics, a bi-annual prize established in 1991 and presented by the

AMS in recognition of an outstanding contribution to mathematics research by a woman in the previous six years. Established in 1996 and named after the mathematician Etta Z. Falconer, the *Etta Z. Falconer Lecture* is an award and lecture series sponsored by the AWM and the MAA. The *Krieger-Nelson Prize* is presented since 1995 by the Canadian Mathematical Society in recognition of an outstanding woman in mathematics. The *AWM-Sadosky Prize in Analysis* is awarded to an outstanding young female researcher in mathematical analysis. Other distinctions awarded by the AWM include the *Michler Memorial Award*, the *Schafer Prize* (awarded since 1990 to an undergraduate woman in recognition of excellence in mathematics), and the *AWM-Microsoft Research Prize* (awarded to recognize exceptional research in algebra by an early-career woman).

It is worth mentioning the recent creation of fellowships and other opportunities that seek to address the paucity of women at the highest levels of research in mathematics. For example, the *Joan and Joseph Birman Fellowship for Women Scholars*, established in 2015 by AWM, offers exceptionally talented women extra research support during their mid-career years. In this context, the research network conferences, sponsored by AWM,[9] and the Summer Research for Women in Mathematics program sponsored by the Mathematical Sciences Research Institute (MSRI)[10] should also be noted as related institutional efforts.

8. The Popularization of Mathematics

Ensuring that society recognises the value of mathematics and its study is no easy undertaking for researchers, yet it is a fundamental task. Television and radio programmes, together with journals, books, magazines, films, documentaries, and scientific websites also represent a very useful instrument in this regard. Some well-known disseminators of mathematics include Ian Stewart (Folkestone, 1945), a science fiction writer and mathematician; David Herbert Fowler (Blackburn, 1937-2004), mathematician and historian; and Martin Gardner (Tulsa, 1914-2010), a popular writer known for his books on recreational mathematics.

[9] https://awmadvance.org/research-networks/, last accessed on July 18, 2019.
[10] http://www.msri.org/srw2019 last accessed on July 18, 2019.

In this regard, one expert who manages to combine scientific research with the entertainment world is Jin Akiyama (Tokyo, 1946), the most famous mathematician in Japan who has long hosted a programme with large audiences bringing recreational mathematics to the general public. Marcus du Satoy (London, 1965) is a well-known British scientist who has dedicated several BBC programmes entirely to mathematics. Other representative names are Clifford A. Pickover (New Jersey, 1957), Simon Singh (Wellington, 1964), Adrián Paenza (Buenos Aires, 1949), and Antonio Pérez (Madrid, 1954), who hosted a TVE program called *Mathematical Universe*, for which I hold great affection.

The *Leelavati Prize*, as noted above in Section 4, is not intended to reward mathematical research, but rather dissemination activities in the widest possible sense. Awarded every four years, it was established in 2010 and, for the moment, the prize winners are:

2010: Simon Singh, a British popular science author, theoretical and particle physicist, journalist, and TV producer, whose works largely contain a strong mathematical element. Singh has also produced documentaries and works for television to accompany his books:

2014: Adrián Paenza, an Argentine journalist and PhD in mathematical sciences who was awarded for his decisive contributions to changing the mind of a whole country about the way it perceives mathematics in daily life;

2018: Ali Nesin (Istanbul, 1957), founder of Nesin Mathematics, Art, and Philosophy Villages, was awarded for his outstanding contributions towards increasing public awareness of mathematics in Turkey.

Luckily, nowadays there exist more and more prizes that are given in connection with the popularization of mathematics. For example, the Societé Mathematique de France created the *D'Alembert Prize* to reward an action (book, radio or TV programmes, websites, apps, etc.) which spread knowledge about mathematics and its recent developments to a wide audience. The *JPBM Communications Award,* from the SIAM, the AMS, the MAA, and the American Statistical Association, is given annually to reward and encourage communicators who, on a sustained basis, bring mathematical ideas and information to non-mathematical audiences.

Gradually other organizations are also beginning to recognize work in this area. The International Commission on the History of Mathematics founded in 1989 the *Kenneth O. May Prize and Medal in History of Mathematics*, an award for the encouragement and promotion of the history of mathematics internationally. Besides the *Otto Neugebauer prize* from the EMS, awarded in recognition of highly original and influential work in the field of history of mathematics, the *Albert Leon Whiteman Memorial Prize,* established in 1998, is awarded by the AMS for notable exposition and exceptional scholarship in the history of mathematics. The *Hirst Prize and Lectureship,* in 2015, was given for contributions to the history of mathematics as a part of the celebrations to mark the LMS 150$^{\text{th}}$ anniversary. Another example is given by the International Congress of Chinese Mathematicians, which presents the *International Cooperation Award* to individuals who promote mathematics through collaboration, teaching, and other forms of support.

In media terms, mathematicians have also gained extensive publicity at the box office and on the big screen and television. Films such as *A Beautiful Mind* (Ron Howard, 2002), *The Imitation Game* (Morten Tyldum, 2014), *Good Will Hunting* (Gus Van Sant, 1997), *Fermat's Room* (Luís Piedrahita, Rodrigo Sopeña, 2007), *Ágora* (Alejandro Amenábar, 2009), *The Oxford murders* (Alex de la Iglesia, 2008), *Moebius* (Gustavo Mosquera, 1996), *Cube* (Vincenzo Natali, 1997), *The Man Who Knew Infinity* (Matt Brown, 2015), or *Hidden Figures* (Theodore Melfi, 2016), as well as TV series such as *Numb3rs* (CBS) and *The Big Bang Theory* (CBS) have helped to make the general public aware of some of the most outstanding personalities or problems in the world of mathematics. In this line, for example, the creators of *Numb3rs* were awarded in 2005 with the *Carl Sagan Award for Public Understanding of Science*, a significant award to individuals who have become concurrently accomplished as researchers and/or educators, and as widely recognized magnifiers of the public's understanding of science.

When we are discussing film and mathematics, we cannot avoid mentioning the so-called *Oracle of Bacon* or the Bacon number, which is basically an actor's collaborative distance from the actor Kevin Bacon (Philadelphia, 1958) who has starred in many films. Mathematics boasts an equivalent to this construct in the form of the *Erdös number,* named after Paul Erdős, one of the most prolific mathematicians in terms of scientific publications, including some 1500 articles and over 500 written jointly with other authors.

So Erdős (Budapest, 1913-1996) has an Erdős number equalling 0, any person who has published jointly with him has an Erdős number equal to 1, and anyone who has published with a joint author of Erdős has an Erdős number of 2, etc. Analogously, there is a *Sabbath number*, which measures the collaborative distance in relation to the British rock band Black Sabbath. A combined *Erdös-Bacon-Sabbath number* is supposedly accessible only to such multitalented individuals as have acting, music, and mathematical sciences in their portfolio. Stephen Hawking has the lowest Erdös-Bacon-Sabbath number recorded, 8, with an Erdös number of 4, and Bacon and Sabbath numbers of 2 each.

There are several prizes to recognize dissemination work done through books. For example, the *Euler Book Prize* is given annually at the Joint Mathematics Meetings by the MAA to an outstanding book in mathematics that is likely to improve the public view of the field. This prize was founded in 2005 and was first given in 2007, as part of the MAA Year of Euler celebration. Also, the *Beckenbach Book Prize*, established in 1986 and the successor to the MAA Book Prize, is intended to recognize the authors of a distinguished, innovative book published by the MAA and to encourage the writing of such books. Moreover, the *Paul R. Halmos-Lester R. Ford Award*, first awarded in 1964, is connected with articles published in the *American Mathematical Monthly* or *Mathematics Magazine*, which publish expository work intended for a wide audience of mathematicians that offer lively, readable, and appealing exposition on a wide range of mathematical topics and the profession. There is also the Chandler Davis Prize for Expository Excellence, established in 2014 and given annually to the authors of an article or essay of outstanding expository quality published in *the Mathematical Intelligencer* in the three previous calendar years.

9. Mathematics competitions

There are several mathematical competitions that get significant media coverage year after year, such as the national and international mathematical olympiads. One of the reasons to participate in mathematics competitions or mathematical olympiads is the challenge and the opportunity they provide, to measure one's own skills with those of the other contestants. In particular, if you have developed a love of mathematics, addressing and solving interesting problems with a certain aesthetic yields immense joy.

Another reason that encourages many young people to train for and compete in mathematical olympiads is the fact that the results obtained in them and the skills associated with such particiation are often used as merits in selection tests, in granting scholarships, and in pursuing studies. In any case, many students join the mathematics olympics training programs because they have the desire to discover their innate skills, develop their potential to the limit, and face and overcome mathematical challenges.

The International Mathematical Olympiad (IMO), the oldest of the International Science Olympiads, is an annual six-problem mathematical olympiad for pre-college students [11], also see [22]. Gold medals are awarded to the highest ranked participants. More than a hundred countries, representing over 90% of the world's population, send teams of up to six students. In the last two decades, the IMO has become an international institution with impact in a large number of countries around the world, fostering the talent of young mathematicians and promoting a certain approach to complex but basic mathematics.

IMO-type mathematical competitions have established their own style of problems, which do not require a very broad knowledge of mathematics and are easy to formulate. However, their resolution is difficult and takes imagination, careful reasoning, and high degree of original thinking. Many mathematicians discovered their love for mathematics through their participation in this type of competitions. In the so-called Hall of Fame of the IMO, there are many famous mathematicians, including several winners of Fields medals, Nevanlinna awardees, and others with important distinctions. In this way, the IMO has acquired its full maturity and its status worldwide. The media coverage about this event includes a BBC fictional film titled $X+Y$ released in 2014 that tells the story of an autistic boy who took part in the Olympiad.

In the United States, the MAA's American Mathematics Competitions program leads the nation in strengthening the mathematical capabilities of the next generation of problem-solvers [33]. This program consists of a series of examinations and curriculum materials that build problem-solving skills and mathematical knowledge in middle and high school students. Through classroom resources and friendly competition, it helps America's educators identify talent and foster a love of mathematics. In Singapore, there are many wonderful educational programs and mathematics contests which children can participate [21].

There are other important competitions too. For example, the *William Lowell Putnam Mathematical Competition* is an annual mathematics competition for undergraduate college students enrolled at institutions of higher learning in the United States and Canada. It is sometimes considered to be the most prestigious university-level mathematics examination in the world, and its difficulty is such that the median score is often zero or one (out of 120) despite being attempted by students specializing in mathematics. Each competitor attempts to solve twelve problems, which can typically be solved with only basic knowledge of college mathematics but require extensive creative thinking. The *SIAM Award* in the *Mathematical Contest in Modeling* is awarded to two of the teams judged "Outstanding" in the Mathematical Contest in Modeling administered annually by the Consortium for Mathematics and Its Applications.

Other international and regional mathematics competitions are the *Mathematical Kangoroo*, the *Tournament of the Towns*, the *Championnat International de Jeux Mathématiques et Logiques, the Mediterranean Mathematics Competition,* the *North East Asian Mathematics Competition*, the *South East Asian Mathematics Competition*, the *Nordic Mathematical Contest* or the *Iberoamerican Mathematical Olympiad*. Other competitions can be viewed in [36].

The *RSA Factoring Challenge*, a challenge put forward by RSA Laboratories in 1991 and ended in 2007, had a wide coverage. The main purpose was to encourage research into computational number theory and the practical difficulty of factoring large integer numbers and cracking RSA keys used in cryptography. They published a list of numbers with exactly two prime factors, known as the RSA numbers, which were generated on a computer with no network connection of any kind, with an important cash prize for the successful factorization of some of them.

The *Paul Erdős Award*, first awarded in 1996, is given by the World Federation of National Mathematics Competitions for those who have played a significant role in the development of mathematical challenges at the national or international level and which have been a stimulus for the enrichment of mathematics learning. This federation also awards the *David Hilbert Award*, first awarded in 1991, to acknowledge mathematicians who have contributed to the development of mathematics worldwide.

The University of Cambridge, England, honours outstanding students of its undergraduate course, called the *Mathematical Tripos*. It is a three-year or a four-year course that is taught in the Faculty of Mathematics and it is widely considered to be a very tough course, and correspondingly rewarding. The range of subjects offered is exceptionally wide. From about 1780 to 1909, the *Old Tripos* was distinguished by a number of features, including the publication of an order of merit of successful candidates, and the difficulty of the mathematical problems set for solution. The list of *wranglers*, students who gain first-class honours in the third year of the course, became in time the subject of a great deal of public attention. Other annual awards to students of the Mathematical Tripos are for example the *Mayhew Prize* and the *Smith-Knight Prize*, awarded to the student showing the greatest distinction in applied mathematics and a research student in mathematics, respectively.

Other notable awards for talented young students include the *Epsilon Awards for Young Scholars Programs*, which support existing summer programs for mathematically talented high school students. These awards get their name from the word that Paul Erdős used to describe a child: epsilon, a word used in mathematics to denote a small quantity. The *Karl Menger Award* from the AMS is given to pre-college students in mathematics as well as mathematically-oriented projects in computer science, physics, and engineering at the Intel International Science and Engineering Fair. The *Junior Fermat Prize in Mathematics* is a research prize in mathematics created in Toulouse in 1989, and awarded every two years, to reward the contribution of a student from French high schools or universities. The *Evaristé Galois Prize*, established in 1962, is aimed at masters or doctorate students for a research, bibliography, or essay on mathematics. The *Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student*, founded in 1995, is an annual award given to an undergraduate student in the United States, Canada, or Mexico who demonstrates superior mathematics research. Other regional prizes include the *Taylor Prize in Mathematics*, for a graduate student of mathematics at the George Washington University; the *Professor Van Amringe Mathematical Prize* from the Department of Mathematics at Columbia University to students who are deemed most proficient in their class in the mathematical subjects designated during the year of the award; the *Frederic Esser Nemmers Prize* in Mathematics, awarded biennially from Northwestern University; the *Tricerri Prize* for doctorate students from an Italian university with a thesis about differential geometry topics.

The *Frank and Brennie Morgan Prize* and the *SIAM Student Paper Prize* are awarded annually for outstanding research in mathematics by students. The *Wallenberg Prize* has been awarded since 1983 by the Swedish Mathematical Society to especially promising younger Swedish mathematicians.

Many students competing mathematical competitions receive honours, but their teachers or coaches usually do not receive any recognition. To make up for this the International Mathematics Education Commission awards every four years the *Felix Klein medal* and the *Hans Freudenthal prize*, in honour of an outstanding career in the service of teaching mathematics. In the same line, the MAA instituted the *Deborah and Franklin Tepper Haimo Awards,* which began in 1991 and are the highest teaching honour bestowed by the MAA. These are meant to recognize extraordinarily successful college or university teachers whose teaching effectiveness has been shown to have had influence beyond their own institutions. The *Award for Impact on the Teaching and Learning of Mathematics*, established by the AMS Committee on Education in 2013, is given annually to a mathematician or group of mathematicians who have made significant contributions of lasting value to mathematics education. Similarly, the *Edyth May Sliffe Award* is given annually to 20 teachers in the United States to reward high school teachers whose students have done well on certain mathematics competitions. The Louise Hay Award and the M. Gweneth Humphreys Award were established in 1990 and 2011, respectively, by the AWM in recognition of contributions of math educators. In France, the *Jacqueline Ferrand Prize* recognizes an innovative educational program in the field of mathematics. In Germany, the Faculty of Electrical Engineering, Computer Science, and Mathematics of the current University of Paderborn annually awards the *Weierstrass Prize* to teaching excellence. In Colombia, the Colombian Mathematical Society awards the *José Celestino Mutis Award for the Teaching of Mathematics*, instituted in 2011, to those teachers of mathematics who have excelled in their professional work and who, through it, have contributed in a fundamental way to the development of mathematics in the country.

Other notable prizes include the *ICTCM Award*, established in 1997 and sponsored by Pearson Addison–Wesley & Pearson Prentice Hall publishers to recognize an individual or group for excellence and innovation in using technology to enhance the teaching and learning of mathematics, and the *Blackwell-Tapia Prize*, founded in 2002, to recognize a mathematical scien-

tist who has contributed and continues to contribute significantly to research in his or her field of expertise, and who has served as a role model for mathematical scientists and students from underrepresented minority groups or contributed in other significant ways to addressing the problem of the underrepresentation of minorities in mathematics.

10. Other Public Ways of Recognition

Besides the usual prizes and awards from professional societies and institutions affiliated with mathematics, recent years have seen other ways of public recognition of mathematical achievements. For example, the *Breakthrough Prize in Mathematics* is an award announced in 2013, and funded by Yuri Milner and Mark Zuckerberg. The prize is given in recognition of scientific advances, and comes with a cash gift of $3 million. Up to three laureates are chosen for the *New Horizons in Mathematics Prize,* at $100,000 which is intended for early-career researchers.[11] A much older tradition of recognition involves university positions; the *Lucasian Chair of Mathematics* was founded in 1663 at Cambridge University as a result of a gift from Henry Lucas for the university. It is one of the most prestigious academic positions in the mathematical sciences. The holders are listed in [17].

Certain general awards, fellowships, and lecture series are named after mathematicians. For example, the *Descartes Prize*, first awarded in 2000, is an annual award in science given by the European Union, named in honour of the French mathematician and philosopher, René Descartes. The prizes recognizes outstanding scientific and technological achievements resulting from European collaborative research.

Some mathematicians have been honoured in other ways; cities and countries choose to honour them by naming streets, institutions, schools, and so on after them. For example, in Paris there are nearly a hundred streets, squares, boulevards, and so on named after mathematicians; see [15]. In addition, when Gustave Eiffel (Dijon, 1832-1923) built his famous Parisian tower, he included the names of 72 prominent French scientists (more than twenty were mathematicians) on plaques around the first stage.

[11] This was the prize Peter Scholze declined in 2016; see Footnote 2.

On the other hand, several countries have recognised their most illustrious and popular scientists by placing their image on banknotes (see Figure 4), coins, or new stamp issues (Figure 5 and [13]).

Figure 4: Some images of mathematicians on banknotes. This figure was created from smaller images obtained from: http://web.olivet.edu/~hathaway/math_money.html, last accessed on July 18, 2019.

Figure 5: Some images of mathematicians on stamp issues. This figure was created from smaller images obtained from: http://jeff560.tripod.com/stamps.html, last accessed on July 18, 2019.

It is worth noting that over 1500 lunar craters have been named after past scientists, erudite scholars, artists, explorers, cosmonauts and astronauts who have made outstanding or significant contributions in their field. Many mathematicians are among those who have given their name to these: Weierstrass, Euler, Gauss, Hilbert.... Specifically, about 300 mathematicians have lunar features (mostly craters) named after them (see [10]). Even, some asteroids and craters on other planets in the Solar System (Mercury, Venus, and Mars) have been named after mathematicians [16].

11. Concluding Remarks

In this report I have tried to paint a contemporary portrait of the prizes for and media coverage of mathematical achievements. I have not been able to list all prizes and awards of course. Nonetheless I hope that I have provided a relatively well-balanced overview of the scenery. One may be skeptical of mathematical prizes; see for instance [1, 12]. One may be skeptical about mathematical competitions; see for instance the points raised in [22]. However it is clear that both prizes and competitions help recognize the work of individual mathematicians and encourage many in their pursuits. They also contribute to the public awareness of our profession.

References

[1] M. J. Barany, "The Fields Medal should return to its roots", *Nature*, Volume 553 18 January 2018, pages 271–273.

[2] K. Barner, "Paul Wolfskehl and the Wolfskehl Prize", *Notices of the American Mathematical Society*, Volume **44** Number 10 (1997), pages 1294–1303.

[3] J. Carlson, A. Jaffe and A. Wiles, eds., *The Millennium Prize Problems*, Clay Mathematics Institute jointly with the American Mathematical Society, Providence, 2006.

[4] M. Cooney, "The world's 23 toughest math questions: DARPA's math challenges", *NetworkWorld*, September 29, 2008; available at https://www.networkworld.com/article/2346451/security-the-world-s-23-toughest-math-questions.html, last accessed on July 18, 2019.

[5] L. Garding, L. Hörmander, "Why is there no Nobel prize in mathematics?", *The Mathematical Intelligencer,* Volume **7** (1985), pages 73-74.

[6] J. Gray, *The Hilbert Challenge*, Oxford University Press, Oxford, 2000.

[7] J. Gray, "A history of prizes in mathematics", pages 3-27 in [3].

[8] K.G. Helsvig, "The Abel Prize: The Missing Nobel in Mathematics?", in *The Abel Prize 2008-2012*, edited by H. Holden and R. Piene (Springer, Berlin, Heidelberg, 2014), pages 1–27.

[9] D. Hilbert, "Mathematical Problems", *Bulletin of the American Mathematical Society*, Volume **8** (1902), pages 437–479.

[10] International Astronomical Union, *Working Group for Planetary System Nomenclature*, Gazetteer of planetary nomenclature, available at https://planetarynames.wr.usgs.gov/, last accessed on July 18, 2019.

[11] International Mathematical Olympiad, available at https://www.imo-official.org/, last accessed on July 18, 2019.

[12] G. Karaali, "On Genius, Prizes, and the Mathematical Celebrity Culture", *The Mathematical Intelligencer*, Volume **37** Issue 3 (2015), pages 61–65.

[13] J. Miller, *Images of Mathematicians on Postage Stamps*, available at http://jeff560.tripod.com/stamps.html, last accessed on July 18, 2019.

[14] J. O'Connor, E. Robertson, *MacTutor History of Mathematics archive*, "Mathematical Societies, Medals, Prizes, and Other Honours", available at http://www-groups.dcs.st-and.ac.uk/~history/Societies/, last accessed on July 18, 2019.

[15] J. O'Connor, E. Robertson, *MacTutor History of Mathematics archive*, "Mathematicians with Paris streets named after them", available at http://www-history.mcs.st-and.ac.uk/Honours/ParisNames.html, last accessed on July 18, 2019.

[16] J. O'Connor, E. Robertson, *MacTutor History of Mathematics archive*, "Planetary features named after mathematicians", available at http://www-history.mcs.st-and.ac.uk/Honours/PlanetaryFeatures.html, last accessed on July 18, 2019.

[17] J. O'Connor, E. Robertson, *MacTutor History of Mathematics archive*, "The holders of the Lucasian chair of mathematics", available at http://www-history.mcs.st-and.ac.uk/Honours/Lucasian.html, last accessed on July 18, 2019.

[18] D. Saari, "How many mathematicians have won Nobels?", *Mitteilungen der Deutschen Mathematiker-Vereinigung*, Volume **14** (2006), page 15.

[19] L. Segura, J. M. Sepulcre, "Arithmetization and rigor as beliefs in the development of mathematics", *Foundations of Science*, Volume **21** (2016), pages 207-214.

[20] J. M. Sepulcre, "Más allá de las matemáticas", in *El Secreto de los Números*, edited by J. Mulero, L. segura, J.M. Sepulcre (University of Alicante Publications, Alicante, 2016), pages 63-84 (*in Spanish*).

[21] Singapore International Math Contests Centre, *Math Contest Scene in Singapore*, available at https://simcc.org/contest/, last accessed on July 18, 2019.

[22] M. K. Siu, "Does Society Need IMO Medalists?", *Journal of Humanistic Mathematics*, Volume **7** Number 1 (January 2017), pages 237–250. Available at https://scholarship.claremont.edu/jhm/vol7/iss1/18/, last accessed on July 18, 2019.

[23] G. Szpiro, *Poincaré's Prize: The Hundred-Year Quest to Solve One of Math's Greatest Puzzles*, Plume, 2008.

[24] The American Mathematical Society, *Prizes and Awards*, available at http://www.ams.org/profession/prizes-awards/prizes, last accessed on July 18, 2019.

[25] The Association for Women in Mathematics, *Prizes*, available at https://awm-math.org/awards/, last accessed on July 18, 2019.

[26] The European Mathematical Society, *Prizes of the European Mathematical Society*, available at http://euro-math-soc.eu/prizes-european-mathematical-society, last accessed on July 18, 2019.

[27] The French Academy of Sciences, *Awards and medals*, available at http://www.academie-sciences.fr/en/Overview/awards-and-medals.html, last accessed on July 18, 2019.

[28] The International Council for Industrial and Applied Mathematics, *ICIAM Prizes*, available at http://iciam.org/iciam-prizes, last accessed on July 18, 2019.

[29] The International Mathematical Union, *Fields medal*, available at https://www.mathunion.org/imu-awards/fields-medal, last accessed on July 18, 2019.

[30] The International Mathematical Union, *IMU Awards, Prizes, and Special Lecture*, available at https://www.mathunion.org/imu-awards/imu-awards-prizes-and-special-lecture, last accessed on July 18, 2019.

[31] The London Mathematical Society, *Grants & Prizes*, available at https://www.lms.ac.uk/grants-prizes, last accessed on July 18, 2019.

[32] The Mathematical Association of America, *MAA Awards*, available at https://www.maa.org/programs-and-communities/member-communities/maa-awards, last accessed on July 18, 2019.

[33] The Mathematical Association of America, *MAA American Mathematical Competitions*, available at https://www.maa.org/math-competitions/about-amc, last accessed on July 18, 2019.

[34] The Norwegian Academy of Science and Letters, *The Abel prize*, available at http://www.abelprize.no/, last accessed on July 18, 2019.

[35] The Society for industrial and Applied Mathematics, *Prizes, Awards and Lectures Sponsored by SIAM*, available at https://archive.siam.org/prizes/sponsored/, last accessed on July 18, 2019.

[36] Wikipedia contributors, *List of mathematics competitions*, Wikipedia, The Free Encyclopedia; available at https://en.wikipedia.org/wiki/List_of_mathematics_competitions, last accessed on July 18, 2019.

[37] Wikipedia contributors, *List of science and technology awards*, `Wikipedia, The Free Encyclopedia`; available at https://en.wikipedia.org/wiki/List_of_science_and_technology_awards#Mathematics, last accessed on July 18, 2019.