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# Social conditions of outstanding contributions to computer science : a prosopography of Turing Award laureates (1966-2016)

*Draft*<sup>1</sup>

Camille Akmut

## **Abstract**

The Turing Award, commonly described as computer science’s highest award and equivalent of the Nobel prize in that discipline, has now been awarded for half a century. In the following, we describe the social regularities that underlie and the conditions that embed these high achievements in computer science innovation.

We find, contrary to a meritocratic ideal of one’s only abilities determining success or recognition within sciences, that several characteristics of scientists, exogenous and non-exogenous alike to their scientific work and identities, are of overbearing or disproportionate importance in defining academic acknowledgement. We find in particular that nationality or birth place, gender and one’s network have a big role in making Turing Award laureates. As do social origins, with a significant portion of Turing Award winners coming primarily from middle- and upper-class family backgrounds, especially households with significant cultural capital (*i.e.* one or both parents hold an advanced degree or are engaged in an academic profession). Reviewing the data before us, we were also unable to ignore the non-participation of visible minorities and non-white computer scientists to the body of Turing Award recipients.

In short, place of birth, nationality, gender, social background, “race” and networks play a role in making Turing Award laureates. This paper also explores the ways in which a social history or sociology of computer science and the wider technology sector may unfold in the future, by discussing theoretical implications, methods and sources.

*Keywords* : computer science, history, sociology, gender, science, technology, ACM, Turing.

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<sup>1</sup>A draft entitled “Social conditions of outstanding contributions in computer science : a statistical analysis of 50 years of Turing award recipients (1966-2016)” was presented in December 2017 at the German Center for Higher Education and Science Research in Berlin.

## 1. Introduction : A belated history of computer science

It is a fact that traditionally, and today still, the history of science is mostly devoted to the study of the canonical scientific disciplines : mathematics, physics and astronomy, chemistry and biology.

5 Here, obscure scribes struggle with various number systems in the Mesopotamia of the 20th century BCE, but no word of Diffie, Merkle or Stroustrup whose contributions are at the heart of much of modern finance, commerce, technology and communication, the very ones that affect us, in the here and now of the 21st century.

10 Yet it is also a fact that there are very few other sciences that have as direct an impact on our lives and hold the potential of fundamentally transforming them as computer science does. Specifically very few who hold as much potential, both in good and bad, to simultaneously uproot, control and threaten them and likewise extend, preserve, document and transmit them.

15 Few other scientific enterprises permeate our lives and those of those we hold dear, down to their most intimate aspects, as that emerging discipline<sup>12345678</sup>. Who we are, how we think, how we communicate, and very likely in the future how we look, how we feel, how we see are just a few of these transformations. It is long overdue that the history of science abandons its cozy canon.

20 And, because computer science is a novel discipline, so is necessarily the

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<sup>1</sup>Brin, Sergey and Page, Larry. 1998. "The anatomy of a large-scale hypertextual Web search engine" *Computer Networks and ISDN Systems* 30(1-7) : 107-117.

<sup>2</sup>Greenwald, Glenn and MacAskill, Ewen. 2013. "NSA Prism program taps in to user data of Apple, Google and others" *The Guardian* 07/06/2013.

<sup>3</sup>Sankar, Pooja. "Pooja Sankar: Building the Piazza Collaboration System" *Computer* 46(3) : 6-7.

<sup>4</sup>Hill, Phil. 2016. "Popular Discussion Platform Piazza Getting Pushback For Selling Student Data" *e-Literate* 10/11/2016.

<sup>5</sup>Li, Yanhong. 2002. "Toward a qualitative search engine" *Internet Computing* 2(4) : 24-29.

<sup>6</sup>Wildau, Gabriel. 2016. "Baidu probed after student death sparks outrage over online ads" *Financial Times* 03/05/2018.

<sup>7</sup>Hern, Alex. 2018. "Facebook logged SMS texts and phone calls without explicitly notifying users" *The Guardian* 29/03/2018.

<sup>8</sup>Ahmed, Maha. 2018. "Aided by Palantir, the LAPD Uses Predictive Policing to Monitor Specific People and Neighborhoods" *The Intercept* 11/05/2018.

history of computer science<sup>9</sup> ; but, better premature than belated.

There is a huge need for a science that looks at computer science, not from the internal point of view of computer science itself, which is concerned primarily with the technical aspects of the discipline *e.g.* the mathematical-electrical  
25 conditions of computer operations understood momentarily as central processing unit, arithmetic logic unit and control unit, and memory and input-output channels<sup>1011</sup>, but from the external point of view of the history or the sociology  
of science ; one ideally that would make strange the technology we take for granted, familiar the unbeknown and alternatively exciting and revolting what  
30 is anticipated. This is meant as such a contribution.

It assumes that history is a worthwhile enterprise, and the social sciences in general, only in so far as they help us better understand ourselves, who we are, where we come from, the world we live in (currently), our current place inside of it, what is (*currently*), what was and what could be (including once more).

35 Brecht famously said that because things were the way they are, things will not stay the way they are. But, speaking on the responsibility of historians, perhaps it is to Marx that we should turn to when historians of science confuse their fascination for numbers, and their intellectual work, for their research objects, thus becoming little more than the lackeys of numbers that the German  
40 economist from Trier once described.

In many ways, when looking at the state of the history of computer science and its applications we can say with little fear that we miss even the most basic of information when it comes to who, outside of a simple procedural history of computer science as a succession of big names, decides what is deemed significant  
45 enough to be brought to the attention of the wider public, what it is categorized as worthy of being financed or otherwise pursued and supported academically.

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<sup>9</sup>We write specifically the history of computer science and not computing, the former we understand to mean in the strictest sense the academic discipline, the latter the much broader history of the attempts to create machines for purposes of automatic computation

<sup>10</sup>This description is based on a simplified Von Neumann architecture.

<sup>11</sup>“The term “computer” is not well defined, and its meaning will change with new developments” (Newell, Perlis and Simon 1967).

Who are the people who make the computing technology that we use? Specifically, who are those who have an above-average influence on its design and direction? And, further : what are the interests of those who make these decisions,  
50 their social characteristics, and so forth?

And, because premature in the case of the history of computer science and computer remains better in most instances than belated, we can answer : presumably 1. white 2. male 3. heterosexual 4. middle- or upper-class 5. from a Western country 6. from the USA 7. from the coastal regions within the United  
55 States 8. educated at a handful of major universities.

And, because we know very little, on a fundamental level, there is a need for research that answers even the most basic of questions, before grand theories can be thought of as important.

We find ourselves in the same position as computer pioneers during the second  
60 half of the 20th century such as Forsythe or Gaurn who concluded that the domain was so new and vast, hence experimental research, though often considered inferior to theory and a detriment to a budding science, should precede general theories.

The topic of this paper will be on the social conditions of outstanding contributions  
65 in computer science and it is based on an analysis of half a century

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*E.g.* Heidegger and the letters he wrote about his Jewish colleagues, the opportunism of Carl Schmitt, that only rivalled Heidegger's during the Nazi period, Sartre and the phone call he made to the Nobel foundation inquiring about the money after having declined it, Michel Foucault and what he did with the personal correspondence of his roommates and the questions on positivism he could not answer (so he made up something else instead), the college essays that Derrida submitted multiple times, the disdain held by Wittgenstein for academics, whom he must have considered barely more than sheeps, the narrowmindedness of Semmelweis' colleagues, Rousseau whose pedagogy stood in stark contrast with his own neglect of his children, the young woman that Rembrandt had locked up in a crazy house because he did care to uphold his promise anymore, Max Planck's opinions on women and women scientists in particular, the historian of science at Uppsala who rejected Foucault's doctoral thesis, but whose name is now only remembered in connection with that event, the colleague of Dover at Oxford he hated so much he could have killed by his own dmission, the Lacour and Green study that never was but still made it in *Science*, the University of Chicago's department of economics' apparent lack of any common sense or moral compass in admitting a former Goldman Sachs trader who had boasted of swindling "widows and orphans" during the subprime morgage crisis to its PhD program, etc..

<sup>12</sup>To break with the myth of the intellectual once and for all, one would be well advised to read the biographies and autobiographies of any number of scientists or academics or artists.

of Turing awards.

## 2. Research directions and methods

The analysis of outstanding performances, in academia and elsewhere, presents a particular challenge to social sciences in so far as these high-achievers, either by  
70 own conception or through common sense notions by mainstream entertainment, journalism, popular science or idealistic scholarship, tend to appear as not bound by the same rules as common lives, the same passions, the same appetites, the faults, the malice, even the pettiness<sup>12</sup>.

In what is arguably computer science's most famous book, *The Art of Com-*  
75 *puter Programming*, one can find such notions. Indeed its author, Donald Knuth, tells us that he wrote the series for “the one person in 50 who has this strange way of thinking that makes a programmer”<sup>13</sup>. In turn, those who find themselves to be among that number, should be highly supportive of such arguments in the process of being elected amongst the lucky few.

80 In another of computer science's revered works, *Structure and Interpretation of Computer Programs*, one learns against expectations from the very beginning that computer science : is not a science, is not about computers and is according to its authors, Sussman and Abelson of MIT, closer to magic.

But, the aim of such a work is not purely for bravado. While demystifying  
85 such notable careers may be one of its effects, it can be and it is encouraged to be read as a way to make appear closer and more attainable, at least more reasonable and realistic, the important, useful and far reaching innovations due to Turing Award winners, in the areas of programming languages, databases, electronic circuits and AI to cite just a few.

90 Starting this research, we had tried to apply classic research questions from the history or sociology of education, of which here are some below.

Is an education at a prestigious college a requirement for great achievements

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<sup>13</sup>Knuth 1997b.

such as the kind recognized the Turing Award? More precisely, does such an affiliation predict the potential for these accomplishments and if so to which degree? Further : is the study of computer science as a degree necessary to  
95 make contributions within that field? If not, is a degree in a science subject necessary? Is precocity an indication of future greatness?

While these are worthwhile objects of research, they were not what we found to be the most interesting relationships between winners and the Turing award.  
100 We did however answer them : we found most of what could have been expected from a research on international scientific prizes, like the Nobel, namely that recipients were much more likely to have been schooled at institutions located on the coastal areas of the United States, in the prime educational regions and also computing centers of California and New England.

105 Intimately linked to questions of educational origins are those of social origins in the study of higher education. These we handle as well. They remain, no matter how out of fashion they may have fallen with certain researchers who believe themselves to be living in post-classes societies, which they can only conclude because they do, important.

110 while looking at the data and reviewing and analyzing it, we were drawn to different outlooks : coming rapidly to the conclusion that women, of which only 3 had won the Turing award since its creation, and none up until 2006, which is to say none for the first 40 years of its existence, were grossly underrepresented among Turing award winners in extents we had rarely met before, we moved  
115 to review the Turing Award from the perspective of the history of gender in science, largely a history of gender inequality and in large parts also exclusion for much of its time span.

We wanted to firstly establish these facts about the participation of women in computer science at its highest levels, but also to understand the situations  
120 of the few women who had made it this far and what had brought them to be recognized in their specific fields of study.

Reviewing the data still, we found that Turing Award laureates were bound by many personal relationships : some had been advised by former winners,

some had studied under them, others had written articles with them, before  
125 being themselves awarded the prize, some even many of these things at the  
same time. And, so, a network analysis helped us visualize these links between  
Turing winners.

The lack of diversity in places of birth, nationality and ethnicity or “race”  
amongst Turing Award laureates, was impossible to ignore, with the great ma-  
130 jority of them white, U.S. American and to some small degree European.

Finally, a comparison with a similar award soon appeared to be essential  
and proved very helpful. This helped objectify structures and relationships and  
unveil inherent qualities, and in turn distinguish those from statistical artifacts,  
by creating a variety of relevant reference points.

135 This research was structured in the following way : a prosopography paired  
with statistics and followed by conclusions as well as theories on the social reg-  
ularities that preside over “genius” *i.e.* high-achievement in computer science.

### 3. Data : or how this study was conducted

Our primary source, for much of the statistical work, were the Turing Award  
140 biographies provided by the ACM<sup>14</sup>.

They contain series of information, themselves already partially coded into  
categories, such as “Birth”, “Education”, “Experience” and “Honors and Awards”.  
They provide indications as to date and place of birth, degrees obtained and  
where these were obtained from, places of employment, etc.

145 As such, they were perfectly suited for the type of study undertaken here,  
called prosopography or collective biography, though we did not keep with the  
categories provided and sometimes had to complete or extend what was found  
in the notices with other sources when information was lacking or non-existent.  
Unfortunately, not all laureates’ biographies featured the same level or depth of  
150 information.

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<sup>14</sup><https://amturing.acm.org>



Of prosopography, Lawrence Stone wrote (has written) that it “is the investigation of the common background characteristics of a group of actors in history by means of a collective study of their lives. The method employed is to establish a universe to be studied, and then ask a set of uniform questions - about birth and death, marriage and family, social origins (...), place of residence, education”<sup>15</sup>.

Historians of science accustomed to working in previous centuries or on more established societies, or, as in this case, disciplines, as well, can think of this collection as they do of the *Biographical memoirs of Fellows of the Royal Society*, which contain biographies for all deceased fellows of the society, with the exception that of the Turing Award biographies we lack sometimes mention of authors<sup>16</sup>, almost always a bibliography and the extent of the information provided does not come close to the on average 20 pages long memoirs.

We have also used other types of information on the ACM, partly produced by itself, as in the case of the Royal Society, partly derived from other scholars, often writing within ACM publications, such as compositions of prize juries and leading committees.

A standout publication that we have relied on in addition to the aforementioned was the biographical dictionary *Computer Pioneers* by J.A.N. Lee<sup>17</sup>. Of much help were also the oral histories conducted by the Computer History Museum and the British Library with individual Turing laureates. In some cases, we used less conventional sources, such as when we relied on the curriculum

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Series for the History of Computing”, jointly with Tomash Publishers of Los Angeles and San Francisco, such as *Babbage’s Calculating Engines: A Collection of Papers*, as volume 2, *The Papers of John Von Neumann*, volume 12, and various other writings including by Turing Award laureates such as Maurice Wilkes or Donald Knuth.

<sup>15</sup>Stone 1971.

<sup>16</sup>No author is mentioned in the case of John Hopcroft for example.

<sup>17</sup>Lee 1995.

<sup>18</sup>The MIT Press has done perhaps more than any other publisher to promote publications on the history of computer science and its applications, including their various social implications, with series such as “History of Computing” and “Inside Technology” and publications like Abbate’s *Inventing the Internet* and *Recoding Gender*. In those same collections, see also Hicks 2017 and Lecuyer 2006 on respectively the situation of pioneering female computer scientists in Britain and the early history of Silicon Valley. This is in addition to the collection of primary sources and original writings published in the “Charles Babbage Institute Reprint

vitae uploaded by Turing Award laureates to the internet. Many monographs published by the MIT Press have also been of general use to us<sup>18</sup>.

175 This information was then aggregated and integrated into a database. The outcome of that process is a table with 64 entries, one for each Turing Award recipient, each in turn containing 39 columns, or the equivalent of about 2500 individual information.

This study comprises all Turing Award laureates from 1966 to and including 180 2016, from Alan Perlis to Tim Berners-Lee.

That being said, the data provided by the ACM was not always perfect. This we discuss separately in the following subsection.

### 3.1. Problems with the data

The problems were multifold. There were errors and inconsistencies or simply 185 absence of information. We provide some examples below.

In what appears to be an indication of nationality, that of Iverson is listed as “United States” instead of Canada. In John Backus’ Turing award biography “Université Henre Poincaré” is misspelled, it should read “Henri Poincaré” after the mathematician. Leonard Adleman’s file mentions “Berkley” instead 190 of “Berkeley”. The information provided on Joseph Sifakis is at odds with that provided by Britannica<sup>19</sup> where education is concerned and incomplete in any case.

In three cases, Rabin, Dahl and Naur, we have no information available on their undergraduate degree ; all three of whom were born outside of America. In 195 these cases, we assume for undergraduate institution the university that granted their masters degree as a proxy (as in all three cases, information becomes available again at that level).

Kenneth Thompson’s bachelor degree is listed as “EECS”, for Electrical Engineering and Computer Science, and as having been obtained in 1965 by his 200 Turing Award biography, though we are not certain this is possible or correct,

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<sup>19</sup>Hosch 2015.

considering that the Department of Electrical Engineering and Computer Sciences at Berkeley was only founded in 1973 while the Department of Computer Science which preceded it had only been or begin to be established in 1968<sup>20</sup>.

Leiden University is unusually referred to as “University of Leyden” in the  
205 biography of Edgar Dijkstra, and although this spelling, of the city and by extension its university, appears in several older English publications<sup>21</sup>, it seems rare.

Sometimes euphemisms are used, such as in the case of the biography of Antony Hoare whose parents, we learn, “were involved in the business of what  
210 was then the British Empire” to mean that his father was a colonial civil servant and his mother the daughter of a tea planter.

In the most extreme of cases, we found errors up to and including in the citations of the laureates themselves : facilitate is spelled “facilitiate” in Wilkinson’s, while the rather uncommon “subsequentially” is used in Newell’s.

215 For them, we had to supplement information with other sources whenever necessary, which we list.

Sometimes, the data, correct, needed to be normalized. We record for instance the Carnegie Institute of Technology as CMU and the New York State College for Teachers as the State University of New York at Albany.

#### 220 4. The Turing Award and the ACM (1947-2018)

The Turing Award was created in 1966<sup>22</sup>. In the ACM’s own words, the Association for Computing Machinery, which oversees the award, the Turing Award is “computing’s most prestigious honor”<sup>23</sup>. It “acknowledges individuals who have made lasting and major contributions to the field.”<sup>24</sup>

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<sup>20</sup>“History — EECS at Berkeley”. <https://eecs.berkeley.edu/about/history>

<sup>21</sup>*E.g.* publications by authors Cole and Jackson in volume 147 of *Nature* from 1941 and Dunin’s “The University of Leyden, And America” in *Paedagogica Historica*, vol. 8, from 1968.

<sup>22</sup>Lee 1972 : 488.

<sup>23</sup>“Turing Award 50”. <https://www.acm.org/turing-award-50>

<sup>24</sup>*Ibid.*

225 Turing awards are awarded once a year to one or many people. When an  
award is given to multiple people, this can be mean that it is either for collective  
work or for an innovation that has multiple, independent contributors<sup>25</sup>. It is  
presented each year in June<sup>26</sup>.

Each winner has a citation, in which is explained the reasons for the nomi-  
230 nation hence the work accomplished by the laureate and for which the award is  
given. This citation can be collective if the award is.

The award is bound with a monetary prize. When it was established, the  
latter was of the amount of 1000 U.S. dollars<sup>27</sup> or the equivalent of about 7,500  
current dollars. That prize money is now 1,000,000 dollars and has been since  
235 2014 when Google became the primary, and possibly sole sponsor<sup>28</sup>. It is un-  
clear, beyond what we know of the philanthropy practices of big corporations  
like it or family dynasties<sup>29</sup>, what Google’s interests are in investing into the  
prize. But, we noted that multiple Turing award winners work or had worked  
for Google : Ken Thompson, where he was one of the creators of the Go pro-  
240 gramming language<sup>30</sup> and Vint Cerf, who is currently “vice president and Chief  
Internet Evangelist” according to his corporate page<sup>31</sup>, for example.

The Turing Award was able to establish itself as the top prize for computer  
scientists fairly quickly. Donald Knuth has referred to it as “the ultimate honor  
in our field”<sup>32</sup>. An early example of this, considering that the prize itself is  
245 relatively new when compared to other similar but more established awards, is  
further given by a necrology of Herbert Simon published in *Science* in 2001,  
where the author, Turing award laureate Edward Feigenbaum, writes : “Before

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<sup>25</sup>See the nominations in the year 2002 and 2007 respectively.

<sup>26</sup>“Call for Nominations, ACM A.M. Turing Award”. [https://amturing.acm.org/call\\_for\\_nominations.cfm](https://amturing.acm.org/call_for_nominations.cfm)

<sup>27</sup>Revens 1972 : 488.

<sup>28</sup>Communications of the ACM 2014.

<sup>29</sup>In recent months, the *Guardian* and other newspapers such as *The New Yorker* reported extensively on these practices in the case of the Sackler family, Purdue Pharma and the drug OxyContin. See Dubb and Costello 2018. Many books have been written about Rockefeller philanthropy : Ettling 1981 or Siegmund-Schultze 2001 for example.

<sup>30</sup>Donovan and Kernighan 2015 : xi.

<sup>31</sup>“Vinton G. Cerf - Google AI”. <https://ai.google/research/people/author32412>

<sup>32</sup>Knuth 2003 : 9.

his Nobel Prize, Simon had already won the A. M. Turing Award, the top accolade for computer science, prompting computer scientists to refer to him as  
250 “our Nobel Prize winner”<sup>33,34</sup>.

But, to better understand the Turing Award we need to look at the ACM, which organizes and promotes and answer a series of questions : specifically, what is the ACM? Who leads it? What is the composition of the ACM Council? What is the composition of the jury of the Turing Award? What role do they  
255 play? This, we do in the following sections.

The Association for Computing Machinery is according to its own description “the world’s largest computing society”<sup>35</sup> as well as the “world’s largest educational and scientific society”<sup>36</sup> with over 100,000 members<sup>37</sup>. It was founded in 1947 in New York City as the Eastern Association for Computing Machinery at  
260 a meeting at Columbia University<sup>38</sup>.

The notice for this meeting stated the purpose of the association to be : “to advance the science, development, construction, and application of the new machinery for computing, reasoning, and other handling of information.”<sup>39</sup>

In 1948 its name was changed to Association for Computing Machinery<sup>40</sup>.  
265 It has had offices in New York City since about 1953<sup>41</sup> and its headquarters are still located there<sup>42</sup>.

It is “governed by a Council consisting of 16 members” and with the exception of the chair of the Publications Board they are elected by the members of the ACM for two-year terms<sup>43</sup>.

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<sup>33</sup>Feigenbaum 2001.

<sup>34</sup>Feigenbaum received the Turing Award in 1994, Simon in 1975.

<sup>35</sup>“About the ACM Organization”.

<https://www.acm.org/about-acm/about-the-acm-organization>

<sup>36</sup>“ACM History”. <https://www.acm.org/about-acm/acm-history>

<sup>37</sup>“ACM at a Glance”. <https://www.acm.org/membership/acm-at-a-glance>

<sup>38</sup>Revens 1972 : 485.

<sup>39</sup>Revens 1972 : 486.

<sup>40</sup>Revens 1972 : 485.

<sup>41</sup>Revens 1972 : 487.

<sup>42</sup>“Contact Information”. <https://www.acm.org/about-acm/contact-us>

<sup>43</sup>“ACM History”. <https://www.acm.org/about-acm/acm-history>

270 The ACM also publishes multiple major computer science journals that are  
of much importance to the research and activities of computer scientists. Its  
oldest publications are the *Journal of the ACM*, first published in January 1954,  
*Communications*, January 1958, *Computing Reviews*, February 1960 and *ACM*  
*Computing Surveys* in March 1969<sup>44</sup>.

275 Arguably best known is the *Communications of the ACM*. One type of pub-  
lication, perhaps one of its outstanding features, found in *Communications* are  
algorithms<sup>45</sup>. They generally appear with accompanying implementations in  
the ALGOL programming language<sup>46</sup> and are numbered in order of publication  
: *e.g.* Algorithm 32, Algorithm 33, etc.. A famous example is Algorithm 64,  
280 published in 1961 by Hoare, which defines the quicksort algorithm (a method  
of sorting arrays of items that is still widely taught and in wide use)<sup>47</sup>.

Two other journals published by the ACM that are of significance for the  
discipline as a whole (as opposed to specialized publications that cover subfields)  
are the *Journal of the ACM*, its oldest publication, and the quarterly *ACM*  
285 *Computing Surveys*, founded in 1969, which, as its name suggests, publishes  
survey articles.

The ACM also publishes various journals called *Transactions* that are each  
dedicated to an area of computer science such as the eponymous *Computer*  
*Systems*, *Graphics*, *Networking* (jointly with the IEEE), etc.

290 A history of the ACM would not be complete without mention of the other,  
big association for computer scientists, although its scope, as its name indicates,  
is different, and in some ways both broader and narrower<sup>48</sup>, the Institute of  
Electrical and Electronics Engineers. The IEEE was founded in 1963, which

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<sup>44</sup>Cochran 1987 : 867.

<sup>45</sup>Knuth cites five important features of algorithms, besides being merely “a finite set of rules that gives a sequence of operations for solving a specific type of problem” : finiteness, definiteness, input, output and effectiveness. See Knuth 1997 : 4-6.

<sup>46</sup>ALGOL was designed by multiple Turing Award laureates : Backus, Perlis, Naur and McCarthy amongst others with further contributions by Wirth and Hoare (ALGOL W).

<sup>47</sup>Hoare 1961.

<sup>48</sup>This puts it into a similar space as the AIEE, American Institute of Electrical Engineers, or the IRE, Institute of Radio Engineers.

is to say about 15 years after the ACM. It promotes itself as the “the world’s  
 295 largest technical professional organization for the advancement of technology”<sup>49</sup>.

In turn, the IEEE has its own awards. Of them the Computer Pioneer  
 Award, established in 1981, is the closest to the Turing Award. Its list of  
 recipients includes many of the same individuals<sup>50</sup>. Its medal features the effigy  
 of Babbage, who, besides Turing, is arguably the most emblematic figure of  
 300 the discipline due to his very early contributions, the Analytical Engine ; and  
 would have been the next obvious choice, with a third option being between  
 either Ada Lovelace, who has the advantage of priority and the disadvantage of  
 womanhood, and Von Neumann, after which things become less clear, though  
 Aiken would certainly be a candidate<sup>51</sup>.<sup>52</sup>

305 Though, note, that, due to the nature of the IEEE, as an association dedi-  
 cated to electrical and electronics engineers, this is not its highest distinction.  
 It is however its highest distinction where computer science is concerned. Its  
 highest honor remains for now the IEEE Medal of Honor, which recognizes “ex-  
 ceptional contribution or an extraordinary career in the IEEE fields of interest”,  
 310 making its pool much broader than just computing. It has been awarded since  
 1917<sup>53</sup>.

Table 1: ACM Turing and IEEE Computer Pioneer awards com-  
 pared

	<i>IEEE Computer Pioneer award</i>	<i>ACM Turing award</i>
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<sup>49</sup><https://www.ieee.org/>

<sup>50</sup>See table below.

<sup>51</sup>And, in fact, an Ada Lovelace award (already) exists, established by the Association for Women in Computing. As does a Von Neumann award in the form of the John von Neumann Theory Prize, for contributions to operations research. It was first awarded in 1975(, which is to say within 10 years of the Turing Award creation.

<sup>52</sup>Bullynck et al. had already considered why Turing was chosen instead of someone else, they “speculate that Turing was preferred over von Neumann, because the latter was associated with hardware engineering rather than with theoretical foundations”, drawing parallels to the uses of Gauss as a conceptual antithesis to computational approaches in mathematics, see Bullynck et al. 2015 : 38.

<sup>53</sup>“IEEE Medal of Honor”.

<https://www.ieee.org/about/awards/medals/medal-of-honor.html>

Ivan Sutherland	1985	1988
Alan Perlis	1985	1966
John McCarthy	1985	1971
Peter Naur	1986	2005
Nicklaus E. Wirth	1984	1987
John Cocke	1989	1987
C.A.R. Hoare	1990	1980
Robert W. Floyd	1991	1978
Douglas C. Engelbart	1992	1997
Ken L. Thompson	1994	1983
Dennis M. Ritchie	1994	1983
Butler Lampson	1995	1992
Marvin Minsky	1995	1969
Robert E. Kahn	1996	2004
Edgar Frank Codd	1996	1982
Frances (Fran) E. Allen	2004	2006
Edward Feigenbaum	2013	1994
Barbara Liskov	2018	2008

We registered 18 commonalities between recipients of both prizes, making up roughly one third and one fifth of each award’s pool of winners respectively. We noted further that for its first ten awards, encompassing the first four years  
315 of its existence, the IEEE seems to have made it a point to distinguish only computer scientists that had not been previously given the Turing award<sup>54</sup> ; after which point, starting in 1985, it started awarding its prize to a series of widely celebrated figures such as Perlis, McCarthy and Naur. This gives insight into the strategies of a newly established prize and what happens when a prize  
320 seeks to reward the same accomplishments as a previous one, but has to deal

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<sup>54</sup>See appendix.



with the latter's own, already established legacy ; as opposed to the Turing award which for the most part had only had to deal with the challenges of being a new prize.

It is also noteworthy that in some instances IEEE's recognition preceded the ACM's, such as in the case of Ivan Sutherland, Peter Naur and Robert Kahn. As the Computer Pioneer award was created 25 years after the Turing award, in some cases comparisons are not possible.

Another key difference between the two prizes is that the Computer Pioneer award is given in much higher frequency to multiple people : it has been awarded to 99 people so far<sup>55</sup> including 19 awards in 1996 alone. Yet another difference when compared to the Turing Award is that in some years, no awards were given such as in 1983, 2005, 2007, 2010 and 2017.

Another prize that could be mentioned, and that may become of interest to future research is the Gödel Prize, who has for particularities when compared to the Turing Award that it is given by a European association, the EACTS<sup>56</sup>, jointly with the ACM, has for limitations theoretical computer science and a reward that is currently significantly lower, 5000\$.

## 5. Educational origins of Turing winners

As previously indicated, we wanted to know where the Turing laureates had studied.

Specific questions included : what proportion had attended the 3 or 4 universities that have crystallized as the main centers for computer science education and research at the end of the 20th century and the beginning of this century in the USA?

Currently, they are commonly understood as being MIT, Berkeley and Stanford and although they all cover the entire spectrum, their areas of strength have

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<sup>55</sup>At the time of this writing, which is to say up to and including the 2018 laureates.

<sup>56</sup>European Association for Theoretical Computer Science.

historically been, hence their reputation as a leading center for computer science founded on, among other things :

- MIT : Artificial Intelligence (AI Lab, founded by Minsky\* and McCarthy\*);
- 350 - Stanford : (Analysis of) Algorithms (Knuth\*, Floyd\*)
- Berkeley : Theory of Computing (Karp\*).

We relied on the Shanghai Ranking, or Academic World Ranking of Universities, the oldest of its kind, having been published since 2003, to objectify these relations<sup>57</sup>.

Table 2: Shanghai Ranking of universities in computer science and engineering (2007-2017)

<i>Institution</i>	<i>CS&amp;ENG 2017</i>	<i>CS 2009-15</i>	<i>ENG 2010-16</i>	<i>ENG 2008-09</i>	<i>ENG 2007</i>
MIT	1	2	1	1	1
Stanford	3	1	2	2	2
Berkeley	2	3	3	4	5

- 355 CS & ENG : Computer Science & Engineering.
- CS : Computer Science.
- ENG : Engineering/Technology and Computer Sciences.

Sources : see appendix for a (the full list of sources.

In trying to establish this for earlier periods, we also relied on Lecuyer's  
 360 history of Silicon Valley between 1930 and 1970, where only two universities appear in the index, a fact which is not only attributable to the geographical limitation to San Francisco : Stanford (26 times) and MIT (6)<sup>58</sup>.

To this group, one can add : CMU, which had been preceded by Carnie Institute of Technology, featured in fourth place or higher in various rankings,

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<sup>57</sup>The Shanghai Ranking has been criticized for a variety of reasons, both theoretical and methodological. Two conflicting reviews that address it from the point of view of reproducibility are present in Florian 2007 and Docampo 2013.

<sup>58</sup>Lecuyer 2006.

365 for its historical significance at least Princeton, known for having been host to  
multiple pioneers of the discipline (Turing, Von Neumann and Simon\*). Also  
noteworthy is Caltech, where Donald Knuth and Juris Hartmanis did their PhD  
and the former spent the first part of his career before joining Stanford.

Further questions we asked included : what are their educational attain-  
370 ments. And, beyond : is a PhD necessary? These we answer later, below.

But, first, we set out to study the educational origins of Turing award win-  
ners. In doing so, we distinguished between undergraduate and graduate insti-  
tutions and handled the case of doctoral schools separately.

We also looked at geographical distribution and movements in the next sec-  
375 tion based on this.

We started by looking at where Turing award winners had obtained their  
undergraduate degrees. Next, we looked at the subject of their bachelor degrees.

Table 3: universities ranked by the number of Turing award winners  
(bachelor)

<i>Institution</i>	<i>Bachelor students</i> n (%)
Berkeley	6 (9%)
Cambridge	4 (6%)
Carnegie Mellon University*	4
Harvard	4
California Institute of Technology	3 (4%)
MIT	3
Oxford	3
University of Chicago	3
Duke	2
Stanford	2
Technion	2
– Total Ivy League**	6 (9%)

n = 64<sup>59</sup> t = 64

\* Previously, Carnegie Institute of Technology.

380 \*\* Including Princeton (1) and Yale (1).

Almost one third, or 28%, of all Turing award winners have gathered at a handful of universities for undergraduate studies : Berkeley, Cambridge, Carnegie Mellon University and Harvard.

385 Further, half of all Turing award winners can be found in 10 institutions alone, all of which, with the exception of Cambridge and Oxford, are US colleges. Technion, in Israel, has had 2 laureates *ex aequo* with Duke and Stanford.

We also provide statistics for the share that Ivy League colleges have in Turing award winners at the bachelor level, less than 10%, but this category, important as we know it to be in many other areas of society, has less significance  
390 in the case of computer science in the sense that it does not include multiple major centers of computer science such as notably Berkeley, where of all the most Turing award winners are found, MIT, CMU and Stanford, to say nothing of Cambridge and other institutions outside of the US.

We left out from the table those institutions that had only one future Turing  
395 laureate among the students they granted bachelor's degrees to<sup>60</sup>. Among those institutions that are only represented by one Turing Award winner at the undergraduate level : Princeton, Yale, ETH Zurich and the University of Michigan - to name a few.

Table 4: Bachelor disciplines ranked by respective number of Turing award winners

<i>Discipline</i>	<i>Bachelor students n (%)</i>
Mathematics*	34 (53%)
Electrical engineering**	11 (17%)

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<sup>59</sup>See appendix for full table.

<sup>60</sup>The full list can be found in the appendix.

Physics***	11 (17%)
Electronics engineering	1
Mechanical engineering	2
Civil engineering	1
Chemistry	1
Astronomy	1
Political science	1
Liberal arts	1
“Greats”	1

n = 64 t = 64

400 In calculating percentages, we do not count Robert Floyd’s first bachelor degree in liberal arts, but still list it.

\* Includes 4 laureates who studied “Applied Mathematics”, “Mathematics and physics”, “Mathematics and Engineering” and “Mathematics and molecular biology”<sup>61</sup>.

405 \*\* Includes Kenneth Thompson’s bachelor degree listed as “EECS” and as having been obtained in 1965<sup>62</sup>.

\*\*\* Includes Robert Floyd’s second bachelor degree.

The oldest student in our sample of Turing award winners, Maurice Wilkes, was born in 1913 and obtained his bachelor degree in 1934, thus at a time when  
410 computer science was not a subject.

This configuration applies to all Turing award winners as they all were awarded bachelor’s degrees before 1965, when the first computer science departments had just begun to being formed in the USA.

The analysis of the bachelor subjects of Turing award laureates offers a  
415 unique perspective into the question of where computer scientists came from

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<sup>61</sup>In a previous attempt at categorization, we had subsumed these under “Applied mathematics (various)” separately.

<sup>62</sup>See our previous discussion of this at the beginning of this paper.

before computer science and the answer that we can provide based on our analysis of Turing award winners is largely from mathematics.

More than half of Turing Award laureates (34 of 64) had studied mathematics as a bachelor's degree subject, 17% of Turing award winners had obtained  
420 a physics bachelor degree (11 of 64) and the same amount an electrical engineering degree with an additional Turing laureate having obtained a degree in electronics engineering (a closely related discipline).

The group of physicists includes Tim Berners-Lee, Donald Knuth is among the mathematicians while Ken Thompson is part of the undergraduate students  
425 in electrical engineering - to give a few examples.

It might seem remarkable that in a study dedicated to computer scientists, none of them should possess an undergraduate degree in that discipline, but as already mentioned before this is in large parts related to and inherent to our demographic study of Turing Laureates, whose birth dates range from 1916 to  
430 1943, making it so that by the time of their entry into college they would have been studying between roughly 1934 and 1961, hence at a time when departments of computer science, and indeed computer science itself, as a discipline that could be studied in undergraduate college or in which one could obtain a bachelor's degree, was virtually unheard of and non-existent.

Departments of computer science are largely a creation of the 1960s. Purdue  
435 founded its own, described as the first in the United States<sup>63</sup>, and possibly the world, in 1962. It awarded its first M.S. degrees in that discipline in 1964 and its first B.S. degrees in 1968<sup>64</sup>. Stanford's was established in 1965<sup>65</sup>. The University of Wisconsin-Madison was possibly the first to award PhDs in computer science,  
440 starting May 1965<sup>66</sup>.

“When I entered the Comp Lab in 1955 there were no models for a curriculum in the subject that today is called computer science. The young faculty

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<sup>63</sup>Rice and Rosen 1994.

<sup>64</sup>Ibid.

<sup>65</sup>Knuth 1972.

<sup>66</sup>See the following historical database of PhD students hosted at the University of Wisconsin-Madison <http://research.cs.wisc.edu/includes/textfiles/phds.65-70.txt>.

offered courses in numerical analysis, switching theory, data processing, computational linguistics and operations research, and outside the Lab I took a variety of courses in applied mathematics, electrical engineering, probability and statistics.” writes Richard Karp of his time at the Harvard Computation Lab<sup>67</sup>.  
 445 “Computer science didn’t exist when I started in ’57. And, it didn’t come into existence until at least 10 years later.” said Frances Allen in her Grace Hopper speech reflecting on her Turing award<sup>68</sup>.

450 Before this, departments of mathematics, and electrical engineering, were often where what would later come to be called distinctively and independently computer science was being done (*e.g.* Princeton, where Von Neumann was a professor and Turing a doctoral student, Manchester, where Turing later worked, and the Moore School of Electrical Engineering at the University of Pennsylvania, where the ENIAC and EDVAC were created and Von Neumann was a  
 455 consultant).<sup>69</sup>.

A small minority of Turing laureates, three in total, or 4% of the total population, had obtained undergraduate in one of the humanities or social sciences, we discuss this in more detail further below.

460 In the second step of our research on the educational origins of Turing Award laureates, we look at their post-graduate institutions. This population comprises Master and PhD students. Where Turing award winners went on to seek a PhD, we register this, otherwise their Master’s degrees.

Table 5: Universities ranked by the number of Turing award winners at the post-graduate level

<i>Institution</i>	<i>Students</i>	<i>Previously</i> <sup>70</sup>	<i>% in/decrease</i>
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<sup>67</sup>Karp 1999 : 148.

<sup>68</sup>Allen 2008.

<sup>69</sup>But, this is not a historical artifact only as recent contributions continue to come from mathematicians *e.g.* Ryan Dahl, creator of Node.js, is a mathematician by training.

<sup>70</sup>At bachelor level.

Berkeley	8	6	33%
Harvard	6	4	50%
Stanford	6	2	200%
Princeton	6	1	500%
MIT	4	3	33%
University of Michigan	3	1	200%
Caltech*	2	3	- 33%
CMU	2	4	- 50%
UUIC <sup>71</sup>	2	0	
Weizmann Institute of Science	2	-**	
Cambridge	1	4	-75%
Oxford***	1	3	-66%
University of Chicago	1	3	-66%
Duke	1	2	-50%
Technion	0	2	
ETH Zurich	0	1	
Ivy League****		14	133%

n = 58<sup>72</sup> t = 58<sup>73</sup>

<sup>465</sup> \* California Institute of Technology.

\*\* The Weizmann Institute of Science only offers post-graduate education.

\*\*\* Including Hoare's postgraduate certificate in statistics.

\*\*\*\* Including Cornell (1) and the University of Pennsylvania (1).

At graduate level, Turing award winners increasingly concentrate at institutions that are more prestigious and are often a “step-up” from their undergraduate college. This places them in a better position to have their work recognized, for this to happen early on and to meet the right people *e.g.* those

<sup>71</sup>University of Illinois at Urbana-Champaign

<sup>72</sup>The full table can be found in the appendix.

<sup>73</sup>The population of Turing Award laureates who have a post-graduate education.



able to make an impact in their careers and recommend them effectively in and possibly outside the academic world as well.

475 This trend is found in the increasing number of future Turing award winners at MIT and Princeton, in the latter case a staggering 500% increase, in the East. On the West coast, they move towards Stanford and Berkeley. Robert Tarjan and Fernando Corbato both leave the California Institute of Technology for Stanford and MIT respectively.

480 The University of Michigan knows a 200% increase at the postgraduate level. Meanwhile Michigan State loses its only student.

Another notable statistic is the increase of 133% in Ivy League colleges attended by Turing award winners between undergraduate and graduate studies. Let us again move closer to the lived realities of the(se) individuals and have  
485 a look at what this means in detail : Charles Bachman moves from Michigan State to UPenn, John Hopcroft from Seattle University to Harvard, Richard Stearns from Carleton College and John McCarthy from Caltech to Princeton.

But, this trend also means a depletion of talent from European institutions. This affects even the very best of European universities, including Oxford (-  
490 66%), Cambridge (-75%) and ETH Zurich. In one case, a student, born in Switzerland, moved from an excellent European university, ETH Zurich, to a relatively minor North American one, the French-language Universite Laval, where he obtained a Master, and then from there upgraded to Berkeley for PhD<sup>74</sup>.

495 Of the sixty-four Turing award winners, six do not have degrees past a bachelor, they are : Tim Berners-Lee (1955; Oxford; physics), Whitfield Diffie (1944; MIT; mathematics), Robert Floyd (1936; Chicago; physics), Arthur Milner (1934; Cambridge; mathematics), and James Wilkinson (1919; Cambridge; mathematics). Neither birth dates, ranging from one extreme to the other of the  
500 wider cohort, nor other indicators such as quality of undergraduate education,

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<sup>74</sup>Niklaus Wirth. This was in the late 1950s, early 1960s. As such, we assume that these international educational moves cannot be attributed to the immediate events of WW2, which did affect the trajectory of numerous Turing laureates and their parents.

with cases representing some of the best attainable outcomes possible in the entire population<sup>75</sup>, or disruption through events like war, absent in two, make any sort of generalization hard.

Lastly, we looked at the highest educational attainments of and the overar-  
505 ching type of degrees obtained - STEM or humanities and social sciences - by Turing winners.

Table 6: Proportion of bachelor and PhD degrees

<i>Degree type</i>	among <i>Turing Award laureates</i>
Bachelor	100% (64)
PhD	81% (52)
Master or PhD	90% (58)

9 out of 10 Turing award winners have education at the post-graduate level. 8 out of 10 have a PhD degree. All Turing award winners possess a bachelor's degree.

510 But, is a PhD degree necessary to do significant contributions to computer science such as the ones recognized by the ACM's Turing Award? No.

Twelve Turing award winners have not obtained a PhD. Among them, some of computer science's most important contributors and revered figures : Kenneth Thompson, creator of UNIX, Tim Berners-Lee, inventor of the World Wide  
515 Web, Whitfield Diffie, who with Hellman, laid out the foundations of public key cryptography, Antony Hoare, who developed major sorting algorithms, and John Backus, to whom we owe the Backus-Norm-Form, which is helpful in classifying languages in terms of their logical structures / grammars.

Here too we think important to connect the statistics we have established  
520 with the lived realities and actual experience of actors. That the issue of the PhD, or the missing PhD in this case, matters we establish with a document from the period. And, although it does not hinder a portion of our population,

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<sup>75</sup>James Wilkinson was Senior wrangler, and at Cambridge was at Trinity college.

one fifth to be exact, from rising to the top of their field, it shows the great concern attached to the issue. This is not without cause as, in fact, certain academic positions, are, in theory at least, only accessible to holders of appropriate  
525 academic titles. And, so, when Donald Knuth wrote a letter of recommendation on behalf of Robert Floyd, he thought good and perhaps even important to note at the end :

“One further remark is perhaps necessary, considering contemporary  
530 ‘standards of society’. Floyd has never gone through the formalities of obtaining a Ph.D. degree. I believe this was due primarily to the fact that he entered graduate school at the University of Chicago when he was only 16 or 17 yours [sic] old, as part of an experimental accelerated education program; this was not a mature enough age  
535 to do graduate work. [Bob was born 8 June 1936, and he began graduate school after receiving a B.A. degree in 1953 at age 17-about five years earlier than usual for American students at the time.] Certainly he has written at least a dozen papers by now each of which is superior to any Ph.D. thesis I have ever seen in computer  
540 science, so the mere fact that he has never formally received the degree should be quite irrelevant.”<sup>76</sup>

Finally, we asked if a degree in mathematics, physics, engineering, biology, chemistry, computer science or one of the neighboring disciplines – contemporarily called STEM – was necessary to do significant contributions to computer  
545 science later in life, the kind recognized by the Turing?

Table 7: STEM vs. humanities and social sciences degrees amongst Turing laureates

	<i>STEM</i>	<i>Humanities and Social Sciences</i>
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<sup>76</sup>Knuth 2003 : 7.

Bachelor	95% (61)	4% (3)
PhD	100%	None
Master or PhD	100% (58)	None

This seems to be the case overall : the great majority of Turing award winners, or 95%, have done their undergraduate degrees in a STEM subject, and 100% beyond that.

But, the history of computer science, mathematics and physics is full of  
 550 outliers and while all Turing Award winners either have a bachelor’s degree or Master or PhD in a STEM subject, some of them come originally from a background in the humanities or the social sciences<sup>77</sup>.

Though, note that of the three Turing award winners who received a bachelor in one of the humanities and social sciences subjects : Herbert Simon majored in  
 555 political science at Chicago, one of the most quantitatively intensive disciplines outside of STEM, at an institution that played a key role in the mathematization of the social sciences, economics in particular, Antony Hoare, who studied Classics at Oxford, “chose to study modern philosophy, which provided a path to understand logic”<sup>78</sup>, an important part of computer science and computer  
 560 science education<sup>79</sup>, while Robert Floyd, also at Chicago, did obtain a liberal arts degree but later supplemented it with a second bachelor’s degree in physics.

Past the undergraduate level however, all Turing winners have a degree in science, technology, engineering or mathematics.

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<sup>77</sup>John Guttag, professor of computer science at MIT, has a BA in English. David Malan, professor of computer science at Harvard, had first studied government before switching subjects. Alston Householder, mathematician and president of the ACM, had a BA and MA in philosophy before earning a PhD in mathematics. Lastly, Einstein famously worked as a patent office employee for 7 years, a work he described later to be that of a “cobbler”, after having been unable to find work as a teacher for almost two years.

<sup>78</sup>This is according to his Turing Award biography.

<sup>79</sup>*E.g.* boolean algebra, set theory, etc.

## 6. Geographical origins and movements of Turing winners

565 Based on our review of educational origins, we turn to the geographical distribution of Turing Award winners and find that they gather at a handful of destinations, heavily skewed toward the USA and within, its coastal regions in particular.

570 One question we received in reaction to these and other findings, from a researcher who was very concerned about “performance” in science studies, was why this was important and “what the point [was]”. This fits into the wider debates happening in fields of research as diverse as those concerned with the role of English in science and the effects of rankings and prizes.

575 We will answer this question before : our findings indicate that the Turing Award, which in all ways is presented as an international award, awarded by an international organization (“members from more than 100 countries”<sup>80</sup>), is in fact very limited in its scope and pool of recipients as we show. It is biased towards countries where English is the main language, it is also biased towards computer scientists who have attended universities from English-speaking countries, thus putting into question whether the Turing Award rewards “lasting  
580 contributions” independently of their place of origin.

Table 8: Place of birth of Turing Award laureates

<i>Country</i>	<i>Turing laureates</i>
USA	41 (64%)
England	5 (7%)
Israel	3 (4%)
British Empire*	2
Canada	2 (3%)
China	1
Denmark	1

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<sup>80</sup>“ACM at a Glance”. <https://www.acm.org/membership/acm-at-a-glance>

Germany**	1
Greece	1
Hungary	1
Italy	1
Latvia	1
Netherlands	1
Norway	1
Switzerland	1
Venezuela	1
— America	44 (68%)
— Europe	14 (21%)
— East Asia	1
— Rest of the World	6 (9%)

n = 64 t = 64

\* Ceylon (now Sri Lanka) and British India.

\*\* Germany (now Wroclaw, Poland).

585 From these data alone, one can tell as much : the pool from which Turing laureates are selected from is extremely biased towards America, particularly the USA. Entire regions of the world are absent, Africa for example, while some of the most populous ones, like East Asia, are grossly underrepresented with only one Turing award winner born in China.

590 68% of Turing Award winners were born in America while almost two thirds, or 64%, were born in the USA alone. Just 18% of Turing award winners were born in the current European Union and about half of them are from England. Less than 10% of Turing laureates, or 6 in total, come from the rest of the World (outside the USA and Europe), including 3 from Israel, 2 from former colonies  
595 of the British Empire, one of which in turn is Antony Hoare whose father was a colonial civil servant, and 1 from China.

The next biggest country of origin for Turing winners is Israel, with two out

of its three Turing winners emigrating to the USA eventually<sup>81</sup>. One Turing winner was born in Venezuela : his parents, Jewish, had emigrated there from Europe<sup>82</sup>.  
600

These findings are at odds with what the ACM writes about the Turing Award in its fact sheet. In one passage, it emphasizes :

“Turing Laureates have hailed from countries around the world including Canada, China, Denmark, India, Latvia, Netherlands, Norway, Israel, Italy, Switzerland, the United Kingdom and the United States.”<sup>83</sup>  
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But, while this statement is positively correct, it does not accurately represent the disproportionate frequency at which US American scientists receive the prize. Not all countries stand on an equal footing when it comes to their scientists’ potential to receive the Turing Award. This is one conclusion that  
610 could be drawn from our data. As such statements never fail to raise objections, we must specify that we do not look so much at the intentions or policies of the ACM or the Turing Award, whether claimed or otherwise agreed upon as policy or even passed as law, but at its verifiable practices. This we do by counting how many Turing laureates come from each country based on information  
615 established by the ACM itself.

By placing the United Kingdom and the United States at the end of its list of countries, an order which does not reflect the alphabetical order, but is the exact order we have established in the above statistics, except in reverse, the  
620 ACM makes clear that is most likely aware of its biases and the issues discussed here.

On the other hand, if such conclusion were wrong, one of few remaining

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<sup>81</sup>Judea Pearl had emigrated to the US by the time of his Master’s degree while Amir Pnueli went there first as a post-doctoral student and later as a professor at NYU, he died in New York.

<sup>82</sup>Manuel Blum.

<sup>83</sup>“About the ACM A.M. Turing Award Fact Sheet.” <https://www.acm.org/binaries/content/assets/awards/about-the-acm-a.m.-turing-award-fact-sheet.pdf>

outcomes would be that all countries standing an equal chance to see one of their citizens receive the prize, the USA is the producer of much better computer  
 625 scientists, such that it would only be logical for the great majority of Turing award winners to come from that country as well.

To further study these phenomena, we took a look at distribution of Turing laureates within the United States, the majority producer of this population (64%).

Table 9: State distribution of Turing award winners within the US

<i>State</i>	<i>Turing Award laureates</i>
New York	9 (21%)
California	8 (19%)
Massachusetts	4 (9%)
D.C.	2 (4%)
North Carolina	2
Pennsylvania	2
New Jersey	2
Wisconsin	2
Alberta	1 (2%)
CT	1
Illinois	1
Kansas	1
Louisiana	1
Nebraska	1
Oregon	1
TX	1
Virginia	1
Washington	1

630 n = 41 t = 41



This analysis unveils that more than half of all US Turing laureates come from 3 states only : New York, California and Massachussets.

There is, beyond this, a strong concentration of future Turing laureates around the Northeast : New York, New Jersey, D.C., Massachussets and further  
 635 away Pennsylvania represent 19 Turing winners or almost half of all laureates based on place of birth.

In total, 17 states have produced at least 1 Turing laureate. This also means in return that of the current 50 states (then 48 states and the 2 territories of Alaska and Hawaii<sup>84</sup>, 33 are absent.

640 [map]

We move forward in our analysis of geographical distribution by using places of study as the next reference point. We later do the same for graduate institutions to follow the population’s movements and transits.

Table 10: Geographical distribution of Turing award winners by (based on) bachelor-granting institutions

<i>Continent, Country, State</i>	<i>%</i>	<i>Previously (born)</i>
North America	44 (68%)	
— USA	42 (65%)	
– California	11 (17%)	8
– Massachusetts	7 (10%)	4
New York metropolitan area*	6	
– New York	4	9
– Pennsylvania	4	2
– Illinois	3	
– Michigan	2	
– North Carolina	2	

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<sup>84</sup>The time range of births of our population is 1916 to 1952. Alaska and Hawaii became states in 1959.

– Colorado	1 (1,5%)	
– Connecticut	1	
– Minnesota	1	
– New Jersey	1	2
– Oregon	1	
– Texas	1	
– Virginia	1	
– Washington	1	
— Canada	2	
Europe	14 (21%)	14
— England	7 (10%)	
— Denmark	1	
— Germany	1	
— Greece	1	
— Italy	1	
— Netherlands	1	
— Norway	1	
— Switzerland	1	
Asia	6 (9%)	
— (British) India	1	
— Israel	4 (6%)	
— Taiwan	1	

n = 64 t = 64

<sup>645</sup> \* New York, New Jersey and Connecticut.

The analysis of the geographical distribution of Turing award winners at the undergraduate level unveils further the large dominance of the USA over all other places (as ascertained by proxy of their bachelor-granting institutions) : no other country comes close to their 2/3 total share of future Turing award

650 laureates.

In Europe, we note no difference between the situation observed in the context of birth places and the stage of bachelor’s degrees : those born in Europe among the Turing laureates stay there for undergraduate studies. This, as we will find later on, will change over time as Turing laureates move towards post-graduate education.

655 Next, we analyze the movements of Turing Award laureates as they move from their respective undergraduate colleges to their respective graduate schools.

Table 11: Geographical destinations of Turing award winners for post-graduate education

	<i>State (% of country)</i>	<i>Increase state</i>	<i>Country</i>	<i>Continent (previously bachelor)</i>
North America				49 (44)
— USA			48 (82%)	
– California	17 (29%)	70%		
– Massachusetts	11 (18%)	72%		
– New Jersey	6 (10%)	72%		
– Michigan	3			
– Pennsylvania	3			
– New York	3			
New York metropolitan area*	9			
– Illinois	2			
– Nebraska	1			
– North Carolina	1			
– Utah	1			
— Canada			1	
Europe				7 (14)
— England			3	

— Denmark			1	
— Greece			1	
— Netherlands			1	
— Norway			1	
Asia				2 (6)
— Israel			2	

n = 58 t = 58

\* New York, New Jersey and Connecticut.

660 In the same way that we observed a shift towards more prestigious univer-  
sities as Turing award winners entered postgraduate schools, we register a big  
geographical shift towards the USA, both being linked of course ; and, within  
that country, a big shift towards the major centers of education and research  
that are California, where almost 1/3 of all Turing Award winners attend grad-  
665 uate school, and Massachusetts, 1/5.

The diversity of outcomes dwindles as now most Turing award winners ag-  
gregate at common places : they increasingly attend colleges located in the same  
states. Attendance of a college in California as well as Massachusetts raises by  
70%, in New Jersey the number of future Turing Award winner grows from 1  
670 to 6 total.

Looking even closer, at happenings within the USA, we note an influx to-  
wards California (previously 8 born there, now 11 studying) and Massachusets  
(4 born, later 7 studying), while important states with comparatively lesser col-  
leges such as New York lose their population of Turing laureates (9 born, less  
675 than half studying or 4).

This has multiple by-effects, but as noted before, the most obvious ones  
are a depletion of talent from other states and countries and continents. Where  
previously 16 states hosted institutions attended by future Turing award winners  
at the bachelor level, now that number is only 10. The number of Turing  
680 laureates in Europe is halved, in Canada, halved, in Israel also and England

more than halved.

Looking closer, more disparities become clear as the only international institutions outside of the US and Europe remaining *ie.* attended by Turing award winners for postgraduate studies are all in Israel. This is compared to bachelor-  
685 level statistics where three countries, including India and Taiwan, were still represented at that stage of our analysis. An additional English university, outside of Oxford and Cambridge, Warwick, appears however post-graduation.

## 7. Social origins of Turing laureates

We are interested in knowing “where do Turing award winners come from and  
690 who are they?” and further “what social regularities can be unveiled (observed) from the study of their collective biographies, in other words, what do they have in common?” This is yet another attempt at answering this basic question, but from a different different assumptions or perspectives.

Here, we study social origins of which we know that they are - along with  
695 other categories of analysis such as education, gender or “race” - important properties of social actors/agents.

At the beginning of last century, Durkheim wrote that few things were more important to the development and understanding of human social behavior than family and education<sup>85</sup>. This has since been verified in countless sociological  
700 studies, but amongst many historians of science, these various levels of experiences remain absent. The world that they create, the one that they lay down on paper when writing about famed and anonymous science makers alike seems

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<sup>85</sup>“Education is the influence exercised by adult generations on those that are not yet ready for social life. Its object is to arouse and to develop in the child a certain number of physical, intellectual and moral states which are demanded of him by both the political society as a whole and the special milieu for which he is specifically destined. (...) Education varies from one caste to another; that of the patricians was not that of the plebeians; that of the Brahman was not that of the Sudra. Similarly, in the Middle Ages, what a difference between the culture that the young page received, instructed in all the arts of chivalry, and that of the villein, who learned in his parish school a smattering of arithmetic, song and grammar! Even today, do we not see education vary with social class, or even with locality?” This is from a posthumous publication entitled *Education and Sociology*. See Durkheim 1956 : 27 ; 67.

eerily disconnected from them, although they themselves must have an immediate or intimate knowledge of their importance for having experienced their  
 705 impact in their own personal lives.

This is an attempt to show how such an analysis could unfold, and what might be gained from it, although we were not able to go as far as we would have liked.

To compile this information, we have used the Turing award biographies.  
 710 Where other sources were used, we specify them in the appendix where the reader will also be able to find a much more detailed table containing the individual information on each winner as well as intermediary categories (*i.e.* categories in various intermediary states of abstraction). And, whereas in the full table, we still made us of a mix of intermediary and final categories, in the  
 715 following, we present the results of the analysis with broad categories.

Unfortunately, for a number of Turing award winners we were not able to find any relevant biographical information in their Turing award notices nor in other places. And, as can be expected from such enquiries, the more one moves up in time the less information is available. This makes a good case for more  
 720 oral history to be undertaken.

Hence note that this analysis is based on a sample of our total population (as we make clear by indicating that it relies on a number of 48 individuals instead of the full 64). This means that the statistics presented provide an indication for the tendencies of the overall population but are subject to a margin of error.

Table 12: Social origins of Turing Award laureates

<i>Background</i>	<i>Total</i>	<i>%</i>
Academic*	21	48%
Business**	5	11%
Low***	5	
Engineering	3	6%
Military	3	

Religious profession	2	
Other	4	
– Civil service	1	
– Professional sports	1	
– Artistic	1	
– Press	1	

725 n = 43 t = 64

\* *E.g.* mathematician, adjunct professor, professor at UCLA, high school physics.

\*\* *E.g.* stockbroker, aerospace executive, president of a power company.

\*\*\* *E.g.* appliance salesman, sea captain, janitor, farmer.

We found that almost 50% of Turing Award winners for whom relevant  
730 biographical information was available had at least one parent employed in a  
teaching or research position or otherwise in possession of an advanced degree  
like the PhD or Master.

As most Turing award winners come from the United States, we relied on  
North-American data to compare these findings with those available on the  
735 general population over the same period.

For this purpose, we looked at the percentage of the US population with a  
college degree, *i.e.* a bachelor's degree or higher, based on information made  
available by the United States Census Bureau<sup>86</sup>.

They indicate that in 1940, barely 4% of the total adult population, aged 25  
740 and older, were in possession of a bachelor or better. During the 1940s, 1950s  
and much of the 1960s this proportion never reached more than 10%.

Note that the median birth year of our population is 1941 with the oldest  
Turing Award winner born in 1916 and the oldest in 1952, which would put the  
birth years of their parents roughly between 1890 and 1930.

745 We have all reasons to believe, considering the steadily upwards trend of the  
curve that now puts the same demographic sample at 33%, that adults in pos-

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<sup>86</sup>United States Census Bureau 2017.

session of a higher education degree were consistently lower than 5% in previous decades. The Census Bureau however does not publish such information before 1940 to our knowledge.

750 Based on this, we think safe to say that : academic backgrounds were vastly overrepresented amongst families of Turing Award laureates, whose parents held college degrees in disporportionately higher frequency than the rest of the population with many of them holding advanced degrees including Master’s and PhDs at a time when these were much more seldom.

755 This must have played a role in making the future Turing award winners : having one parent with an academic background or involved in academia should have exposed them early on to books and contributed to their education at home or in getting them interested in school or otherwise having them perform well there.

760 That these statistics are not only of meaning “on paper” , but also affected the Turing Award winners intimately, in their lives and during childhood, we can ascertain from a qualitative review of their biographies.

About Martin Hellman, inventor of public key cryptography (together with Diffie and Merkle, we know from his biography that : “His father was a high school physics teacher, whose influence and collection of books helped to inspire Hellman’s early interest in science and mathematics.” Of Sutherland we learn that his father was a “practicing engineer with a Ph.D. in civil engineering” and his mother “a teacher who engendered in him and his brother Bert a love of learning.”

770 A particularly striking case of early exposure to culture is Alan Kay. “I had the misfortune or the fortune to learn how to read fluently starting about the age of three. So I had read maybe 150 books by the time I hit first grade.”<sup>87</sup>. From other biographic sources, we learn that in his childhood there were “nearly 6,000 books in the house and many drawings and illustrations.”<sup>88</sup>

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<sup>87</sup>The Davis Group 2011.

<sup>88</sup>Shasha and Lazere 1995.



775 “Since my father was a scientist and my mother was an artist, the  
atmosphere during my early years was full of many kinds of ideas and  
ways to express them. I did not distinguish between “art” and “sci-  
ence” and still don’t. My maternal grandmother was a schoolteacher,  
suffragette, lecturer, and one of the founders of UMASS, Amherst.  
780 My maternal grandfather was Clifton Johnson, a fairly well-known  
illustrator, photographer, and writer (100+ books). He was also a  
musician, and played piano and pipe organ.

One book I read was called *Rockets, Missiles, and Space Travel* by  
Willi Ley. The thing that struck me was that when you go from one  
785 planet to another, you wouldn’t go the way you thought you would.  
You don’t aim the rocket ship at the planet, you aim the rocket ship  
at where the planet is going to be.

By the time I got to school, I had already read a couple of hundred  
books”<sup>89</sup>

790 Meanwhile, at the other end of the social spectrum or scale, Hopcroft, whose  
father worked as a janitor, “claims that because of the lack of family experience  
with higher education, it never occurred to him to look at other than the local  
Seattle University.” Interestingly, Hopcroft, having gone through undergraduate  
education and having presumably been able to gather then the experience he  
795 lacked from home, moved to Stanford.

There may be disagreements with our categorization of elementary, middle  
school or even high-school teachers as belonging inside an academic category,  
or at least in the same fashion as college professions. But, leaving these *a pri-*  
*ori*, theoretical debates aside, and actually listening to or reading about the  
800 experiences of the Turing award winners does give insight, beyond the objective  
world we try to capture, of what the actual, felt reality was, for them. Again,  
we present evidence for this. Richard Karp, for instance, whose father was a

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<sup>89</sup>Shasha and Lazere 1995.

middle-school math teacher, has recounted that :

805 “Education was very much paramount in my parent’s worldview.  
There were four of us, and I’m the oldest of four, and they spaced  
us out at intervals of a college career, so that they could have one  
kid in college at a time. I think the greatest admiration I felt for my  
father was when I visited his class.”<sup>90</sup>

810 His interviewer, Christos Papadimitriou, a noted computer scientist himself,  
whose own father was also a middle school math teacher, asks Karp if they ever  
talked about math together : “We did, but he really didn’t have very advanced  
mathematical knowledge. He was pretty much limited to what he was teaching.  
But, his presence and sense of command in the classroom was something that I  
wanted to emulate. And, I think it’s not an accident that I went into teaching  
815 eventually.”<sup>91</sup> But, this influence is not limited only to the immediate circle  
of parents, as Richard Karp’s case also makes clear : “I had a young aunt  
(...) who taught me how to read, so I read quite early and for that reason I  
skipped a grade. And, so I ended up being a year and a half younger than my  
classmates”<sup>92</sup>.

820 In the following, we give for appraisal a longer passage that makes visible  
and unveils the sometimes very extensive educational strategies used by parents  
of future Turing award laureates.

“– *Interviewer*. You went to public schools in the Boston area?  
What suburb were you in?

825 – *Stonebraker*. We lived in a town called Newbury, which is right  
next to Newburyport. And my father chose that town deliberately  
because at the time they did not have a high school and the town  
would pay the tuition for anyone who could get accepted at Governor

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<sup>90</sup>Simons Foundation 2013.

<sup>91</sup>Ibid.

<sup>92</sup>Ibid.

Dummer Academy, which happens to be within the town boundaries.  
 830 It's in the same general league as St. Mark's, Milton Academy and  
 Browne and Nichols, those kinds of places. Both of my brothers  
 and I got to go to Governor Dummer as day students with tuition  
 paid by the town, which would not have been financially possible  
 otherwise.

835 – *Interviewer*. That was certainly very shrewd on his part. What  
 were the particular subjects you were interested in when you were  
 going to school?

– *Stonebraker*. Well my SATs sort of say it all. I made 800 on the  
 math SAT (...)<sup>93</sup>

840 Note 800 is the highest score attainable on the Math portion of the SAT, the  
 standardized test used for college admission in the United States. Stonebraker  
 himself went to Princeton after high school.

Next, we looked at the relationship between social origins and precocity *i.e.*  
 the age at which the laureates obtained the Turing award.

845 Looking at the 10 youngest Turing award winners, we found that over 50%  
 came from households where at least one of the parents held an advanced degree,  
 Master and beyond, or was otherwise engaged in an intellectual profession.

Table 13: Youngest Turing laureates and social background

<i>Name</i>	<i>Family background</i>
Donald Knuth	Academic (Teacher)
Robert Tarjan	Academic (Psychiatrist, APA president)
Kenneth Thompson	n/a <sup>94</sup>
Dennis Ritchie	Academic (Bell Labs)

<sup>93</sup>Computer History Museum 2007.

<sup>94</sup>The only available information on Kenneth Thompson's father is "US Navy", which we have coded as military in the table in appendix, but we do not know what position he held there or what his educational attainments were.

Marvin Minsky	Academic (Surgeon)
Edsger Diskstra	Academic (Teacher)
Robert Floyd	n/a
Stephen Cook	Academic (Professor)
Alan Perlis	n/a
John McCarthy	Non-academic (Labor organizer, Manager <i>Daily Worker</i> )
Dana Scott	n/a

Among the eleven youngest Turing winners, whose ages ranged from 36 to 44 at the time of their nomination, more than half come from academic back-  
850 grounds. This includes the following professions for their parents : one professor, two teachers, one Bell Labs employee, one surgeon and one psychiatrist APA president.

Even amongst Turing winners with formally non-academic backgrounds, their family circumstances are such that they have access to culture early. This  
855 is the case of McCarthy for example, who was born “into a politically engaged family in Boston”, his father was a labor organizer and Business Manager of the *Daily Worker*, a Communist newspaper, while his mother “was active in the suffrage movement” and “both parents were members of the Communist Party”<sup>95</sup>.

860 To trial-control this information, we have also looked at the same data for the oldest Turing Award winners, who ranged from age 77 to 68 at the time their work was recognized by the ACM and the Turing award given to them.

Table 14: Oldest Turing winners and social background

<i>Name</i>	<i>Family background</i>
Peter Naur	Non-academic (Painter and heiress)
Judea Pearl	n/a

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<sup>95</sup>Markoff 2011.

Frances Allen	Academic (low) (Farmer and elementary-school teacher)
Douglas Engelbart	Non-academic (Electrical engineer, radio shop owner)
Leslie Lamport	n/a
Michael Stonebraker	Academic (School teacher)
Whitfield Diffie	Academic (Professor)
Ole-Johan Dahl	Non-academic (Sea captain)
Martin Hellman	Academic (Teacher)
Barbara Liskov	Academic ( <i>Harvard Law Review</i> Lawyer)
Frederick Brooks	n/a

Due to the lack of information on certain laureates' background it is hard to make any definitive claims, but from the information we have available we noted that among the demographic of oldest Turing winners, families were more often more distant from academic background and their professions more heterogeneous.

## 8. Networks of Turing Award winners

Who studied under whom? Who wrote with whom? Who worked with whom? Who teaches *with* whom? Who employs whom? Who wrote about whom? Lastly, who penned whose necrology? We found all of these questions (and relationships) to apply to our object of study.

In following up with our intention to better understand who the Turing winners are and their sociological characteristics, we lastly looked at their networks.

We started by assembling a number of relationships, such as student-advisor relationships. In parentheses, we identify Turing award winners by the year of their nomination.

Table 15: Networks of Turing award winners, PhD advisor/student

<i>PhD advisor</i>	<i>PhD student</i>
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Alonzo Church	Alan Turing
	Michael Rabin (1976)
	Dana Scott (1976)
Claude Shannon	Ivan Sutherland (1988)
Howard Aiken	Kenneth Iverson (1979)
	Frederick Brooks (1999)
John McCarthy (1971)	Dabbala Reddy (1994)
	Barbara Liskov (2008)
Herbert Simon (1975)	Edward Feigenbaum (1994)
Marvin Minsky (1969)	Manuel Blum (1995)
Robert Floyd (1978)	Ronald Rivest (2002)
	Robert Tarjan (1986)
Manuel Blum (1995)	Shafi Goldwasser (2012)
	Silvio Micali (2012)

We found the relations of type advisor to student to be particularly significant : at least 8 future Turing Award laureates studied under previous winners.  
880 10 Turing winners, which is to say 5 pairs, had the same PhD advisor.

In one case, we found this relationship type to be particularly strong : a Turing winner, Manuel Blum, who had himself been advised by a Turing winner, Marvin Minsky, went on to advise 2 future Turing award winners, Shafi Goldwasser and Silvio Micali<sup>96</sup>.

885 We extended this into a graphical network analysis and concentrated on the relations between Turing Award winners of type student and advisor, where we identified a minimum of 20 edges.

### **Graph : networks of Turing award winners**

We present here the first results of what may become a larger research on

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<sup>96</sup>They themselves may well go on to advised or have already advised future Turing winners

890 networks amongst Turing winners and computer scientists.

These results are in their early stages and as such were not able to present all of the research.

We were interested in knowing how much personal networks affected Turing award winners.

895 We asked : was it significant when students wrote their dissertation under previous winners? Was it significant when they wrote articles together with them? Did this correlate with them winner the prize later?

Below, we present some pointers. We start by looking at the networks between PhD students and advisors. We find that there are many relationships  
900 binding future and past winners at this stage.

We then moved on to study relationships between co-authors and co-workers.

Table 16: Networks of Turing Award laureates, co-authors

	<i>Co-author(s)</i>
Alan Perlis (1966)	Allen Newell (1975) [1967]
	Herbert Simon (1975) [1967]
John Cocke (1987)	Frances Allen (2006) [1971 <sup>97</sup> ; 1976]

Table 17: Networks of Turing Award laureates, co-workers

	<i>Colleague(s)</i>
Alan Perlis (1966)	Allen Newell (1975) [Carnegie]
	Herbert Simon (1975) [Carnegie]
John Cocke (1987)	Frances Allen (2006) [IBM]
Kenneth Iverson (1979)	Frederick Brooks (1999) [Harvard]
Donald Knuth (1974)	Robert Floyd (1978) [Stanford]
	George Forsythe (ACM President) [Stanford]

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<sup>97</sup>Allen and Cocke 1972.

As a convention, we list the Turing Award winner with the earliest nomination on the left. In the case of colleagues, and co-authors, the direction of the relationship, and its structure, cannot be identified as readily as between PhD  
 905 advisor and PhD Student : a PhD advisor advises the student and commonly has many students.

Table 18: Networks of Turing award winners, professor/student

<i>Professor</i>	<i>Student</i>
Donald Knuth (1974)	Robert Tarjan (1986) [PhD course advisor] <sup>98</sup>
Howard Aiken	Frederick Brooks (1999) <sup>99</sup>
Ivan Sutherland (1988)	Alan Kay (2003) <sup>100</sup>

Table 19: Networks of necrologies (amongst Turing laureates)

<i>Living scientist</i>	<i>Dead scientist</i>
Peter J. Denning (ACM President)	Alan Perlis (1966) <sup>101</sup>
Donald Knuth (1974)	George Forsythe (ACM President) <sup>102</sup>
	Robert Floyd (1978) <sup>103</sup>
Edward Feigenbaum (1994)	Herbert Simon (1975) <sup>104</sup>

As we have done in previous developments, we are not merely concerned with (interested in) capturing objective relationships, but also to explore what their incidences are in the actual, lived lives of the actors. And, so, what exactly  
 910 does it mean to have a network and what advantages might, in this case the Turing winners, gain from it?

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<sup>98</sup>Tarjan 2012.

<sup>99</sup>Hosch 2018.

<sup>100</sup>Packer and Jordan 2002 : 122.

<sup>101</sup>Denning 1990.

<sup>102</sup>Knuth 1972.

<sup>103</sup>Knuth 2003.

<sup>104</sup>Feigenbaum 2001.



We look at the example of the relationships, primarily at Stanford, between Knuth and Floyd and to some extent Forsythe. The three of them, two Turing winners, and one ACM president, build a strong network of self-referential  
915 recommendations and support and promotions<sup>105</sup>

In 1962, Donald Knuth first became aware of Robert Floyd through his 1961 article “A descriptive language for symbol manipulation”<sup>106</sup>. During the 1960s, Robert Floyd contributed “a great deal of his time” to work on Knuth’s landmark *The Art of Computer Programming*. Meanwhile, from 1964 to 1966,  
920 George Forsythe had been ACM president. In 1965, he co-founded the department of computer science at Stanford with mathematician John Herriot<sup>107</sup>. In 1968, Donald Knuth joined Stanford’s newly formed CS department. George Forsythe then asked Knuth to write a letter of recommendation for Floyd to be appointed professor at Stanford that same year<sup>108</sup>. Here is a sample of its  
925 content :

“I don’t know anyone I could recommend more highly. He is the most gifted man in his ‘age bracket’ that I have ever met. Several of his published papers have been significant mileposts in the development of computer science (...). I have also had the pleasure of carrying  
930 on frequent correspondence with him for five years (...) While I was editing the ACM Communications and Journal, I asked him to serve as referee for several papers (...) He is a true Computer Scientist!”

That same year of 1968, Floyd joined Stanford. In 1973, he succeeded Forsythe as chair of the department of computer science at Stanford as the  
935 dean’s choice. He remained in that position for three years. In 1974, Donald Knuth was awarded the Turing Award. 4 years later, Robert Floyd was awarded

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<sup>105</sup>The source for all following developments, unless otherwise stated, is Knuth himself, see Knuth 2003.

<sup>106</sup>Floyd 1961.

<sup>107</sup>Knuth 1972.

<sup>108</sup>We do not know what prompted this, or how and when the Forsythe-Floyd relations started.

the same<sup>109</sup>.

This recommendation was followed by many other. In 1974 Knuth wrote another letter for the American Academy of Arts and Sciences. In 1975 he  
940 wrote yet another to the John Simon Guggenheim Memorial Foundation.

Relationships, or edges, don't stop at recommendations for faculty positions or places in academic societies, but also take on the more indirect and perhaps less obvious form of scientific references ; of which we know especially in the contemporary period just how great and powerful their role can be for the  
945 advancement of one's career<sup>110</sup>.

And, in the *The Art of Computer Programming*, the discipline's perhaps most revered book in the field of algorithms, if not in its entirety, no other author is more quoted than Floyd. Its publication spans from 1968 to the present day, although it was undertaken in 1962. In the 1997 third edition of  
950 Volume 1, Knuth thanks two people by name : his wife and Robert Floyd.

“I have, of course, received assistance from a great many people during the years I have been preparing these books and for this I am extremely thankful. Acknowledgements are due, first to my wife (...) ; secondly, to Robert W. Floyd, who contributed a great deal of his  
955 time towards the enhancement of this material during the 1960s.”<sup>111</sup>

In 2001 Robert Floyd died. In 2002 Donald Knuth gave a one-hour keynote speech to the Stanford Computer Forum. In 2003 he wrote a necrology for Floyd.

When looking back at their relationships, Knuth wrote unequivocally : “No-  
960 body has influenced my scientific life more than Bob Floyd. Indeed, were it not for him, I might well have never become a computer scientist.”

As such, we could write with a biographer of Turing that “when looking at

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<sup>109</sup>Unfortunately, we do not possess information on who was on the Turing Award committee during that period.

<sup>110</sup>This is due to the increasing importance of various rankings.

<sup>111</sup>Knuth 1997 : x.

the work of influential thinkers it is easy to underestimate the role that others played in their work. Having an active, supportive mentor can make all the difference, and Newman played this role for Turing throughout his professional life.”<sup>112</sup> For Floyd, we can say that Knuth played that role.

But, sometimes these kinds of relationships, and their directions, take on much more indirect ways such as when Alan Kay later in life recruited the brother of Ivan Sutherland at Xerox.

970       ”Alan knew my brother Ivan Sutherland from his time at Utah, and I suspect that Alan had a hand in recruiting me to Xerox PARC SSL.”<sup>113</sup>

Besides the immediate relationships between Turing award laureates, we found significant the relationships they had indirectly through common, prominent computer scientists :

We lastly found significant that many Turing laureates had studied or been advised by very prominent figures of computer science, which certainly must have helped in getting their work exposed to the ACM or the Turing committee.

Sutherland was advised by Shannon, Iverson and Brooks as already mentioned by Howard Aiken.

## 9. Gender (1) : the ACM council and Turing Award jury (1947-2018)

In three successive sections, we study the incidence of gender in the context of computer science and the Turing Award in particular. We answer successively : how are women represented within 1. the jury of the award 2. the ACM as a whole 3. the Turing Award itself.

In large parts, the history that we write, the statistics we drew from the various archives, left little place for other, alternative narratives, is a history of exclusion.

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<sup>112</sup>Bernhardt 2016 : 147.

<sup>113</sup>Piumarta and Rose 2010 : 30.

In short : women are underrepresented at all levels of the prize and its  
 990 various parent institutions. They are underrepresented on the level of the jury  
 (2 men for every woman), the ACM (it took the association 40 years to agree  
 on a female president) and among laureates, most of all there.

In the following table series, we explore the overarching theme of gender and  
 the ACM. In the first of these tables, we look at the composition of the ACM  
 995 council, the body that governs the ACM.

Table 20: Gender of ACM presidents (1947-2018)

<i>Decade</i>	<i>Men</i>	<i>Women</i>
1947-1949	2	0
1950-1959	5	0
1960-1969	5	0
1970-1979	4	1
1980-1989	4	1
1990-1999	3	2
2000-2009	3	2
2010-2018	3	1

Table 21: gender of ACM vice-presidents (1947-1975)

<i>Decade</i>	<i>Men</i>	<i>Women</i>
1947-1949	2	0
1950-1959	5	0
1960-1969	5	0
1970-1975	2	1

In her history of the ACM, Cochran remarks that “Sammet was the first  
 woman to lead ACM and became president after many years of activity in the

association”<sup>114</sup>. This is to say that for the first 27 years of its existence the ACM had only had male presidents.

1000 A review of the ACM council unveils further that in the first 25 years of its existence, it had only had male presidents and male vice-presidents.

Further, for the first forty years of its existence, the ACM had only been been succesful in finding two qualified and willing female presidents : Adele Goldberg followed in the footsteps of Sammet exactly a decade later.

1005 By the time it had existed for half a century, the ACM had only had three female presidents : Jean Sammet, from 1974 to 1976, Adele Goldberg, from 1984 to 1986, and Gwen Bell, from 1992 to 1994.

The ACM, we do not know when this tradition started, but it existed at least in 1975, publishes letters by acting presidents : in them, they for instance  
1010 outline their vision for the ACM or discuss current issues within the organization (*e.g.* lacking finances) amongst other things.

In trying to better understand, gender relations, especially at its highest echelon, of which we know from other domains, that it is there that gender inequalities are the most intense, to the detriment of women who are rarely  
1015 present at such a level<sup>115</sup>, we looked at the “president’s letters” of Jean Sammet.

We were all the more surprised when Sammet entitled hers, a series of six letters of roughly two pages each, “The Great Diversity in ACM”, but never acknowledged in them her own situation as the first female president or what we can only assume based on our statistics, both of the Turing award and the  
1020 ACM council, must have been a stark underrepresentation of women in leading positions (at the ACM).

Instead, she describes as the most controversial issues those pertaining to whether the ACM should engage in critical debates on the role of technology in society (she cites as examples the “Unique Identifier, ABM [and] privacy

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<sup>114</sup>Cochran 1987 : 869.

<sup>115</sup>Only 5% of the largest listed companies in Europe have a woman for (as) CEO. See European Commission 2016.

1025 legislation”<sup>116</sup>).<sup>117</sup>

This coincides with the research of Toland into the politics of the ACM. In her article we learn that Sammet, while being in favor of women’s rights, specifically the Equal Rights Amendment, that was hotly debated within and outside the ACM in around 1972 she felt that it was not the role of the ACM  
1030 to become a voice in those debates, much to the anger of other ACM members and staff who saw things differently<sup>118</sup>.

At around the same time as Sammet published her president’s letters, that same year, in, 1975, former vice-president of the ACM Council, Bruce Gilchrist published a report in *Communications of the ACM* called “Discrimination in  
1035 the Employment of Women in the Computer Industry”, in which he refers to a previous piece of legislature, the Equal Pay Act of 1964, and assures that “the lack of qualified individuals”, by which he means women, “does not, of course, explain the unequal pay”, but ultimately concludes that “caution should be exercised before making unequivocal claims of wage discrimination against  
1040 women.”<sup>119</sup>

Despite his experience, twice, as secretary, from 1960 to 1962, and vice-president, from 1962 to 1964, it does not occur to him, as it had neither to Sammet, to address the situation at the ACM itself, which at that time had very much stayed a men’s club until the arrival of the latter, if one takes for  
1045 criterium the composition of the ACM Council.

By the turn of the 20th century, something happened within the ACM, or perhaps it was the changes in society that made the ACM change, that made it

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<sup>116</sup>We assume that UUID, a large number that serves to uniquely identify pieces of software or hardware on computers, or the system as a whole, and agent-based modeling, a statistical-computational technique used to predict behaviors based on data collected on (about) individuals or groups, for instance potential criminal activity as inferred or determined from various personal characteristics, are what Sammet refers to here. It would be hard to pinpoint what pieces of legislation she meant, possibly none in particular as she also hints at the future, but note that two years before she wrote this the Privacy Act of 1974 had been enacted in her country ; whose purpose it was to establish a framework under which personally identifiable information could be gathered about individuals by US federal agencies.

<sup>117</sup>Sammet 1996 : 53.

<sup>118</sup>Toland 2017.

<sup>119</sup>Weber and Gilchrist 1975 : 417-418.

so that its gender politics, as we can tell externally from looking at the statistics, were radically redefined to include women.

1050 But, it took the ACM almost sixty years to start actively looking for female staff at its highest level. This, we conclude from the sudden (abrupt) jump in frequency at which women start to appear as presidents of the ACM starting with the term of Gwen Bell : in short succession, Barbara Simons (1998-2000), Maria Klawe (2002-2004) and Wendy Hall (2008-2010) were elected president.

1055 In the case of the US-based ACM, we believe that of much importance are the events immediately preceding and accompanying the nomination of Bell in the years 1991 and 1992.

The first saw the highly publicized testimony of Anita Hill against then Supreme Court nominee, now member Clarence Thomas, whose assistant she 1060 had been at the Department of Education and the EEOC, for sexual harassment<sup>120</sup>. This was followed in 1992, the latter dubbed “Year of the Woman”, by a wave of women elected to Senate and House the following year. But, as a retrospective editorial of the *New York Times* makes clear : “The law changed, too. The month after the hearings, Congress passed a law that allowed sexual 1065 harassment victims to seek damage awards as well as back pay and reinstatement.”<sup>121</sup>

In 1993, the *Vienna Declaration and Programme of Action* was adopted by the United Nations in June of 1993. It read : “The full and equal participation 1070 of women in political, civil, economic, social and cultural life, at the national, regional and international levels, and the eradication of all forms of discrimination on grounds of sex are priority objectives of the international community”.

From all the information that we have at our disposal, we can only assume

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<sup>120</sup>This made the front page of several widely distributed national magazines and newspapers such as Time, whose October 21 1991 issue was entitled “America’s watershed debate on sexual harassment”. This was followed by the October 28 issue of People, whose title read : “Anita Hill put the issue on the front page.” In New York, where the ACM is headquartered, this also made the front page of the New York Post, “Hill Passes Lie Detector”, it read in bold print on October 14 of that same year. (Refer to the appendix for this) See appendix 2)

<sup>121</sup>New York Times 2011.

that the ACM took note of these wider changes within society, be it in law, in popular opinion, in politics, in the media or in the workplace, at the highest of international levels.

To provide some more context, and to better situate the changes within the ACM in comparison to the wider technology world, we have looked at the practices of big technology companies during that same period.

We picked those companies that were the most relevant to our study of the Turing award in the sense that these are the companies where many of them were employed.

Table 22: Gender and big technology companies' CEOs and presidents (1914 - 2013)

<i>CEO / President</i>	<i>IBM (1914-2011)</i>	<i>Bell Labs (1925-2013)</i>	<i>Intel (1968-2013)</i>
Men	11	8	5
Women	0	0	0

IBM appointed its first female CEO in 2012, almost a century after its creation. Bell Labs has yet to appoint a woman as president. In 2018, Intel has yet to appoint a female CEO as the company celebrates its 50th anniversary.

Gender-exclusionary practices are common place and have been common place for decades at big technology companies such as IBM and Intel, if we take the way they look at and treat how they select their leadership as measurement.

As such we should look at the ACM's own practices a little less harshly : it had committed, beginning at the latest in the 1990s, to correct its gender gap. But, the ACM only appears progressive in comparison to peers who have, in some cases, century old track records of ignoring women for its highest executive position.

We know from other research, that individuals, when expressing opinions on women's rights or LGBT individuals, answer differently depending on the setting



1095 and their interlocutor<sup>122</sup>. IBM does not mind female typists, it does not mind  
female programmers, it does not mind even female vice-presidents. But, in the  
same way as certain individuals express support for progressive causes in public,  
and express opposite ones at home, there is few better instances to ascertain  
the actual positions of companies, including those and in particular those active  
1100 in the technology sector who have long claimed otherwise, than when they  
select what is most precious to them, when making those decisions that could  
affect them in the equally most beneficial and detrimental fashion. “Women  
cannot be entirely trusted to perform at the highest of levels” would be an  
accurate expression of their intimate views. Little more can be concluded from  
1105 the above statistics. And, if their intentions were different or other than what  
could be interpreted from numbers, we should quote Virginia Woolf, who wrote  
in *Orlando* that : “A woman knows very well that, though a wit sends her his  
poems, praises her judgment, solicits her criticism, and drinks her tea, this by no  
means signifies that he respects her opinions [or] admires her understanding”<sup>123</sup>.

1110 9.1. *Gender, the jury and the award (1966-2018)*

Table 23: gender balance within the Turing award committee

<i>Year</i>	<i>Men</i>	<i>Women</i>
2012 <sup>124</sup>	50% (4)	50% (4)
06/2013 <sup>125</sup>	60% (3)	40% (2)
08/2013 <sup>126</sup>	66% (4)	33% (2)
10/2013 <sup>127</sup>	62% (5)	37% (3)
08/2014 <sup>128</sup>	57% (4)	42% (3)
10/2014 <sup>129</sup>	62% (5)	37% (3)
09/2015 <sup>130</sup>	62% (6)	37% (2)

<sup>122</sup>Two meta-studies give an overview on the state of research in psychology into (this area)  
these areas : Paluck and Green 2009 and Pettigrew and Tropp 2006.

<sup>123</sup>Woolf 2008.

11/2016 <sup>131</sup>	87% (7)	12% (1)
07/2017 <sup>132</sup>	85% (6)	14% (1)
07/2017(2) <sup>133</sup>	83% (5)	16% (1)
09/2017 <sup>134</sup>	66% (6)	33% (3)
05/2018 <sup>135</sup>	66% (6)	33% (3)
Average	5.08	2.33

The jury for the award is consistently skewed towards men. At no point, in the interval that we have had access to, which encompasses seven years of committee changes, though incomplete in some parts, were we able to observe a jury that was in majority women. At best, there was a short equilibrium<sup>136</sup>.  
 1115 At worst, men outnumbered women 7 to 1 in the jury of the Turing Award<sup>137</sup>.

This means that, on average, for the period from 2012 to 2018, more than double the men sat on the jury of the Turing award than did women (approximately 15 men for every 7 women).

There is much to believe, based on our review of ACM council staff, for which  
 1120 we had access to much older archives, as well as other information presented elsewhere here, that gender ratios within the jury of the Turing award were for long periods of time during its history, especially in earlier decades, of the kind we observed and possibly much worse.

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<sup>124</sup> Archive from 09/11/12.

<sup>125</sup> Archive from 02/06/13.

<sup>126</sup> Archive from 28/08/13.

<sup>127</sup> Archive from 15/10/13.

<sup>128</sup> Archive from 21/08/14.

<sup>129</sup> Archive from 04/10/14.

<sup>130</sup> Archive from 06/09/15.

<sup>131</sup> Archive from 30/11/16.

<sup>132</sup> Archive from 03/07/17.

<sup>133</sup> Archive from 21/07/17.

<sup>134</sup> Archive from 20/09/17.

<sup>135</sup> Archive from 10/05/18.

<sup>136</sup> Jury composition on 09/11/2012.

<sup>137</sup> Jury composition on 30/11/2016.

Because the committee headed by a chair, we also provide information on  
1125 this : in 2012, Ravi Sethi was chair, in 2013, Adele Goldberg, in 2014, Barbara  
Liskov, in 2015, Michael Jordan, in 2016, David Salesin, in 2017, Alfred Spector,  
who still holds that position at the time of this writing.

We have no information on the powers and prerogatives of the chair and as  
such cannot elaborate on this.

## 1130 10. Gender (2) : Winners and losers

We turn now to the laureates. We avoid here explicitly the term winners,  
as, we find that, there are losers among the winners. And, that demographic is  
women.

Table 24: gender distribution of Turing award winners

<i>Men</i>	<i>Women</i>
95% (61)	4% (3)

n = 64 t = 64

1135 In the 50 years of the Turing award, 95% of recipients of the prize have been  
men. It took the jury of the Turing award 40 years to find its first qualified  
female (women) prize winner in Frances Allen, in 2006.

Only 3 women won the Turing award between 1966 and 2016. They are  
Frances Allen, Barbara Liskov and Shafi Goldwasser. Their awards were all  
1140 given in rapid succession, in 2006, 2008 and 2012.

From scholarship written on other awards, we know that this is part of a  
very consistent pattern : of the Nobel Prize, a 1991 study of female laureates  
opens by saying that “barely 10 times has [it] been awarded to women since its  
creation in 1901.”<sup>138</sup>

1145 Did the ACM and the Turing award change or did the world around them?

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<sup>138</sup>Folsing 1991.

In any case, these drastic changes can probably be viewed as fitting inside wider movements, demands and reforms within society, in the U.S. and many parts of the rest of the world.

Note that this also coincides, as we show elsewhere here, with changes within  
 1150 the governance of the ACM itself that make it so that women begin to be elected as presidents of the ACM starting in the mid-1990s ; and we have much reason to believe similar changes to take place in the Turing Award committee, though this cannot be said for certain without access to the relevant archives.

Table 25: gender distribution of Turing award winners split by decade (1940s-2010s)

<i>Decade</i>	<i>Women</i>	<i>Men</i>
1966-1969	0 (%)	4 (100%)
1970-1979	0 (%)	13 (100%)
1980-1989	0 (%)	12 (100%)
1990-1999	0 (%)	12 (100%)
2000-2009	2 (%)	14 (87.5%)
2010-2016	1 (%)	9 (90%)

As such, we cannot help but ask : was the jury unable to find qualified  
 1155 female applicants in previous decades, in fact for much of its history, because the ACM itself was an institution that did not value, or otherwise encourage, and at least objectively did not practice diversity within its governance?

Do women start to appear among the winners of the prize at the beginning of this century, because at the turn of the previous one the ACM started appointing  
 1160 women as presidents and included them in the jury of the prize as well?

That an award dedicated to computer science need not necessarily be this way, we can ascertain by looking at other, similar awards' practices, in this case we have consistently used the IEEE, the other big association relevant to computing and computer science, as reference point and specifically its Computer

1165 Pioneer Award.

In the case of the Computer Pioneer Award, the first award made to a woman was in the year 1997, Frances Snyder-Holberton, which puts it almost 10 years before the same was done for Frances Allen by the Turing Award. This means, put otherwise, that it took the IEEE and the Committee of the Computer  
1170 Pioneer Award about 15 years to reward women with its highest distinction in the discipline since its creation in 1981.

Finally, we asked : how long did it take for women to be recognized for their work, in the context of the Turing award, compared to their male peers or counterparts?

Table 26: Number of years needed to obtain the Turing Award, split by gender

	<i>Men</i>	<i>Women</i>
<i>Age (avg)</i>	55	65

1175  $n = 64$   $t = 64$

On average, it took women 10 years longer than their male counterparts to obtain the Turing award. This, we measured by calculating the difference between the year of birth of Turing winners and the year they won the award.

Frances Allen, the first woman to win the award, was 74 at the time of her  
1180 nomination, Barbara Liskov 69, and Shafi Goldwasser, who has obtained the award the most recently of all three, 54. This makes Allen the third oldest Turing award winner ever and Liskov the tenth.

The youngest 10 Turing Award winners ranged from age 36 to 44. In more detail yet, this also means that the youngest 25 Turing award winners were  
1185 all men. The youngest Turing award winner ever was Donald Knuth, who obtained it when he was 36 years old, followed by Robert Tarjan, 38 and Kenneth Thompson, 40. They are followed by four individuals who obtained it at age 42 respectively : Dennis Ritchie, Marvin Minsky, Edsger Dijkstra and Robert

Floyd.<sup>139</sup>

1190 Let us look closer at these happenings and at two examples in particular  
that we hold for exemplary of the disparities between both sexes when it comes  
to the recognition of their work within computer science.

After completing a bachelor's degree in mathematics, Frances Allen worked  
as a high school math teacher for two years before obtaining a master's degree  
1195 in that same discipline from the University of Michigan, where she learned how  
to program on an IBM 650 from Bernard Galler<sup>140</sup>, and joining IBM Research  
as a programmer in 1957. Her first assignment there was to teach Fortran to  
employees, which lead her to study the Fortran compiler developed by John  
Backus. Much of her work at IBM from then on focused on compilers<sup>141</sup>. This  
1200 included developing a compiler for Stretch and Harvest - Stretch, one of the  
earliest supercomputers, and Harvest, a coprocessor developed by the NSA for  
codebreaking - with support for three programming languages including Alpha  
which she had worked on. She then contributed to Project Y<sup>142</sup>, whose goal was  
to be many times faster than the previous project, Stretch. For the Project Y  
1205 computer, a compiler was built whose optimizer<sup>143</sup> Allen wrote. Project Y later  
became ACS, IBM's Advanced Computing System. The ACS-1 had in turn for

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<sup>139</sup>Note Dennis Ritchie was a close collaborator of Kenneth Thompson and their Turing was awarded jointly, while Robert Floyd was Donald Knuth's most important scientific influence according to himself.

<sup>140</sup>President of the ACM between 1968 and 1970, Vice-president from 1966 to 1968. See appendix.

<sup>141</sup>A compiler is a piece of software "that reads a program written in one language (...) and translates it into an equivalent program in another language". This definition is based on Aho, Sethi and Ullman 1986 : 1.

<sup>142</sup>In her interview with Guy Steele, who also wrote her Turing biography, Allen refers to the project as "System Y". See Steele 2011. Brian Randell, who worked on the project from 1964 to 1966, and Lynn Conway, from 1965 onwards, (both colleague of Allen and Cocke at IBM,) keep with the nomenclature "Project Y". See Randell 2015 and Conway 2011.

<sup>143</sup>In the classic compiler design book *Compilers: Principles, Techniques, and Tools*, which descends from a previous book by Aho and Ullman published in 1977, Aho, Sethi and Ullman write of code optimization : "Ideally, compilers should produce target code that his as good as can be written by hand. The reality is that this goal is achieved only in limited cases (...). However, the code produced by straightforward compiling algorithms can often be made to run faster or take less space, or both. This process is achieved by program transformations that are traditionally called *optimizations*. Compilers that apply code-improving transformations are called *optimizing compilers*."

ambition to be many times faster than the reference machine at that point<sup>144</sup>  
and later evolved into ACS-360 when a decision was made to support another  
system<sup>145</sup>. It was abandoned in 1969. After this, Frances Allen went on to  
1210 work on ECS, the Experimental Compiling System<sup>146, 147</sup>

On both of these projects, Y and ACS, Allen collaborated with John Cocke,  
who was seven years her senior and was also key in the development of the RISC  
architecture.

Together they wrote a series of articles and reports that reflected much of  
1215 her practical work done at IBM on optimizing compilers such as the 1971 “A  
Catalog of Optimizing Transformations”<sup>148</sup>. These joint publications were pre-  
ceded by Allen’s own, including “Program Optimization”, published internally  
in 1966<sup>149</sup>. In 1969 Cocke and Schwartz’ *Programming languages and their com-  
pilers* was published at the Courant Institute, “an extremely good summary of  
1220 the work done in the field”<sup>150</sup>, followed in 1970 by Cocke’s own paper (research)  
on (compiler) optimization “Global common subexpression elimination”<sup>151</sup>.

In recognition of her contributions, the ACM wrote in her Turing citation  
that it had awarded her its highest distinction : “For pioneering contributions  
to the theory and practice of optimizing compiler techniques that laid the foun-  
1225 dation for modern optimizing compilers and automatic parallel execution.”

And, yet, it awarded Cocke and Allen the Turing Award in 1987 and 2006  
respectively. This is to say that between both nominations lie almost 20 years.

Is it important to mention in this context, that, compared to the IEEE’s own

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<sup>144</sup>The IBM 7090 mainframe computer.

<sup>145</sup>The IBM System/360 mainframe.

<sup>146</sup>See Allen et al. 1980 for an overview of this project.

<sup>147</sup>Unless otherwise stated, the sources for these information are : the Turing Award biog-  
raphy of Frances Allen ; Smotherman 2017 ; Steele : 2011.

<sup>148</sup>IBM Research Report RC 3548 from September 1971. Republished in Allen and Cocke  
1972.

<sup>149</sup>Allen 1969. “Allen’s seminal paper on Program Optimization (published internally in  
April, 1966 and in an expanded version in the open literature in 1969), resulted from the  
ACS work.” according to the her IEEE Computer Pioneer award biography. <https://www.computer.org/web/awards/pioneer-frances-allen>

<sup>150</sup>Cocke and Schwartz 1969 ; Pollack 1971.

<sup>151</sup>Cocke 1970.

practices, the gap between Cocke's and Allen's nomination for the Computer  
1230 Pioneer Award is similar. The latter prize was awarded to both of them in  
1989 and 2004 respectively hence a gap in differentiated recognition of 15 years  
(versus 19 years).

Margaret Rossiter who has looked at the wider history of women in science  
in the USA and has written what is to our knowledge the reference text on the  
1235 subject for that country, the three-volume *Women Scientists in America*, has  
sought to generalize her findings by postulating the "Matilda Effect" in science.

In the abstract to her seminal article, she writes : "Recent work has brought  
to light so many cases, historical and contemporary, of women scientists who  
have been ignored, denied credit or otherwise dropped from sight that a sex-  
1240 linked phenomenon seems to exist"<sup>152</sup>.

Perhaps the best example for such phenomena is the fate of Lise Meitner,  
who not only had to overcome the great prejudices of her times against women  
in both secondary and higher education<sup>153</sup>, as the second woman ever to obtain  
a PhD in physics at the University of Vienna<sup>154</sup>, but whose 30 year collaboration  
1245 with Otto Hahn had for outcome that he only was awarded the Nobel prize.

Much of the same could be written about Marie Curie, the first woman to win  
the Nobel, whose 1903 Nobel prize in physics was only jointly awarded to her as  
well as her husband, in addition to Becquerel, on account of the intervention of  
prominent Swedish mathematician Mittag-Leffler ; and other important female  
1250 scientists of past periods.

In the preface to her monograph on female Nobel winners, Folsing writes :  
"At the yearly Nobel Prize ceremony, in Stockholm, the Swedish king almost  
only deals with an assortment of men. Women, if at all, appear to the ceremony  
as wives and as such fulfill a role barely more than decorative. Only in the most

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<sup>152</sup>Rossiter 1993.

<sup>153</sup>Women in Austria were not allowed to study at university up until 1899. They were also  
banned from attending high school, at least this was the case in 1892 in Vienna, where Meitner  
was born. See Folsing 1991 : 148.

<sup>154</sup>Sime 1996.



1255 exceptional of cases is a female scientist able to join the laureate ranks.”<sup>155</sup>  
She lists four additional women whose contributions were overshadowed by that  
their male colleagues with regard to the Nobel : Mileva Maric, and Albert  
Einstein, Chien Shiung Wu, and Tsung Dao Lee and Chen Ning Yang, Rosalind  
Franklin, and Francis Crick, James Watson and Maurice Wilkins, and Jocelyn  
1260 Bell Burnell, and Anthony Hewish. But, let us go back to computer science,  
and the Turing Award.

Drawing on the work of Rossiter, computer scientist Lynn Conway, who was  
a colleague of Allen and Cocke<sup>156</sup>, has spoken of “the erasure of women” in  
computer science, partly based on her own experiences and her work on VLSI  
1265 design and at IBM<sup>157</sup>.

A summary search reveals that now their important introductory textbook<sup>158</sup>  
on the topic can be regularly found attributed to Carver Mead only while their  
legacy is in the process of crystallizing as “Mead & Conway revolution”<sup>159</sup>.

In her case, her accomplishments were long unknown and her scientific legacy  
1270 further complicated by the fact that she was a transgender woman and that her  
previous accomplishments were cut off from her new identity and life. Due to  
this, her education, at MIT, was interrupted and she was later fired from IBM  
shortly after she came out<sup>160</sup>.

### 11. Gender (3) : gendered research : the labor division within com- 1275 puter science. The gendered division of research topics

In following developments, we take a closer look at what we call the “labor  
division within computer science”, which sees men, depending on whichever  
hierarchy is currently in place, active and overrepresented in the most prestigious

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<sup>155</sup>Folsing 1991 : 7. Our translation.

<sup>156</sup>Conway was staff at IBM and also worked on the ACS project, see Conway 2011.

<sup>157</sup>Conway 2016.

<sup>158</sup>Mead and Conway 1980.

<sup>159</sup>See appendix.

<sup>160</sup>Conway 2000; Hiltzik 2000.

areas of computer science, with women computer scientists in employment in  
1280 others.

Indeed, we see no coincidence in the fact that the most prominent women  
computer scientists all did work in software-related areas like compilers, as Allen  
did, like Hopper did, and the “original ladies of the ENIAC”. They did so  
because men were busy doing the real work of machine design, like Cocke himself  
1285 did, like Neumann did before him, and he whomever he may be who came before  
them.

Regarding this balance of tasks, Alan Kay has said of his employment of  
programmer in the US Army in the early 1960s :

“They needed programmers. This was back in the days when pro-  
1290 gramming was a low status profession and most of the programmers  
were women. My boss was a woman. They also were taking lin-  
guists who had served in Europe when they came back to the United  
States. It was actually a pretty interesting bunch. I had a friend  
who was a black guy who did what today we would call an operating  
1295 system.”<sup>161</sup>

This is in complete reversal with our knowledge of current happenings in the  
technology sector, where the most prestigious positions are all within software  
(*e.g.* AI, ML) while women may be found, if at all, in systems engineering jobs,  
or subaltern accounting or support positions, often the only women present at  
1300 these companies<sup>162</sup>.

The labor division within computer science research can be traced back to  
its very beginnings : Babbage created the analytical engine, while Ada wrote  
programs for it, wrote a report for it and helped document/promote it. What  
was unexpected, however, was that it was she, an amateur mathematician with  
1305 little more than basic knowledge of mathematics as one historian of science

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<sup>161</sup>Shasha and Lazere 1995.

<sup>162</sup>This relies on ethnographic observations.

highlights<sup>163</sup>, would be the one to understand and theorize on the true nature and important role of the new machine. She understood clearly, and wrote accordingly in her notes, that it was its potential to compute more than just numbers that mattered<sup>164</sup>.

1310 This divide between machines (contemporaneously called “systems”<sup>165</sup>, also alternatively referred to as “hardware”, “computer architecture”, “computer systems”, or indeed simply “systems”, and in past centuries as “engines”) and software is at the heart of many developments within computer science. Historically, women have made contributions in those areas, men in the former  
1315 ones. This is all the more significant, as the formerly prestigious area of hardware systems originally populated primarily by men has become subordinate to computational software developments (AI) and this balance is now reversed.

In the following we ask the questions : what areas have attracted female Turing award winners? Ultimately is there a link between gender and research  
1320 areas?

To answer this, we looked at the various domains of computer science that Turing award winners had made contributions in and correlated them with gender (of which the following table is the outcome).

We listed the areas in descending order according to the number of women  
1325 that we found in them (as a percentage of total Turing award winners within these areas) together with other key areas<sup>166</sup>.

Table 27: gender distribution of Turing award winners by research areas

<i>Area</i>	<i>Women</i> (% of total)
Compilers	1 (33%)

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<sup>163</sup>Swade 2008.

<sup>164</sup>Lovelace 1843.

<sup>165</sup>Although, this is also applied to (large) software and although this can also mean virtual machines.

<sup>166</sup>The full table is available in the appendix

Operating Systems	1 (25%)
Computational Complexity	1 (14%)
Cryptography	1 (14%)
Programming Languages	1 (11%)
Computer Architecture	0%
Computer Hardware	0%
Computer Systems	0%

Of 32 total areas listed by the ACM, 5 only feature women, or 15%. They are : compilers, operating systems, computational complexity, cryptography and programming languages. In turn, this also means that 27 areas are completely  
1330 void of women : the Turing Award committee seems to come to the conclusion that in all of those 27 areas there were no women that had made “lasting contributions” that were on the same level as those of the men whose work had respectively been recognized as worthy of the distinction.

The areas from which women are absent include much of systems, algorithms  
1335 (combinatorial algorithms, analysis of algorithms) and various other fields of mathematics (*e.g.* numerical analysis, numerical methods).

The table reveals on the other hand “feminine” areas of computing, which is to say areas of computing where women are not only active but were judged worthy of the prize, we list them again here with their respective percentages  
1340 : compilers (33%), operating systems (25%), computational complexity (14%), cryptography (14%) and programming languages (11%).

This fits with our general knowledge of the historic participation of women in computing, which saw them mostly working with programming languages during and after WW2<sup>167</sup>.

1345 The percentages that we indicate are mostly useful in the sense that they

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<sup>167</sup>We refer to the quote by Alan Kay provided elsewhere here and especially to the monograph by Abbate, *Recoding Gender*, which contains many interviews with female computer scientists and programmers from that period.

1350 give indications as to gender ratios and the proportion of men vs. women working within certain areas, with compilers and operating systems, both strongly connected domains, and often taught in combination, being the most “feminine” areas of computer science, at least based on the historical statistics drawn from the Turing Award.

In the following we attempt a broad classification of areas that go beyond the results exhibited previously<sup>168</sup>.

Table 28: big areas of computing and female Turing award winners

<i>Main areas</i>	<i>Women (% of total)</i>
<b>Software</b>	<b>8.6%</b>
– Compilers	33% (1)
– Operating Systems	25% (1)
– Programming Languages	11% (1)
– Objected Oriented Programming	0% (0)
– Software Engineering	0% (0)
– Software	0% (0)
– Programming	0% (0)
– Databases	0% (0)
<b>Systems (Hardware)</b>	<b>0%</b>
– Computer Architecture	0% (0)
– Computer Hardware	0% (0)
– Personal Computing	0% (0)
– Computer Systems	0% (0)
<b>Artificial Intelligence and Machine Learning</b>	<b>0%</b>
– Artificial Intelligence	0% (0)
– Machine Learning	0% (0)

<sup>168</sup>The full table is available in the appendix. As with all such attempts, trying to subsume complexity into simpler forms necessarily means losing some of their distinctive qualities. We feel there is room for improvement here.

<b>Cryptography</b>	<b>14%</b>
– Cryptography	14% (1)
<b>Computational complexity</b>	<b>7%</b>
– Computational Complexity	14% (1)
– Analysis of Algorithms	0% (0)
<b>Mathematics (other)</b>	<b>0%</b>
– Combinatorial Algorithms [comb. optimization]	0% (0)
– Numerical Analysis	0% (0)
– Numerical Methods	0% (0)
– Proof Construction	0% (0)
<b>Misc.</b>	-
– Education	0% (0)
– Graphics	0% (0)
– Interactive Computing	0% (0)
– Internet Communications	0% (0)
– List Processing	0% (0)
– Verification of Hardware and Software Models	0% (0)
– Parallel Computation	0% (0)
– Data Structures	0% (0)
– Error Correcting Codes	0% (0)
– Program Verification	0% (0)

Note : categories are not listed alphabetically, but by order of number of women, then degree (including of certainty) to which the individual category belongs to the overarching one (*e.g.* Software, Systems, etc.).

To provide some more context for these developments and to extrapolate on them, we try to integrate these findings into the broader history of women's place in computing.

It is interesting that the history of computers, computer science and com-

1360 puting in general, should be so strange. Indeed, it subverts much of our current  
notions on the role and place of women within technology. There they operate  
various, for the most part experimental machines, and program their novel sys-  
1365 tems, while here they are grossly underrepresented, in education, in industry,  
in academia and various other places.

1365 Early computer pioneers, starting with Ada Lovelace in the previous century,  
were in fact women. Babbage created the analytical engine, but she was the  
one who understood its purpose was much bigger than just that of calculator.  
“It might act upon other things besides number”, she wrote in her notes<sup>169</sup>.

1370 Women in computing are met again during WW2 when men became un-  
available and thus many women were thrust into technological employment,  
as someone had to operate the emerging wave of computers after all. They  
became typists, programmers, they punched cards to be processed by these new  
machines, some made extraordinary contributions, in fact many of the early  
programming languages and compilers were the works of women.

1375 In the late 1950s, as men had come back from duty, women were courted  
by big companies such as IBM, presumably because they were the ones who  
had primarily operated computers during the war and as such had the most  
experience. In one famous brochure, from the “My Fair Ladies” campaign, a  
typewriter with flowers overlaid on top catered to women especially<sup>170</sup>.

1380 In the 1960s and 1970s, it had become common for major manufacturers  
of computers to display women as objects of their advertisements : they were  
alternatively seen typing while holding manuals, filing various tapes and in  
one ad a woman wearing high heel boots and not much else is stepping on a  
computer<sup>171</sup>.

1385 In the late 2010s, male recruits in major Chinese tech companies such as  
Baidu, the leading search engine in that country among other things, and Al-  
ibaba, a leader in e-commerce, are lured with promises of working in the same

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<sup>169</sup>Lovelace 1843.

<sup>170</sup>See appendix.

<sup>171</sup>See appendix

company as attractive young women : one is dancing on a pole while two other’s presumably scripted dialogue include the line “I love tech boys”<sup>172</sup>.

1390 A brief history of women in computing sees them going from amateur mathematicians to programmer typists to ad-pinups, from 1850 to the present, with a very late recognition starting to happen at the end of the last century when the IEEE gave its highest distinction in computing to one of the original ladies of the ENIAC, Frances Snyder-Holberton, in 1997 and when the ACM followed  
1395 in 2006 by giving Frances Allen its Turing Award.

## 12. Ethnicity and the Turing Award

We use “race”, because of its prevalence in US-centric discussions and use that term, as it is commonly understood there, equivalently with ethnicity.

Looking at the ethnicity or “race” of Turing award winners, we come to  
1400 the conclusion that here as well entire groups are objectively excluded from its select - both academically and also socially as we have shown - pool of winners.

In a first attempt, we use birth place as proxy and reassess previously presented data to this effect.

Table 29: Turing laureates from outside North America and Europe

<i>Country</i>	<i>Turing winners</i>
North America*	43 (64%)
Europe	14 (21%)
Outside Europe / North America	7
– Israel	3 (4%)
– British India	1
– Ceylon	1
– China	1
– Venezuela	1

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<sup>172</sup>See appendix.



\* USA and Canada.

1405 But, we are able to go further as we know in detail, from our prosopography,  
who are behind the countries and what their circumstances are : in the case of  
Ceylon, Antony Hoare, who is white, in the case of Venezuela, Manuel Blum,  
whose Jewish parents had left Europe, in the case of British India, Dabbala  
Reddy who is not white.

1410 None of the Turing laureates are black. None of them come from Africa.  
None of them are American-African or Hispanic.

The table we established based on this knowledge and our findings, may not  
be perfect but it should be attempted :

Table 30: Race and Turing laureates

<i>Demographics</i>	<i>Turing Award laureates</i>
Whites	59 (92%)
— North America*	43
— Europe	14
— Ceylon**	1
— Venezuela***	1
Non-whites	5 (7%)
— Israel	3
— British India	1
— China	1

n = 64 t = 64

1415 This analysis is based on places of birth and our knowledge of the population  
based on collective biography (prosopography).

\* There are no African-Americans among the Turing Award laureates.

\*\* Antony Hoare, whose father was a colonial civil servant and who is white.

\*\*\* Manuel Blum, whose parents emigrated to Venezuela from Europe.

1420 Over 90% of Turing laureates are white and only 7% are non-white.

To establish this, and to provide more evidence, we have also approached the problem from another perspective. The ACM provides not only biographies from Turing Award laureates, but also photographs. We have used this resource as well.

1425 We proceeded to make a collage from them by using simple HTML code to load the images of Turing winners directly from the ACM website. The result of this is as follows, in the figure entitled “Ethnic (and gender) diversity amongst Turing winners”.

1430 In our review of Turing award winners between 1966 and 2016, we were only able to distinguish 2 non-white Turing Award laureates. They are Raj Reddy and Andrew Yao, of Indian and Chinese descent respectively. The overwhelming majority of Turing laureates is primarily from European ancestry. A significant portion is of Jewish origin<sup>173</sup>.

### 13. Making an award : the politics of careful biographical attribution 1435 and the erasure of diversity

When Alfred Nobel established the Nobel Prize at the end of the 19th century, he explicitly named physics, chemistry, physiology or medicine, literature and peace in his 1895 will<sup>174</sup>. For these disciplines or areas, the first Nobel Prizes were awarded in 1901.<sup>175</sup>

1440 The original provisions of the Nobel prize did not - and sometimes could not - include a number of subjects, such a prominently mathematics or economics. Another one is computer science, which only became an individual discipline during the 1960s. In the case of mathematics, the Fields Medal serves as the discipline’s highest distinction<sup>176</sup>.

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<sup>173</sup>Goldwasser, Feigenbaum, Blum, etc.

<sup>174</sup>A copy of the relevant parts of Nobel’s will can be found in Nobel Foundation 1972 : x.

<sup>175</sup>Ibid : 638-639.

<sup>176</sup>For a discussion of the absence of a Nobel in mathematics, see Morrill 1995. He concludes, citing various previous commentaries, that Nobel may not have felt that mathematics had “sufficient relevance to human development” and rejects in the process competing explanations regarding a supposed rivalry between Nobel and mathematician Mittag-Leffler.

Figure 1: ethnic and gender diversity amongst Turing winners



1445 One of the primary challenges faced by creators of a new prize can be summed  
up as follows : how to give stature and prestige to something just recently  
created? Historically, there have been a number of ways that groups behind  
such awards have employed to deal with this fundamental problem, such as  
naming their prize a distinguished figure, associating it with an established  
1450 institution, dote it with a large monetary reward (or any of those combined).

Of the so-called “Nobel prize in economics”, created two years after the  
Turing Award, in 1968, it has convincingly been argued that it relied on an  
usurpation of symbolic capital : the creators, Bank of Sweden, by naming the  
prize after the older and more established Nobel prize had successfully monop-  
1455 olized the former’s reputation for their own<sup>177</sup>.

From other perspectives, much has been written, but effectively not enough,  
about the erasure of various groups from the scientific enterprise, particularly  
and most obvious women<sup>178</sup>.

In the case of the Turing, there was no such obvious attempt to use the  
1460 stature of another prize. Instead the creators used the name of arguably the  
most iconic of all computer scientists ; both due to his foundational contribu-  
tions in many fields of the discipline, but also for his involvement in decrypting  
the Nazi codes during WW2 as well as for the more remarkable aspects of his  
personal life.

1465 This is most evident in the ACM promotional video entitled “The origins of

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hosts a collection of materials relating to the event, redirects to it as “Promotional Video”.  
We hypothesize that this may have been the context for its creation.

<sup>177</sup>Lebaron 2002.

<sup>178</sup>The most authoritative account of the history of women in science is perhaps Rossiter’s  
three-volume monograph called *Women Scientists in America*. For Europe, see the work of  
Annette Vogt amongst others.

<sup>179</sup>“A.M. Turing Award Video”. <https://amturing.acm.org/amtv.cfm>. The title or mention  
“The origins of the ACM A.M. Turing Award” stands above the video as well. This page  
links to [https://www.youtube.com/watch?v=f\\_8s451zYYE](https://www.youtube.com/watch?v=f_8s451zYYE) entitled “The ACM A.M. Turing  
Award”.

<sup>180</sup>The platform on which the video is hosted, YouTube, gives the following indication “Pub-  
lished on 16 Jan 2013”, but we believe the date of its creation to be 2011. This is based  
on the following URL, [delivery.acm.org/10.1145/2330000/2322176/AMTuringACM2011.mp4](https://dl.acm.org/citation.cfm?id=2322176)  
(note that this URL has been stripped from parameters, as its delivery is dependent on  
various individual information such as IP, it is not directly accessible). The URL <https://dl.acm.org/citation.cfm?id=2322176>, title “ACM Turing Centenary Celebration”, which

the award”<sup>179</sup><sup>180</sup>. It is more than two-thirds a biography of Alan Turing - this includes the first minute - while less than twenty seconds of its almost 2 minute running time is on the award itself proper.

In this brief passage that concerns the award, as opposed to selected passages from Turing’s life, the narrator explains : “In 1966, the Association for  
1470 Computer Machinery instituted the Turing award to honor the memory of Alan Turing. Over the years, it has become universally recognized as computing’s most prestigious award, given each year to individuals selected for making lasting major technical importance to the computing community.” In this both  
1475 presentational and representational video the words ”lasting major technical words” are highlighted. But, it is also useful to note what is not.

No biography is neutral, neither in form nor in content, and in this case, it takes on the format of a list or succession of Turing’s various accomplishments : his 1936 paper “On computable numbers”, Bletchley Park, his later work on  
1480 artificial intelligence<sup>181</sup> (“Can machines think?”) are referenced.<sup>182</sup>

But, both what is mentioned and left out is of importance : no word on his personal life. This is noteworthy in the sense that the Prize does not shy away from politics in other instances, for instance when it mentions the political activities of one winner who had been been an opponent to Norway’s joining of  
1485 the European Union. As such, it would be surprising that where Alan Turing was concerned, any bits of private biography, of which we now know just how important they are to understanding his life, would suddenly be considered irrelevant.

“But Kristen was not just a pioneer and researcher in informatics.  
1490 He was an engaged social and political citizen, involved in several aspects of society, including politics. During the intense political

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<sup>181</sup>Turing 1950.

<sup>182</sup>It should be mentioned here that where common or popular presentations of Turing’s contributions to computer science go, recent scholarship has sought to reevaluate the exact role played by Turing and the nature of his legacy. See Haigh 2014, Daylight 2014 and 2015 and Bullynck et al. 2015.

fight before the 1972 Referendum on whether Norway should become member of the European Common Market, he worked as coordinator for the large majority of youth organizations that worked against membership. He also was the leader (1990-1995) of Norway's No to the EU movement, which argued against Norwegian membership of the European Union and led to victory in the 1994 referendum.”<sup>183</sup>

In the biographies of the laureates it publishes, the ACM neither blends out politics, nor family life, nor marital details, and the various conclusions that can be drawn from those as to sexual orientation or political affiliation or societal attitudes. We can only assume that, if it did not consider them to be irrelevant in the case of Turing, they must have then been inconvenient. Biographical details are only welcome as long as they fit the mainstream image of heterosexuality where sexuality is concerned, while, well noted, digressions are permitted in all other thinkable domains of politics and personal health (from one winner, we learn of his chain smoking habits through his Turing Award biography) and marriage and divorce.

“John was renowned for the breadth of his intellect, for his energy, for his insights and for his unconventional working methods. He often wandered the halls of IBM seeking out colleagues to chat with. He was a chain smoker, so an effective method of locating him was to follow the trail of his cigarette butts in the ash trays.”<sup>184</sup>

This omission has also to be pointed out for another reason, namely that according to mathematician Andrew Hodges, author of the classic (authoritative) 1983 biography of (on) Turing called *The Enigma*, Alan had “played a central role in world history”, not for his politics, or lack thereof, but rather this was because “it was his individual freedom of mind, including his sexuality, that

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<sup>183</sup>Turing Award biography of Kristen Nygaard.

<sup>184</sup>Turing Award biography of John Cocke.

mattered”<sup>185</sup>.

One might even be tempted to use the words that professor Hofstadter has  
1520 used when talking of Sara Turing, the mother of Alan Turing, “whitewash”<sup>186</sup>,  
and conclude that the ACM found attractive the idea of naming their prize  
after the most iconic of all computer scientists, but found very advantage in the  
notion that this man had also lived a life outside of mainstream society and  
been homosexual.

1525 At a minimum, we must paraphrase him in writing that this was most likely  
because the organizers of the prize, like his mother, “wore conventional blinders  
and did not want to see, let alone say”<sup>187</sup>. In fully embracing the name and  
legacy of Turing, the ACM could have contributed to the progressive civil rights  
movements of the times that saw the creation of the award in the late 1960s,  
1530 by stating all that he had been, the resilience he had shown both in science and  
life<sup>188</sup>. And, that in any case they had used his name, the name of another  
man, because it was those kinds of characteristics they hoped to see in future  
winners (in addition to scientific merit).

But, it seems that, even now, this is a part of Alan Turing’s life and legacy  
1535 the ACM would rather not be seen associated with openly. It cherry picked  
parts from his biography, only those parts it deemed the best, creating a fairy  
tale of a well-fitted, neither too modest, for he had been a great man and this  
was to be an equally great prize, nor too abrasive portrait of a complex person

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<sup>185</sup>Hodges 2014 : xv.

<sup>186</sup>Hodges 2014 : xii.

<sup>187</sup>Hodges 2014 : xiii.

<sup>188</sup>Alan Turing was subject of a lawsuit on 31st of March 1952, *Regina v. Turing and Murray*. Considering his status and the nature of the lawsuit (“gross indecency” based on the *Criminal Law Amendment Act 1885*, a Victorian era legal phrase for gay sex), it seems likely that in the following almost 15 years between this event and the creation of the Turing award, knowledge of this must have been public, including in America. Hodges refers to one newspaper article from that period (“University Reader Put on Probation. To have Organo-Therapeutic Treatment” by the Wilmslow newspaper) and also cites an episode where Turing announced the events to Max Newmann in the refectory, presumably of the University of Manchester, “in a particularly loud voice”, for all to hear. See Hodges 2014 : 464, 471, 472. But, he also writes that during the inquest, which had been attended by “a row of journalists”, “nothing was mentioned that hinted at sex, the trial, blackmail or anything of the kind” and that following this event “the national press made remarkably little of it, and nothing was said regarding the 1952 trial”. For this, see Hodges 2014 : 488.

; an image of a person that is ultimately non-existent for no one lives, not even  
1540 the greatest of mathematicians, not even and everyone knows not Archimedes,  
in the abstract, otherworldly confines of mathematical research alone ; the same  
kind of willful denial and misplaced politeness that had made Turing's existence  
so hard and ultimately tragic in lifetime, and his place inside the rigid structures  
left over by Victorian society so unlivable, painful and strange<sup>189</sup>.

1545 This is all the more incomprehensible and incompatible with a view of a  
computer science prize that only cared about intrinsically scientific discoveries -  
if such a view was tenable, to which many philosophers and historians of science  
would have a very different one to oppose, one grounded in the actual, historical  
development of sciences - as the Turing Award pages inject many elements from  
1550 personal life into the biographies they craft for the Turing laureates, highlight-  
ing often the most original and colorful aspects of their personalities and lives -  
this winner worked as a store clerk after emigrating to America and another was  
a poor student throughout high school - in portraits that ultimately culminate  
in a synthesis of scientific advancements and personal life, often deeply interwo-  
1555 ven, and where biography has a value other than (is not) merely accidental or  
incidental or otherwise anecdotal.

Alan Turing was born in 1912. He died in 1953 at age 41. Neither Bletchley  
Park, nor his much quoted paper of 1936 gives us any insight into the anomaly  
that was his shortened life or helps us understand much of it, but an authentic  
1560 portrait would. He died prematurely because he had the misfortune of being

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<sup>189</sup>For the sake of exhaustivity, we should mention that many poor biographies have been written about Turing, starting with his own mother's, who, as Hodges states, was writing about a stranger whose work she had not the intellectual capabilities to understand and whose personal life she arranged to her own satisfaction. Jack Copeland, a philosophy professor, has managed the incredible feat of discussing Turing's death over ten pages from the perspective of plausible modes, reviewing in great detail the many possibilities he had conjured up in his mind, without considering in his expose the cumulative sum of social climate, the law, the lawsuit, the chemical castration, the general reprobation against homosexuality, the absence of a normal future, the absence of a normal past, that can never be made good, or anything that would have occurred to anyone discussing the suicide, since it has been ruled so, of a homosexual man in early 20th century Britain, having gone through the legal and medical and criminal apparatus reserved to gay men of that time. We are aware of other biographies that attempt to assess the lawsuit against Turing from the point of view of Logic.



born into a society whose entire fabric, founded on the latest of scientific, political, psychological, psychiatric, judicial, criminal and societal consensus, seemed to agree, for the most part, that homosexuality was wrong and abnormal and that those who were it thus deserved reprobation, prison and exclusion from normal lives ; a society deeply unkind to and unfit for people like him. For this, he  
1565 lost his employment and underwent chemical castration to avoid imprisonment. He killed himself shortly after<sup>190</sup>

We must mention that subsequently, there has been disagreement about the nature of Turing's death, much of it originating from his mother, Sara Turing,  
1570 who argued early on it was an accident<sup>191</sup>. However, we also know from Hodges that she had a strong inclination for shaping her son's legacy according to her own preconceptions and wishes, rather than truth<sup>192</sup>. This thesis was later reactivated by Jack Copeland in his book *Turing. Pioneer of the Information Age*, in which he goes to great length to discuss all thinkable alternatives, including  
1575 murder, whilst also simultaneously paying extraordinarily little concern to the social context<sup>193</sup> Further, he employs, by choice or ignorance, none of the critical tools that are common place amongst historians where the use of primary sources are concerned. Of Sara Turing's biography, he comments for instance naively "Turing's mother Sara provides an intimate and often amusing picture  
1580 of him in her biography"<sup>194</sup>. In this, Hodges' discussion of the role of Sara Turing in shaping her son's legacy immediately after his death, and the ways she has constructed her biography, her narrative choices, and the incomplete source material she has drawn from, is far superior<sup>195</sup>. The influence of her biography cannot be understated as this served as source for many publications  
1585 during the 1960s and 1970s<sup>196</sup>. Chris Bernhardt follows Copeland in his own

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<sup>190</sup>The cause of death was established as suicide (by the inquest), see Hodges 2014 : 488.

<sup>191</sup>Ibid.

<sup>192</sup>Hodges 2014 : 531-533.

<sup>193</sup>Copeland 2014 : 223-234.

<sup>194</sup>Copeland 2014 : 239.

<sup>195</sup>Hodges 2014 : 530-533

<sup>196</sup>Hodges 2014 : 533

book, *Turing's Vision*, but provides no new information<sup>197</sup>.

We were not able to find any references anywhere on the pages of the ACM to any of these events and with certainty not in the video that is meant to introduce the award. In this context, we also reviewed the 2012 “ACM Turing Centenary Celebration” : its event program<sup>198</sup>, a 20-page brochure/pamphlet, also does not mention any of these details. Interestingly enough, however, the first panel is dedicated to “Turing the man”, but it relegates history largely to the episodic narration of “amusing incidents”<sup>199</sup> and its role to little more than that of cocktail party entertainment. We also reviewed the content produced on the occasion of the 50th anniversary of the Turing award in 2017 and were neither there able to find any comprehensive biography of the man they had chosen to name their prize after. For this event, they produced a 5 minute video, as well as a shorter 2 minute version, and in both cases as soon as the “Computing and Machinery Intelligence” part of Turing’s biography is reached, published in 1950, or 2 years before his death, the narration abruptly comes to a stop<sup>200</sup>.

These are the politics of careful attribution by which one is able to claim for themselves the stature, not of an older prize, as the so-called “Nobel in economics” had done, but of a great man who had preceded them, and whose many noteworthy accomplishments presumably made him palatable to the committee when settling on a name for their newly created prize, without having to deal with those deemed less consensual or perhaps marketable parts that make up a person’s life.<sup>201</sup>

But, from his biographers we know now that Alan Turing “took no particular

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<sup>197</sup>See Bernhardt 2016 : 159-161.

<sup>198</sup>“ACM Turing Centenary Celebration. Official Program.” <https://portalparts.acm.org/2330000/2322176/fm/frontmatter.pdf>

<sup>199</sup>Ibid : 4. (Page 4 of the pamphlet.)

<sup>200</sup>For the 5 minute version, see [https://www.youtube.com/watch?v=MtGa\\_xvCgc&feature=youtu.be](https://www.youtube.com/watch?v=MtGa_xvCgc&feature=youtu.be). The 2 minute version is found here <https://www.youtube.com/watch?v=17qprc16a-Y>. More information on this event can be found here : <https://www.acm.org/turing-award-50>

<sup>201</sup>Bullynck et al. have argued that what specifically made Turing attractive to the ACM was that he represented a theoretical foundation for computing, see Bullynck et al. 2015.

1610 pains to hide [his sexuality]”<sup>202</sup> at a time when homosexuality was a criminal offense (punished by imprisonment and what was in many cases, objectively, the death of one’s social life). Alan Turing had lived an authentic personal life, as much as the society he had lived in, and their (dominant) belief system, permitted. And, it was this that was whitewashed.

1615 Essential to giving legitimacy to the criminalization of homosexuality were scientific societies like the ACM : they gave scientific seating to the aforementioned laws and policies. In the case of homosexuality, one association particularly stands out, the APA, the American Psychiatric Association, responsible for the formulation of the *DSM*<sup>203</sup>, a large body of prescriptive text used by psychol-  
1620 ogists and psychiatrists in the treatment of their patients that has both national and international influence<sup>204</sup>. In its first edition, *DSM I*, published in 1952, the APA classified homosexuality amongst mental disorders under the overarching category of “000-x60 Sociopathic Personality Disturbance” as “000-x63 Sexual deviation”, along with “pedophilia, fetishism and sexual sadism (including rape,  
1625 sexual assault, mutilation).”<sup>205</sup> In *DSM-II*, published in 1968, homosexuality remained a mental disorder except that it was now part of the reworked nomenclature of “302 Sexual deviations” ; of sexual deviations, the APA writes “[t]his category is for individuals whose sexual interests are directed primarily toward objects other than people of the opposite sex, toward sexual acts not usually  
1630 associated with coitus, or toward coitus performed under bizarre circumstances as in necrophilia, pedophilia”<sup>206</sup>. First listed amongst such practices : “302.0 Homosexuality”.<sup>207</sup>

These were the times Alan Turing lived in, this was the context in which he

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<sup>202</sup>Hodges 2014 : xiii.

<sup>203</sup>*Diagnostic and Statistical Manual of Mental Disorders*.

<sup>204</sup>The power held by their profession prompted Canguilhem to note, with the University of Paris in mind, that from the Faculty of psychology to the nearest police station, one had only to walk the street down.

<sup>205</sup>American Psychiatric Association 1952 : 39.

<sup>206</sup>American Psychiatric Association 1968 : 44.

<sup>207</sup>In recent history, the APA, has done much of what it had done for the pathologization of homosexuality, for transgenderism, from *DSM-III* onwards, thus shifting it into a psychiatric-psychological matter instead of a civil and general medical one.

produced his work, these were the psychological elites of his day. It is a part of  
1635 his legacy. Had it not been for it, Turing would have almost certainly lived a  
longer, he might have lived another 40 years, and the Turing award might have  
been the Von Neumann award ; and Turing its first winner<sup>208</sup>.

The erasure of diversity, far from what may be argued is just a statistical  
artifact or aberration, few qualified women lead to a small body to recruit  
1640 Turing Award laureates from, was a foundational act of the prize. Not much is  
left of that what had made the life of Turing, after whom the prize is named,  
ultimately the way it was, with all its quirks, his much admired and written  
about freedom of spirit and independence of mind, once retold by the ACM  
except for a sterile, convenient, incomplete promotional portrait<sup>209</sup>.

1645 In England, homosexuality was decriminalized in 1967<sup>210</sup>. In 2013, Alan  
Turing received a posthumous royal pardon<sup>211</sup> and in 2017 a law called “Alan  
Turing Law” was passed to pardon all other 49,000 men affected<sup>212</sup>. As of 2017,  
homosexuality remains criminalized in 72 countries and punishable by death in  
8<sup>213</sup>.

1650 “An awards program (...) would be a fitting activity for the Associa-  
tion as it enhances its own image as a professional society. (...) The  
award itself might be named after one of the early great luminaries  
in the field”<sup>214</sup>

With such detachment, could the then chairman of the ACM Awards Com-  
1655 mittee write on the day of 29th of August of 1966, shortly before the creation  
of the Turing Award.

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<sup>208</sup>The ACM in fact did consider naming the Turing Award the Von Neumann award in 1966, see ACM 1966.

<sup>209</sup>Historians of the Middle ages, no doubt, would have called this document a hagiography had this material belonged and been relevant to their objects and time period of study.

<sup>210</sup>*Sexual Offences Act 1967*.

<sup>211</sup>Davies 2013.

<sup>212</sup>*Policing and Crime Act 2017*.

<sup>213</sup>Duncan 2017.

<sup>214</sup>Association for Computing Machinery 1966.

## 14. Conclusion

We wanted to make sense of complex human behaviors, linked to academic and career choices, and, perhaps more importantly, look at them rationally where otherwise common sense and passion might prevail, and hopefully demystify the rules that govern professional and academic trajectories and successes, particularly those prone to idealism, because particularly notable, distinguished.

This paper sought to offer both an evidence-based overview of computer science grounded in statistical analysis as well as an anti-thesis to idealist conceptions of scientific development.

Our results were that, contrary to ideals of abilities alone determining success or recognition within the sciences that several factors had a disproportionate importance. We found that gender and network, as objectified among others by a systematic review of PhD advisors, colleagues and co-authors, play a big role in making future Turing Award winners. And further, in particular, that gender not only played a role in making careers, but influenced the choice of research topics following a pattern of historical bias. So far, only 3 women have received the prestigious prize<sup>215</sup>.

But beyond this, we also came to the conclusion that diversity was not only absent when reviewing the laureates, but that the award itself had sought to erase diversity in the very act of naming the prize after Alan Turing on the basis on a carefully constructed biography that omitted much of his life and struggles as a homosexual computer scientist in the early 20th century. His sexuality, we often hear, or read, did not play a role, and he himself is portrayed as not having wanted to become a gay icon, but it is not doing so, to recognize that his work as a scientist was made harder because of it, that it was interrupted by it and that his early interests in science may have stemmed from an early love<sup>216</sup>

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<sup>215</sup>For a speech by Frances Allen on this important issue, see Allen 2008.

<sup>216</sup>"I regarded my interest in my work, and in such things as astronomy (to which he introduced me) as something to be shared with him and I think he felt a little the same about me." he wrote to the mother of Christopher Morcom. See Hodges 2014 : 61.

The Turing Award represents what it seeks to objectively, at least impar-  
1685 tially recognize : a field that for the most part, though through many clever  
marketing tricks it tries to make appear otherwise, remains closed off to much of  
the population, women, visible minorities, and much of the world demographic  
outside of the United States and Europe.

A growing field within the social sciences is preoccupied with the “reflexivity”  
1690 of measurements, that is to say the effects that rankings, of which awards are  
one variety, have on the reality they try or claim to capture ; in other words  
what Marx had long called before them “real effects”. The Turing Award is a  
prime example of such an occurrence. It does not find women, because it does  
not reward women. It does not find minorities to reward, because it does not  
1695 reward minorities.

This was, essentially, the history of the Turing award in the 20th century.  
Will it operate differently in this one?

We have raised some questions, important questions as we felt, that we do  
we were not always able to answer. But, we have done our best to present the  
1700 evidence and where mistakes were made, they were honest.

We anticipate or hope they will be useful to those, in the present, in the  
here and now of the 21st century CE, who are entangled in the contemporary  
debates around gender gaps in technology, in politics, in the universities, among  
presidents of scientific organizations, such as the ACM, or private companies  
1705 such as IBM and its many new competitors.

To questions such as “what is the point of all this?”, we can only say that,  
and maintain that, there is intrinsic value in uncovering these happenings.

It is significant perhaps that when the ACM ordered, we assume, a book to  
be made on its history and released it last year, none of the research, and none  
1710 of the researchers, sought to study these questions<sup>217</sup>.

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<sup>217</sup>Its index table features a total of five 5 entries relating to the Turing Award. Nikivincze  
does point out that so far only 3 women have won the Turing Award in the context of her  
study of female PhDs in computer science. In the same volume, Toland has done remarkable  
work on the SIGCAS, the Special Interest Group on Computers and Society, of the ACM :  
see Toland 2017, in particular the appendix.

*Communities of Computing* is described as “the first book-length history of the Association for Computing Machinery (ACM)”. “Featuring insightful profiles of notable ACM leaders (...) and honest assessments of controversial episodes, the volume deals with compelling and complex issues involving ACM and computing.”<sup>1715</sup>

It warns, it “is not a narrow organizational history of ACM committees and SIGs<sup>218</sup>”, but it does not consider that it is precisely the history of these and other committees and institutions, even from the perspective of the most conservative of organizational histories, as long as it counted and numbered who had done what when and for how long, very much as we have done here<sup>1720</sup> essentially, for the Turing Award committee, the ACM leadership, and the rest, that would have given them the information they needed to come to similar conclusions (as we have).

Over the years, the ACM has shown great concern in its history and has made many efforts to preserve and write its own history, starting with the very first issue of its first journal, when its president, Samuel Wilson, wrote about the functioning of the association in its first 6 years<sup>219</sup>. This was followed up in the early 1960s when it asked its fourth president, Franz Alt, to do the same<sup>220</sup>. But, in many ways, because it limited these efforts to what it disavows now as “mere institutional history”, it never quite tackled the issues that might in fact have mattered, on a personal level<sup>221</sup>, and few others matter more, to the people that it employed : to the women it did not promote to top roles in particular, to the many women it did not consider for the Turing Award, and the award itself for which it created a partial biography of a man, mirroring much of what it had done for its own.<sup>1735</sup>

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<sup>218</sup>SIGs are specific interest groups within the ACM, each dedicated to one area of computing or computer science.

<sup>219</sup>Wilson 1954.

<sup>220</sup>the result of which is the 1962 article listed in the bibliography.

<sup>221</sup>“Instead of repeating the abstruse technicalities of my trade, I would like to talk informally about myself, my personal experiences, my hopes and fears, my modest successes, and my rather less modest failures.” With those words, started the Turing award lecture of Antony Hoare. See Hoare 1980.

Actors have a view of history, and their own most of all. But, that is only one thing. And, it is explicitly not enough for historians to give their own of theirs. The other, just as important, are the structures they live in, and those that determine their lives, not completely, but in some ways certainly. History,  
1740 as we understand it, as one of the social sciences, begins at the meeting of these two levels, between subjectively felt and structural reality.

—

In Europe, the major centers of computing are barely a mystery : in England, Cambridge, Oxford and London, in Switzerland, Zurich and Lausanne, in Scot-  
1745 land, Edinburgh. And, so, the question is rather which researchers will do the work and more pragmatically which institutions will support them.

In 1993, mathematician and computer pioneer (scientist) Herman Goldstine, one of the creators of the ENIAC, the first electronic digital computer, wrote in the preface to *The Computer from Pascal to von Neumann*, a history he had  
1750 himself shaped : “It is now 20 years (...) ; the world has been totally changed by the impact of the computer on our ways of thinking and acting. We all know, or at least sense, the many ways in which computer technology and its applications have modified our lives and ways of thought. They are so manifold that it would serve no useful purpose for me to detail examples here.”<sup>222</sup> The  
1755 history of computer science and computing cannot be premature. It is belated, but at this point, better late than never.

“Without the right to tinker and explore, we risk becoming enslaved by technology”<sup>223</sup> according to computer scientist Andrew Huang. Historians, particularly historians of science, have a crucial role to play in this context. And a  
1760 responsibility too. They do so at much less risk than the “applied sociologists” of this world and the next.

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We quoted Brecht at the beginning of this paper, according to whom because

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<sup>222</sup>Goldstine 1993 : ix.

<sup>223</sup>Huang 2013 : ii.



things were the way the way they were, they do not need to stay the way they  
1765 are.

History is one of the primary tools by which we can bring strangeness into  
our present and turbulence and cracks into a seemingly well structured and  
homogeneous surface, folly and unreason into a we are assured well-adjusted  
present ; it helps us step back from our daily lives and gives us the means to  
1770 reconsider the normal, current order of things as, objectively, one version of  
many possible and attainable others.

In this century, data has become the currency with which we pay for a variety  
of services. We pay for them by exchanging our memories. But, they, who rob  
us of our dreams, rob us of our lives.

1775 In the days when Sussman was a novice, Minsky once came to him as he sat hacking at the PDP-6.

“What are you doing?”, asked Minsky.

“I am training a randomly wired neural net to play Tic-tac-toe”, Sussman replied.

1780 “Why is the net wired randomly?”, asked Minsky.

“I do not want it to have any preconceptions of how to play”, Sussman said. Minsky then shut his eyes.

“Why do you close your eyes?” Sussman asked his teacher.

“So that the room will be empty.”

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<sup>224</sup>This article is wrongly printed as “The First 25 Years: ACM 1947-1962”, which does not make sense mathematically. It does handle the period up to 1972. This article was reprinted in *Communications* in 1987, with no modifications as far as we could tell, other than cosmetic, with the same mistake, together with Cochran’s which extends it by covering the (period) ACM’s history from 1972 to 1987, as well as Franz Alt’s original 1962 article on the first 15 years of the ACM.

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## Appendix

Listing of supplementary documents

- *Table : Turing Award laureates (1966-2016)*
- *Table : Turing Award laureates by bachelor institutions*
- *Table : ACM council (1947 - 2018)*
- *Table series : CEOs/Presidents of IBM, Bell Labs and Intel (1914-2018)*
- *Table series : Turing award committees (2012-2018)*
- *Table : Female Turing winners and areas of computing*
- *Image series : Gender through corporate archives (1950s-present)*
- *Table : social origins of Turing winners (full table)*
- *Table : IEEE Computer Pioneer Award winners (1981-2018)*

Table 31: Turing Award laureates (1966-2016)

<i>Year</i>	<i>Winner</i>
<b>1966</b>	Perlis, Alan J
<b>1967</b>	Wilkes, Maurice V.
<b>1968</b>	Hamming, Richard W
<b>1969</b>	Minsky, Marvin
<b>1970</b>	Wilkinson, James Hardy (“Jim”)
<b>1971</b>	McCarthy, John
<b>1972</b>	Dijkstra, Edsger Wybe
<b>1973</b>	Bachman, Charles William
<b>1974</b>	Knuth, Donald (“Don”) Ervin
<b>1975</b>	Newell, Allen
	Nabin, Michael O.
	Simon, Herbert (“Herb”) Alexander
<b>1976</b>	Rabin, Michael O.
	Scott, Dana Stewart
<b>1977</b>	Backus, John
<b>1978</b>	Floyd, Robert (Bob) W
<b>1979</b>	Iverson, Kenneth E. (“Ken”)
<b>1980</b>	Hoare, C. Antony (“Tony”) R.
<b>1981</b>	Codd, Edgar F. (“Ted”)
<b>1982</b>	Cook, Stephen Arthur
<b>1983</b>	Ritchie, Dennis M.*
	Thompson, Kenneth Lane
<b>1984</b>	Wirth, Niklaus E
<b>1985</b>	Karp, Richard (“Dick”) Manning
<b>1986</b>	Hopcroft, John E
	Tarjan, Robert (Bob) Endre
<b>1987</b>	Cocke, John

<b>1988</b>	Sutherland, Ivan
<b>1989</b>	Kahan, William (“Velvel”) Morton
<b>1990</b>	Corbato, Fernando J (“Corby”)
<b>1991</b>	Milner, Arthur John Robin Gorell (“Robin”)
<b>1992</b>	Lampson, Butler W
<b>1993</b>	Hartmanis, Juris
	Stearns, Richard (“Dick”) Edwin
<b>1994</b>	Feigenbaum, Edward A (“Ed”)
	Reddy, Dabbala Rajagopal (“Raj”)
<b>1995</b>	Blum, Manuel
<b>1996</b>	Pnueli, Amir
<b>1997</b>	Engelbart, Douglas
<b>1998</b>	Gray, James (“Jim”) Nicholas
<b>1999</b>	Brooks, Frederick (“Fred”)
<b>2000</b>	Yao, Andrew Chi-Chih
<b>2001</b>	Dahl, Ole-Johan
	Nygaard, Kristen
<b>2002</b>	Adleman, Leonard (Len) Max
	Rivest, Ronald (Ron) Linn
	Shamir, Adi
<b>2003</b>	Kay, Alan
<b>2004</b>	Cerf, Vinton (“Vint”) Gray
	Kahn, Robert (“Bob”) Elliot
<b>2005</b>	Naur, Peter
<b>2006</b>	Allen, Frances (“Fran”) Elizabeth
<b>2007</b>	Clarke, Edmund Melson
	Emerson, E. Allen
	Sifakis, Joseph
<b>2008</b>	Liskov, Barbara



<b>2009</b>	Thacker, Charles P. (Chuck)
<b>2010</b>	Valiant, Leslie Gabriel
<b>2011</b>	Pearl, Judea
<b>2012</b>	Goldwasser, Shafi
	Micali, Silvio
<b>2013</b>	Lamport, Leslie
<b>2014</b>	Stonebraker, Michael
<b>2015</b>	Diffie, Whitfield
	Hellman, Martin
<b>2016</b>	Berners-Lee, Tim

Table 32: Shanghai Ranking of universities in computer science and engineering (2007-2017)

<i>Institution</i>	<i>CS &amp; ENG* 2017</i>	<i>CS* 2009-2015</i>	<i>ENG* 2010-2016</i>	<i>ENG 2008-2009</i>	<i>ENG 2007</i>
MIT	1	2	1	1	1
Stanford	3	1	2	2	2
Berkeley	2	3	3	4	5

\* Computer Science & Engineering

\*\* Computer Science

\*\*\* Engineering/Technology and Computer Sciences

Sources :

– Academic Subjects - Computer Science & Engineering (2017)

<http://www.shanghairanking.com/shanghairanking-subject-rankings/computer-science-engineering.html>

– ARWU-SUBJECT / ARWU-Computer Science

<http://www.shanghairanking.com/SubjectCS2009.html>

<http://www.shanghairanking.com/SubjectCS2010.html>

<http://www.shanghairanking.com/SubjectCS2011.html>

<http://www.shanghairanking.com/SubjectCS2012.html>

<http://www.shanghairanking.com/SubjectCS2013.html>

<http://www.shanghairanking.com/SubjectCS2014.html>

<http://www.shanghairanking.com/SubjectCS2015.html>

– ARWU-FIELD / ARWU-ENG / Engineering/Technology and Computer Sciences

<http://www.shanghairanking.com/FieldENG2007.html>

<http://www.shanghairanking.com/FieldENG2008.html>

<http://www.shanghairanking.com/FieldENG2009.html>

<http://www.shanghairanking.com/FieldENG2010.html>

<http://www.shanghairanking.com/FieldENG2011.html>

<http://www.shanghairanking.com/FieldENG2012.html>

<http://www.shanghairanking.com/FieldENG2013.html>

<http://www.shanghairanking.com/FieldENG2014.html>

<http://www.shanghairanking.com/FieldENG2015.html>

<http://www.shanghairanking.com/FieldENG2016.html>

Table 33: universities ranked by number of Turing award winners based on bachelor's degrees (full)

<i>Institution</i>	<i>Bachelor students n (%)</i>
Berkeley	6
Cambridge	4
Carnegie Mellon University*	4
Harvard	4
California Institute of Technology	3
MIT	3
Oxford	3
University of Chicago	3
Duke	2
Stanford	2
Technion	2
Carleton College	1
Case Institute of Technology	1
City College of New York	1
Columbia	1
Copenhagen University*	1
ETH Zurich	1
Hebrew University	1
Queen's University	1
Leiden University**	1
Marburg	1
Michigan State	1
National Technical University of Athens	1
National University of Taiwan	1
New York State College for Teachers****	1
NYU	1

Oregon State University	1
Oslo****	1
Princeton	1
Sapienza University, Rome	1
Seattle University	1
Tel Aviv University	1
Toronto	1
University of Colorado at Boulder	1
University of Madras*****	1
University of Michigan	1
University of Texas at Austin	1
University of Virginia	1
Yale University	1

n = 64 t = 64

\* Previously, Carnegie Institute of Technology.

\*\* Registered by the ACM as University of Leyden.

\*\*\* Now, State University of New York at Albany.

\*\*\*\* Proxy by Master's degree.

\*\*\*\*\* Now, Anna University, Chennai.

Table 34: Universities ranked by the number of Turing award winners at the post-graduate level (full)

<i>Institution</i>	<i>Students</i>
Berkeley	8
Harvard	6
Princeton	6
Stanford	6
MIT	4
University of Michigan	3
Caltech*	2
CMU**	2
UUC***	2
Weizmann Institute of Science	2
Brandeis	1
Cambridge	1
Columbia	1
Copenhagen	1
Cornell	1
Duke	1
National Technical University of Athens	1
Oslo	1
Oxford****	1
Polytechnic Institute of Brooklyn*****	1
Toronto	1
UCLA	1
University of Amsterdam	1
University of Chicago	1
University of Pennsylvania	1
University of Utah	1

Warwick	1
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n = 58 t = 58

Methodology : we register the PhD institution, where a laureate has a PhD, and the Master's degree institution otherwise, for postgraduate study.

\* California Institute of Technology.

\*\* Previously, Carnegie Institute of Technology.

\*\*\* University of Illinois at Urbana-Champaign.

\*\*\*\* Including Hoare's postgraduate certificate in statistics.

\*\*\*\*\* Now, New York University Tandon School of Engineering.

Table 35: universities ranked by the number of Turing award winners based on PhD (full)

<i>Institution</i>	<i>Bachelor students n (%)</i>
Berkeley	7
Harvard	6
Princeton	6
Stanford	6
MIT	4
California Institute of Technology	2
CMU 2	
University of Illinois Urbana-Champaign	2
University of Michigan	2
Weizmann Institute of Science	2
Brandeis	1
Cambridge	1
Copenhagen	1
Cornell	1
Duke	1
National Technical University of Athens	1
Polytechnic Institute of Brooklyn	1
Toronto	1
UCLA	1
University of Amsterdam	1
University of Chicago	1
University of Utah	1
Warwick	1

n = 52 t = 52

### Appendix : ACM council (1947 - 2018)

Let us preface this by saying that we have a very good knowledge of the period going from the creation of the ACM in 1947 up to 1975, for which we possess information on all presidents, vice-presidents and secretaries, so far as we know. In this first table, empty cells imply that the personnel (listed) remains unchanged from one year to the other.

For the period from 1976 to 2016, we are missing many information, including (on) nearly all of the vice-presidents and some of the secretaries. In this second table, where appointments are presented in two-year spans, which correspond to the length of their term, empty cells take on the meaning of lack of information.

Table 36: ACM council (1947 - 2018)

<i>Year</i>	<i>President</i>	<i>Vice-president</i>	<i>Secretary</i>
1947	John H. Curtiss	John W. Mauchly	Edmund C. Berkeley
1948	John W. Mauchly	Franz L. Alt	
1949			
1950	Franz L. Alt	Samuel B. Williams	
1951			
1952	Samuel B. Williams	Alston Scott Householder	
1953			E. Bromberg
1954	Alston Scott Householder	D. Lehmer	
1955			
1956	John W. Carr III	Richard W. Hamming	Jack Moshman
1957			
1958	Richard W. Hamming	Harry D. Huskey	
1959			
1960	Harry D. Huskey	Jack Moshman	Bruce Gilchrist
1961			



1962	Alan J. Perlis	Bruce Gilchrist	Herbert S. Bright
1963			
1964	George E. Forsythe	Herbert S. Bright	E. H. Jacobs
1965			
1966	Anthony Oettinger	Bernard A. Galler	Donne Parker
1967			
1968	Bernard A. Galler	Walter M. Carlson	
1969			
1970	Walter M. Carlson	Anthony Ralston	C. L. Bradshaw
1971			
1972	Anthony Ralston	Jean Sammet	J. Hamblen
1973			
1974	Jean Sammet	Herbert R. J. Grosch	
1975			
1976-78	Herbert R. J. Grosch		
1978-80	Daniel D. McCracken		
1980-82	Peter J. Denning		
1982-84	David H. Brandin		Adele Goldberg
1984-86	Adele Goldberg		
1986-88	Paul W. Abrahams		
1988-90	Bryan S. Kocher		
1990-92	John R. White		
1992-94	Gwen Bell		
1994-96	Stuart H. Zweben		
1996-98	Charles House		
1998-2000	Barbara Simons		
2000-02	Stephen R. Bourne		
2002-04	Maria M. Klawe		
2004-06	David Patterson		

2006-08	Stuart Feldman		
2008-10	Dame Wendy Hall		
2010-12	Alain Chesnais		
2012-14	Vinton G. Cerf		
2014-16	Alexander L. Wolf		
2016-18	Vicki Hanson	Cherri M Pancake	Elizabeth F. Churchill

Sources :

This is compiled primarily from Revens 1972, "ACM Past Presidents"<sup>225</sup> and "ACM Council". <https://www.acm.org/governance/acm-council>

Note that there is disagreement between these two sources on the appointment of John Mauchly as president. Revens gives 1948, the ACM 1949 as starting year. We followed Revens in adopting 1948. Further Revens lists Herbert Bright as "H.S. Bright" then "H. Bright".

For the following people, we provide this additional information : Richard Hamming is the 1968 Turing award winner. John Carr III published various articles in ACM publications between 1952 and 1986<sup>226</sup>. Alston Scott Householder was a mathematician (Oak Ridge National Laboratory)<sup>227</sup>. Jack Moshman, PhD mathematics (Oak Ridge National Laboratory, Rutgers, Bell Labs)<sup>228</sup>. Herbert S. Bright, MS electrical engineering (Bell Labs)<sup>229</sup>. John Hamblen (University of Missouri-Rolla) was secretary of the ACM, 1972-1976<sup>230</sup>. Adele Goldberg became secretary of the ACM in 1982<sup>231</sup>

<sup>225</sup><https://www.acm.org/governance/past-presidents>

<sup>226</sup>For a list of his publications, see : [https://dl.acm.org/author\\_page.cfm?id=81100073002&coll=DL&dl=ACM&trk=0](https://dl.acm.org/author_page.cfm?id=81100073002&coll=DL&dl=ACM&trk=0)

<sup>227</sup>For his presidential address to the ACM, see : Householder 1956

<sup>228</sup>This is based on information provided by his obituary published in the *Washington Post*, 26/08/2014.

<sup>229</sup>See his biographical entry in Lee 1995.

<sup>230</sup>Austing 1977 :643

<sup>231</sup>This, we know from the "Oral History of Adele Goldberg" undertaken by the Computer

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History Museum in 2010. Bruce Gilchrist (Columbia University) was a member of the ACM council and is the author of several publications in ACM journals<sup>232</sup>. (Is D. Lehmer, mathematician Derrick Henry Lehmer of UC Berkeley?)

**Table series : CEOs/Presidents of IBM, Bell Labs and Intel (1914-2018)**

Table 37: CEOs of IBM (1914-2018)

<i>Year</i>	<i>President</i>
1914-1956	Thomas J. Watson
1956-1971	Thomas J. Watson Jr.
1971-1973	Thomas Vincent Learson
1973-1981	Frank T. Cary
1981-1985	John R. Opel
1985-1993	John F. Akers
1993-2002	Louis V. Gerstner Jr.
2002-2011	Samuel J. Palmisano
2012-now	Virginia “Ginni” Rometty

Source :

- “Former CEOs”. <http://newsroom.ibm.com/former-CEOs>

- “Virginia M. Rometty”. [https://www-03.ibm.com/ibm/history/exhibits/chairmen/chairmen\\_11.html](https://www-03.ibm.com/ibm/history/exhibits/chairmen/chairmen_11.html)

Table 38: Presidents of Bell Labs (1925-2018)

<i>Year</i>	<i>President</i>
1925-1940	Frank Jewett
1940-1951	Oliver Buckley
1951-1959	Mervin Kelly
1959-1973	James Fisk
1973-1979	William Baker
1979-1991	Ian Ross

1991-1995	John Mayo
1995-1999	Dan Stanzione
1999-2001	Arun Netravali
2001-2005	Dan Stanzione
2005-2013	Jeong Kim
2013-2013	Gee Rittenhouse
2013-now	Marcus Weldon

Source : “Presidents of Bell Labs”. <https://www.bell-labs.com/about/history-bell-labs/presidents/>

Table 39: CEOs of Intel (1968-now)

<i>Year</i>	<i>President</i>
1968-1975	Robert Noyce
1975-1987	Gordon Moore
1987-1998	Andy Grove
1998-2005	Craig Barrett
2005-2013	Paul Otellini
2013-now	Brian Krzanich

Source :

- “Intel CEOs: A Look Back”. <https://newsroom.intel.com/editorials/intel-ceos-a-look-back/>

- “Brian Krzanich”. <https://newsroom.intel.com/biography/brian-m-krzanich/>

**Table series : Turing Award committees (2012-2018)**

**09/11/2012**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	Ravi Sethi	Avaya Labs
Member	Frances Allen	Stanford University
	Michael J Carey	IBM Fellow Emerita
	Jennifer Chayes	Microsoft Research
	Adele Goldberg	Neometron
	Michael I. Jordan	UC, Berkeley
	Barbara Liskov	MIT
	David H Salesin	University of Washington/Adobe
	Per O Stenstrom	Chalmers University of Technology

**02/06/2013**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	Adele Goldberg	Pharma Capital Partners
Member	Michael I. Jordan	UC, Berkeley
	Barbara Liskov	MIT
	David H Salesin	University of Washington/Adobe
	Per O Stenstrom	Chalmers University of Technology

**28/08/2013**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	Adele Goldberg	Pharma Capital Partners

Member	Michael I. Jordan	UC, Berkeley
	Barbara Liskov	MIT
	David H Salesin	University of Washington/Adobe
	Ravi Sethi	Avaya Labs
	Per O Stenstrom	Chalmers University of Technology

**15/10/2013**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	Adele Goldberg	Pharma Capital Partners
Member	Michael I. Jordan	UC, Berkeley
	Barbara Liskov	MIT
	David H Salesin	University of Washington/Adobe
	Ravi Sethi	Avaya Labs
	Per O Stenstrom	Chalmers University of Technology
	Eva Tardos	Cornell University
	Leslie G Valiant	Harvard University

**21/08/2014**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	Barbara Liskov	
Member	Adele Goldberg	Pharma Capital Partners
	Michael I. Jordan	UC, Berkeley
	David H Salesin	University of Washington/Adobe
	Per O Stenstrom	Chalmers University of Technology
	Eva Tardos	Cornell University

	Leslie G Valiant	Harvard University
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**04/10/2014**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	Barbara Liskov	
Member	Alex Aiken	Stanford University
	Adele Goldberg	Pharma Capital Partners
	Michael I. Jordan	UC, Berkeley
	David H Salesin	University of Washington/Adobe
	Per O Stenstrom	Chalmers University of Technology
	Eva Tardos	Cornell University
	Leslie G Valiant	Harvard University

**06/09/2015**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	Michael I. Jordan	
Member	Alex Aiken	Stanford University
	Barbara Liskov	MIT
	David H Salesin	University of Washington/Adobe
	Alfred Z Spector	
	Per O Stenstrom	Chalmers University of Technology
	Eva Tardos	Cornell University
	Leslie G Valiant	Harvard University



**30/11/2016**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	David H Salesin	
Member	Alex Aiken	Stanford University
	Michael J Carey	
	David Heckerman	
	Alfred Z Spector	
	Per O Stenstrom	Chalmers University of Technology
	Eva Tardos	Cornell University
	Leslie G Valiant	Harvard University

**03/07/2017**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	Alfred Z Spector	
Member	Alex Aiken	Stanford University
	Michael J Carey	
	David Heckerman	
	Per O Stenstrom	Chalmers University of Technology
	Eva Tardos	Cornell University
	Leslie G Valiant	Harvard University

**21/07/2017**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	Alfred Z Spector	

Member	Alex Aiken	Stanford University
	Michael J Carey	
	David Heckerman	
	Eva Tardos	Cornell University
	Leslie G Valiant	Harvard University

**20/09/2017**

<i>Position</i>	<i>Name</i>	<i>Affiliation</i>
Chair	Alfred Z Spector	
Member	Alex Aiken	Stanford University
	Michael J Carey	
	Shafi Goldwasser	
	David Heckerman	
	Joseph Sifakis	
	Olga Sorkine-Hornung	
	Eva Tardos	Cornell University
	Leslie G Valiant	Harvard University

**16/05/2018 (current composition, no changes)**

<i>Position</i>	<i>Name</i>	<i>Institution</i>
Chair	Alfred Z Spector	
Member	Alex Aiken	Stanford University
	Michael J Carey	
	Shafi Goldwasser	
	David Heckerman	

	Joseph Sifakis	
	Olga Sorkine-Hornung	
	Eva Tardos	Cornell University
	Leslie G Valiant	Harvard University

Table 52: Female Turing winners and areas of computing

<i>Area</i>	<i>Women (% of total)</i>
Compilers	33% (1)
Operating Systems	25% (1)
Computational Complexity	14% (1)
Cryptography	14% (1)
Programming Languages	11% (1)
Analysis of Algorithms	0% (0)
Artificial Intelligence	0% (0)
Combinatorial Algorithms	0% (0)
Computer Architecture	0% (0)
Computer Hardware	0% (0)
Computer Systems	0% (0)
Data Structures	0% (0)
Databases	0% (0)
Education	0% (0)
Error Correcting Codes	0% (0)
Graphics	0% (0)
Interactive Computing	0% (0)
Internet Communications	0% (0)
List Processing	0% (0)
Machine Learning	0% (0)
Numerical Analysis	0% (0)
Numerical Methods	0% (0)
Objected Oriented Programming	0% (0)
Parallel Computation	0% (0)
Personal Computing	0% (0)
Program Verification	0% (0)
Programming	0% (0)

Proof Construction	0% (0)
Software	0% (0)
Software Engineering	0% (0)
Verification of Hardware and Software Models	0% (0)

Table 53: Turing award winners listed by age (asc)

<i>Age</i>	<i>Name</i>
36	Donald Knuth
38	Robert Tarjan
40	Kenneth Thompson
42	Dennis Ritchie
42	Marvin Minsky
42	Edsger Dijkstra
42	Robert Floyd
43	Stephen Cook
44	Alan Perlis
44	John McCarthy
44	Dana Scott

Table 54: social origins of Turing winners (full)

	<i>Father</i>	<i>Mother</i>	<i>Social category</i>
Adleman	Appliance salesman <sup>233</sup>	Bank teller <sup>234</sup>	Low
Allen	Farmer <sup>235</sup>	Elementary-school teacher <sup>236</sup>	Academic (low)
Bachman	College football coach (Michigan State) <sup>237</sup>		Professional sports (Upper-middle class)
Backus	Wealthy stockbroker		Business (high)
Berners-Lee	Mathematician and computer scientist (Ferranti Mark I) <sup>238</sup>	Mathematician and programmer (Ferranti Mark I) <sup>239</sup>	Academic (both) ((very) high)
Blum			
Brooks			
Cerf	Aerospace executive <sup>240</sup>	Homemaker <sup>241</sup>	Business (high) (possibly engineering)
Clarke			

<sup>233</sup>Turing Award biography.

<sup>234</sup>Ibid.

<sup>235</sup>Turing Award biography.

<sup>236</sup>Ibid.

<sup>237</sup>Charles W. Bachman (1892-1985). See New York Times 1985. His biographical entry at the College Football Hall of Fame provides further details : Northwestern, Kansas State (1920-27), Florida (5 years), Michigan State (1933-42 ; 1944-46) and Hillsdale College, see [http://www.collegefootball.org/famer\\_selected.php?id=30056](http://www.collegefootball.org/famer_selected.php?id=30056)

<sup>238</sup>Conway Berners-Lee (1921-).

<sup>239</sup>Mary Lee Woods (1924-2017). Sources : Ferry 2018.

<sup>240</sup>Vinton Thurston Cerf. Sources : Jerome 2000.

<sup>241</sup>Ibid.

Cocke	President of Duke Power Company (Duke Energy) and member of the Board of Trustees of Duke University <sup>242</sup>		Business (high)
Codd	Leather manufacturer <sup>243</sup>	Schoolteacher <sup>244</sup>	Academic
Cook	Chemist for a subsidiary of Union Carbide and adjunct professor at SUNY <sup>245</sup>	Homemaker and occasional English teacher at Erie Community College <sup>246</sup>	Academic (both)
Corbato	Professor of Spanish literature at UCLA <sup>247</sup>	(graduate student at Berkeley) <sup>248</sup>	Academic (both)
Dahl	(descended on both sides from long lines of sea captains) <sup>249</sup>	Housewife <sup>250</sup>	Low (“neither his sister nor his brother was academically inclined”) <sup>251</sup>
Diffie	Professor specializing in Iberian history at City College of New York <sup>252</sup>	Writer and scholar <sup>253</sup> (passed away while he was in high school)	Academic (both)

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<sup>242</sup>Turing Award biography.

<sup>243</sup>Turing Award biography.

<sup>244</sup>Ibid.

<sup>245</sup>Turing Award biography.

<sup>246</sup>Ibid.

<sup>247</sup>Turing Award biography.

<sup>248</sup>Ibid.

<sup>249</sup>Turing Award biography.

<sup>250</sup>Ibid.

<sup>251</sup>Ibid.

<sup>252</sup>Bailey Wally Diffie. Turing Award biography.

<sup>253</sup>Justine Louise Whitfield. Ibid.



Dijkstra	High-school chemistry teacher and president of the Dutch Chemical Society <sup>254</sup>	”never held a formal job” (“had a lasting influence on his approach to mathematics and his emphasis on elegance.”) <sup>255</sup>	Academic
Emerson			
Engelbart	Electrical engineer who owned a radio shop (died when Engelbart was 9 years old) <sup>256</sup>		Engineering
Feigenbaum	(“stepfather took him on frequent visits to the Hayden Planetarium of the American Museum of Natural History”) <sup>257</sup>		
Floyd			
Goldwasser			
Gray	(U.S. Army (“an amateur inventor, patented a design for a ribbon cartridge for typewriters that earned him a substantial royalty stream”))	English teacher (“raised by his mother”) <sup>258</sup>	Academic
Hartmanis	Senior Latvian army officer (died during WW2) <sup>259</sup>		Military
Hellman	High school physics teacher <sup>260</sup>		Academic

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<sup>254</sup>Turing Award biography.

<sup>255</sup>Ibid.

<sup>256</sup>Turing Award biography.

<sup>257</sup>Turing Award biography.

<sup>258</sup>Turing Award biography.

<sup>259</sup>Turing Award biography.

<sup>260</sup>Turing Award biography.

Hoare	Colonial civil servant <sup>261</sup>	Daughter of a tea planter <sup>262</sup>	Civil service (presumably high)
Hopcroft	Janitor (“working class family”) <sup>263</sup> (Hopcroft’s grandfather was ”Jacob Nist, founder of the Seattle-Tacoma Box Company”)		Low
Iverson	Rabbi		Religious profession
Kahan	Ran a factory <sup>264</sup>	Created dress designs for the factory run by her husband	Business <sup>265</sup>
Kahn	(Through his father, related to futurist Herman Kahn)		
Karp	Middle school math teacher <sup>266</sup> (Junior high school teacher)		Academic

<sup>261</sup>Sources : oral histories by the British Library and the Computer History Museum.  
<https://sounds.bl.uk/related-content/TRANSCRIPTS/021T-C1379X0052XX-0000A0.pdf>  
[http://archive.computerhistory.org/resources/text/Oral\\_History/Hoare\\_Sir\\_Antony/102658017.05.01.pdf](http://archive.computerhistory.org/resources/text/Oral_History/Hoare_Sir_Antony/102658017.05.01.pdf)

<sup>262</sup>Ibid.

<sup>263</sup>Turing Award biography.

<sup>264</sup>Turing Award biography.

<sup>265</sup>Ibid.

<sup>266</sup>2013 video interview of Richard Karp by the Simons Foundation. <https://www.simonsfoundation.org/2013/12/13/richard-karp/>

Kay	Scientist <sup>267</sup> / physiologist, designed prostheses for arms and legs <sup>268</sup> / Designed arm and leg prostheses <sup>269</sup>	artist and musician <sup>270</sup> / Musician <sup>271</sup>	Academic (grandmother was a lecturer and one of the founders of UMASS)
Knuth	Teacher in a Lutheran high school and a church organist <sup>272</sup> (Ran a small printing company and taught bookkeeping at Milwaukee Lutheran High School)		Academic
Lamport			
Lampson			(“Born in Washington DC and educated at The Lawrenceville School, an elite boarding school 6 miles from Princeton New Jersey.”) <sup>273</sup>

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<sup>267</sup>Shasha and Lazere 1995.

<sup>268</sup>Ibid.

<sup>269</sup>Turing Award biography.

<sup>270</sup>Shasha and Lazere 1995.

<sup>271</sup>Turing Award biography.

<sup>272</sup>Turing Award biography.

<sup>273</sup>Turing Award biography.

Liskov	Harvard, <i>Harvard Law Review</i> “Distinguished tax lawyer in San Francisco” <sup>274</sup>	Dancer (graduated from Berkeley) <sup>275</sup>	Academic (Artistic / Liberal professions)
McCarthy	Labor organizer and later Business Manager of the Daily Worker, a national newspaper owned by the Communist Party USA <sup>276</sup> (Organizer for the Amalgamated Clothing Workers in Los Angeles)	Worked for a wire service, then for the Daily Worker and finally as a social worker <sup>277</sup>	Press (Business) (Labor organization)
Micali			
Milner	Military family residing on the South coast of England <sup>278</sup>	Military family residing on the South coast of England	Military <sup>279</sup>
Minsky	Eye surgeon <sup>280</sup>	Jewish activist <sup>281</sup>	Academic (Medical)
Naur	Painter <sup>282</sup>	“no particular profession but came from a wealthy commercial background” <sup>283</sup>	Artistic (Upper class)

<sup>274</sup>Moses Samuel Huberman. San Francisco Chronicle 2010 ; The Harvard Crimson 1926.

<sup>275</sup>San Francisco Chronicle 2010.

<sup>276</sup>John Patrick McCarthy. Turing Award biography. Additional sourcee : Markoff 2011.

In Markoff 2005, there is an important information regarding the chronology : “an Irish immigrant who later became business manager of (...) *The Daily Worker* after the family moved to Los Angeles because of their young son’s health problems.”

<sup>277</sup>Ida Glatt. Ibid.

<sup>278</sup>Turing Award biography.

<sup>279</sup>Ibid.

<sup>280</sup>Swedin 2005 : 188.

<sup>281</sup>Ibid.

<sup>282</sup>Turing Award biography.

<sup>283</sup>Ibid.

Newell	Prominent professor of radiology at Stanford Medical School <sup>284</sup>		Academic
Nygaard			
Pearl			
Perlis			
Pnueli	Professor (one of the founders of Tel-Aviv University and chaired the Hebrew literature department) <sup>285</sup>	Teacher <sup>286</sup>	Academic (both)
Rabin	Rabbi		Religious profession
Reddy	Farmer	Homemaker	Low ("first member of his family to attend college")
Ritchie	AT&T Bell Laboratories <sup>287</sup>		Academic
Rivest			
Scott			
Shamir			
Sifakis			

<sup>284</sup>Robert R. Newell. Turing Award biography.

<sup>285</sup>Prof. Shmuel Yeshayahu ("Shay") Pnueli. Turing Award biography.

<sup>286</sup>Henya Pnueli. Ibid.

<sup>287</sup>Turing Award biography.

Simon	engineer Cutler-Hammer Manufacturing Company, and later also engaged in private practice as a patent attorney. awarded honorary doctorate in 1934 by Marquette University <sup>288</sup> / Worked for the Cutler-Hammer manufacturing company helping to design control devices <sup>289</sup>	Piano teacher until marriage, then housewife <sup>290</sup>	Academic
Stearns			
Stonebraker	Engineer <sup>291</sup>	School teacher <sup>292</sup>	Academic
Sutherland	“Practicing engineer with a Ph.D. in civil engineering” <sup>293</sup>	Teacher <sup>294</sup>	Academic (both)
Tarjan	Psychiatrist (president of the APA) <sup>295</sup> (Child psychiatrist, ran a state hospital)		Academic (Medical)
Thacker	Electrical engineer <sup>296</sup> (in the aeronautical industry (graduated from Caltech)	Cashier and secretary (raised their two sons on her own)	Engineering (?)
Thompson	(US Navy) <sup>297</sup>		Military (?)

<sup>288</sup>Simon 1980.

<sup>289</sup>Turing Award biography.

<sup>290</sup>Simon 1980.

<sup>291</sup>Oral history by the Computer History Museum. <http://archive.computerhistory.org/>

[resources/access/text/2012/12/102635858-05-01-acc.pdf](http://resources/access/text/2012/12/102635858-05-01-acc.pdf)

<sup>292</sup>Ibid.

<sup>293</sup>Turing Award biography.

<sup>294</sup>Ibid.

<sup>295</sup>American Journal of Psychiatry 1993.

<sup>296</sup>Turing Award biography.

<sup>297</sup>Turing Award biography.

Valiant	Chemical engineer <sup>298</sup>	Multilingual translator <sup>299</sup>	Engineering
Wilkes	Financial officer for the estate of the Earl of Dudley <sup>300</sup>	Housewife <sup>301</sup>	Business
Wilkinson	“humble family in the dairy business (...) of five children” <sup>302</sup>	“humble family in the dairy business (...) of five children” <sup>303</sup>	Low
Wirth			
Yao			

n = 64 t = 64

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<sup>298</sup><http://www.heidelberg-laureate-forum.org/blog/laureate/leslie-g-valiant/>

<sup>299</sup>Ibid.

<sup>300</sup>Turing Award biography.

<sup>301</sup>Ibid.

<sup>302</sup>Turing Award biography.

<sup>303</sup>Ibid.

Image series : Gender through corporate archives (1950s-present)

Images : IBM's "My Fair Ladies" campaign (1950s)



Source : IBM Archives<sup>304</sup>



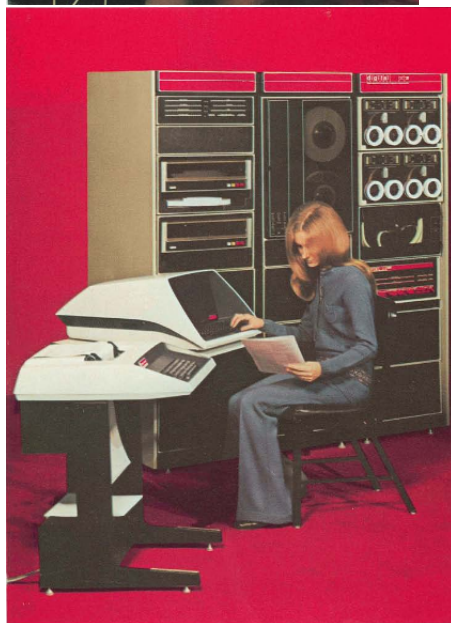
Source : unknown<sup>305</sup>.

<sup>304</sup>[http://sysrun.haifa.il.ibm.com/ibm/history/witexhibit/wit\\_decade\\_1950.html](http://sysrun.haifa.il.ibm.com/ibm/history/witexhibit/wit_decade_1950.html).

<sup>305</sup><http://globalnerdy.com/wordpress/wp-content/uploads/2007/02/my-fair-ladies.jpg>



Images : Digital Equipment Corporation's PDP-11 and 8 ads (1970s)



Source : 1970 PDP-11 brochure (top, front cover, bottom, p. 11)<sup>306</sup>

<sup>306</sup>Computer History Museum. <http://archive.computerhistory.org/resources/text/DEC/pdp-11/Digital.PDP-11.1970.102646128.pdf>.



Source : ca. 1971 PDP-8 family advertisement<sup>307</sup>

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<sup>307</sup>Computer History Museum.  
minicomputers/11/intro/1910.

<http://www.computerhistory.org/revolution/minicomputers/11/intro/1910>

Video captions : Alibaba recruitment campaign (2010s)



Source : Alibaba recruitment videos<sup>308</sup>

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<sup>308</sup>Human Rights Watch 2018.

Image : Matilda effect in computer science

The image shows a Google search result for the book "Introduction to VLSI Systems" by Carver Mead. The search bar at the top contains the text "Introduction to VLSI Systems". Below the search bar, there are tabs for "All", "Images", "Videos", "News", "Shopping", and "More", with "All" selected. The search results show "About 6 150 000 results (0,38 seconds)". The main result is for the book "Introduction to VLSI systems" by Carver Mead. Below the title, there is a "Did you like this book?" section with thumbs up and down icons. The description of the book is: "Mos devices and circuits - Integrated system fabrication - Data and control flow in systematic structures - Implementing integrated system designs : from circuit topology to patterning geometry to wafer ...". It also mentions "Originally published: 1978" and "Author: Carver Mead". Below this, there is a section "People also search for" with a "View 25+ more" link. This section displays five book covers with their titles and authors: "Introduction to VLSI Systems" by Ming-Bo Lin, "Principles of CMOS VLSI Design" by Kamran Eshraghian, "VLSI Systems and Com..." (partially visible), "Introduction to VLSI Circuits and Systems" by John P. Uyemura, and "CMOS VLSI Design: A Circuit and System Perspective" by David Harris. A "Feedback" link is visible at the bottom right of the search results area.

Accessed 05/2018.

Table 55: Turing award winners by research topics

<i>Analysis of Algorithms</i>	Hopcroft, John E (1986)
	Knuth, Donald (“Don”) Ervin (1974)
	Lamport, Leslie (2013)
	Pearl, Judea (2011)
	Tarjan, Robert (Bob) Endre (1986)
<i>Artificial Intelligence</i>	Feigenbaum, Edward A (“Ed”) (1994)
	Minsky, Marvin (1969)
	Newell, Allen (1975)
	Pearl, Judea (2011)
	Reddy, Dabbala Rajagopal (“Raj”) (1994)
	Simon, Herbert (“Herb”) Alexander (1975)
	Valiant, Leslie Gabriel (2010)
<i>Combinatorial Algorithms</i>	Karp, Richard (“Dick”) Manning (1985)
<i>Compilers</i>	Allen, Frances (“Fran”) Elizabeth (2006)
	Cocke, John (1987)
	Perlis, Alan J (1966)
<i>Computational Complexity</i>	Blum, Manuel (1995)
	Cook, Stephen Arthur (1982)
	Goldwasser, Shafi (2012)
	Hartmanis, Juris (1993)
	Micali, Silvio (2012)
	Stearns, Richard (“Dick”) Edwin (1993)
	Valiant, Leslie Gabriel (2010)
<i>Computer Architecture</i>	
	Brooks, Frederick (“Fred”) (1999)
	Cocke, John (1987)
	Thacker, Charles P. (Chuck) (2009)
	Wilkes, Maurice V. (1967)

<i>Computer Hardware</i>	Wilkes, Maurice V. (1967)
<i>Computer Systems</i>	Corbato, Fernando J (“Corby”) (1990)
<i>Cryptography</i>	Adleman, Leonard (Len) Max (2002)
	Blum, Manuel (1995)
	Goldwasser, Shafi (2012)
	Micali, Silvio (2012)
	Rivest, Ronald (Ron) Linn (2002)
	Shamir, Adi (2002)
	Yao, Andrew Chi-Chih (2000)
<i>Data Structures</i>	Hopcroft, John E (1986)
	Tarjan, Robert (Bob) Endre (1986)
<i>Databases</i>	Bachman, Charles William (1973)
	Codd, Edgar F. (“Ted”) (1981)
	Gray, James (“Jim”) Nicholas (1998)
	Stonebraker, Michael (2014)
<i>Education</i>	Wilkes, Maurice V. (1967)
<i>Error Correcting Codes</i>	Hamming, Richard W (1968)
<i>Finite Automata</i>	Rabin, Michael O. (1976)
	Scott, Dana Stewart (1976)
<i>Graphics</i>	Sutherland, Ivan (1988)
<i>Interactive Computing</i>	Engelbart, Douglas (1997)
<i>Internet Communications</i>	Cerf, Vinton (“Vint”) Gray (2004)
	Kahn, Robert (“Bob”) Elliot (2004)
<i>List Processing</i>	Newell, Allen (1975)
	Simon, Herbert (“Herb”) Alexander (1975)
<i>Machine Learning</i>	Valiant, Leslie Gabriel (2010)
<i>Numerical Analysis</i>	Kahan, William (“Velvel”) Morton (1989)
	Wilkinson, James Hardy (“Jim”) (1970)
<i>Numerical Methods</i>	Hamming, Richard W (1968)

<i>Objected Oriented Programming</i>	Dahl, Ole-Johan (2001)
	Nygaard, Kristen (2001)
<i>Operating Systems</i>	Brooks, Frederick (“Fred”) (1999)
	Liskov, Barbara (2008)
	Ritchie, Dennis M. (1983)
	Thompson, Kenneth Lane (1983)
<i>Parallel Computation</i>	Valiant, Leslie Gabriel (2010)
<i>Personal Computing</i>	Kay, Alan (2003)
	Lampson, Butler W (1992)
	Thacker, Charles P. (Chuck) (2009)
<i>Program Verification</i>	Dijkstra, Edsger Wybe (1972)
	Pnueli, Amir (1996)
<i>Programming</i>	Backus, John (1977)
	Dijkstra, Edsger Wybe (1972)
	Knuth, Donald (“Don”) Ervin (1974)
	Perlis, Alan J (1966)
<i>Programming Languages</i>	Backus, John (1977)
	Hoare, C. Antony (“Tony”) R. (1980)
	Iverson, Kenneth E. (“Ken”) (1979)
	Kay, Alan (2003)
	Lampport, Leslie (2013)
	Liskov, Barbara (2008)
	Milner, Arthur John Robin Gorell (“Robin”) (1991)
	Naur, Peter (2005)
	Wirth, Niklaus E (1984)
<i>Proof Construction</i>	Lampport, Leslie (2013)
	Milner, Arthur John Robin Gorell (“Robin”) (1991)
<i>Software</i>	Floyd, Robert (Bob) W (1978)
	Stonebraker, Michael (2014)

<i>Software Engineering</i>	Brooks, Frederick (“Fred”) (1999)
<i>Verification of Hardware and Software Models</i>	Clarke, Edmund Melson (2007)
	Emerson, E. Allen (2007)
	Sifakis, Joseph (2007)

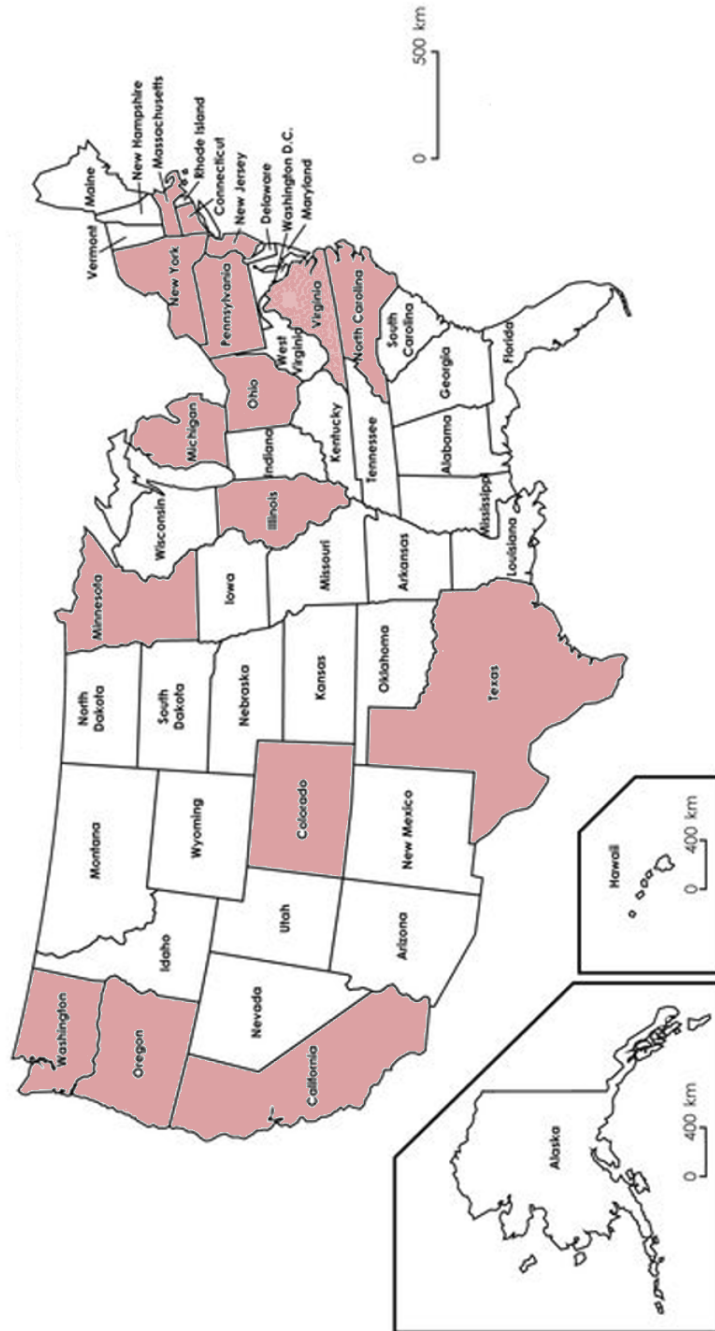
Source : ACM<sup>309</sup>. The categories are ACM’s own.

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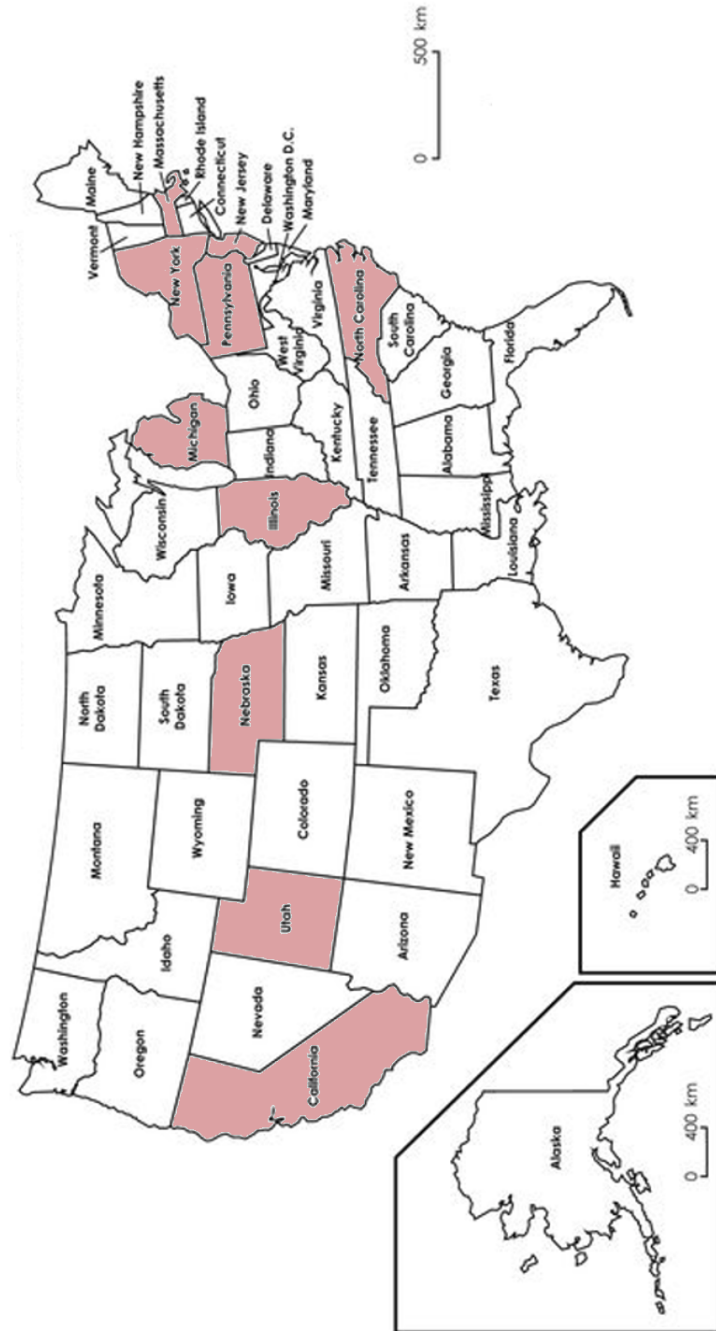
<sup>309</sup>“A.M. Turing Award Winner Research Subjects. <https://amturing.acm.org/bysubject.cfm>



US states with colleges attended by Turing laureates (bachelor)



US states with colleges attended by Turing laureates (Master of PhD)



```

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}
.row img {
    width: 100%;
}
</style>
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</div>
<div class="column">
  
</div>
<div class="column">
  
</div>
<div class="column">
  
</div>
<div class="column">
  

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Table 56: IEEE Computer Pioneer award winners (1981-2018)

<i>Year</i>	<i>Winner</i>
<b>1981</b>	Jeffrey Chuan Chu
<b>1982</b>	Arthur Burks
<b>1982</b>	Harry D. Huskey
<b>1984</b>	Willem L. van der Poel
<b>1984</b>	Nathaniel Rochester
<b>1984</b>	Nicholas C. Metropolis
<b>1984</b>	Jerrier A. Haddad
<b>1984</b>	John Vincent Atanasoff
<b>1985</b>	Heinz Zemanek
<b>1985</b>	David J. Wheeler
<b>1985</b>	Ivan Sutherland
<b>1985</b>	Alan Perlis
<b>1985</b>	John McCarthy
<b>1985</b>	John G. Kemeny
<b>1986</b>	Adriann van Wijngaarden
<b>1986</b>	James H. Pomerene
<b>1986</b>	Peter Naur
<b>1986</b>	Cuthbert C. Hurd
<b>1987</b>	Nicklaus E. Wirth
<b>1987</b>	Arthur L. Samuel
<b>1987</b>	Reynold B. Johnson
<b>1987</b>	Robert R. Everett
<b>1988</b>	Marcian E. Hoff, Jr.
<b>1988</b>	Freidrich L. Bauer
<b>1989</b>	Gordon D. Goldstein
<b>1989</b>	F. Joachim Weyl
<b>1989</b>	Marshall C. Yovits

<b>1989</b>	Mina S. Rees
<b>1989</b>	Ralph L. Palmer
<b>1989</b>	James A. Weidenhammer
<b>1989</b>	John Cocke
<b>1990</b>	C.A.R. Hoare
<b>1991</b>	Thomas E. Buchholz
<b>1991</b>	Thomas E. Kurtz
<b>1991</b>	Robert W. Floyd
<b>1991</b>	Bob O. Evans
<b>1992</b>	Douglas C. Engelbart
<b>1992</b>	Stephen W. Dunwell
<b>1993</b>	Willis H. Ware
<b>1993</b>	Jack S. Kilby
<b>1993</b>	Erich Bloch
<b>1994</b>	Ken L. Thompson
<b>1994</b>	Dennis M. Ritchie
<b>1994</b>	Harlan D. Mills
<b>1994</b>	Gerrit A. Blaauw
<b>1995</b>	Kenneth Olsen
<b>1995</b>	Marvin Minsky
<b>1995</b>	Butler Lampson
<b>1995</b>	David Evans
<b>1995</b>	Gerald Estrin
<b>1996</b>	Antonin Svoboda
<b>1996</b>	Arnolds Reitsakas
<b>1996</b>	Ivan Plander
<b>1996</b>	Grigore C. Moisil
<b>1996</b>	Romuald W. Marczyński
<b>1996</b>	Alexey A. Lyapunov

<b>1996</b>	Sergey A. Lebedev
<b>1996</b>	Laszlo Kozma
<b>1996</b>	Antoni Kilinski
<b>1996</b>	Laszlo Kalmar
<b>1996</b>	Robert E. Kahn
<b>1996</b>	Lubomir Georgiev Iliev
<b>1996</b>	Jiri Horejs
<b>1996</b>	Jozef Gruska
<b>1996</b>	Victor M. Glushkov
<b>1996</b>	Norbert Fristacky
<b>1996</b>	Edgar Frank Codd
<b>1996</b>	Richard F. Clippinger
<b>1996</b>	Angel Angelov
<b>1997</b>	Frances Elizabeth (Betty) Snyder-Holberton
<b>1997</b>	Homer (Barney) Oldfield
<b>1998</b>	Irving John (Jack) Good
<b>1999</b>	Herbert Freeman
<b>2000</b>	Georgiy Lopato
<b>2000</b>	Gennady Stolyarov
<b>2000</b>	Harold W. Lawson
<b>2001</b>	William H. Bridge
<b>2001</b>	Vernon L. Schatz
<b>2002</b>	Robert W. Bemer
<b>2002</b>	Per Brinch Hansen
<b>2003</b>	Martin Richards
<b>2004</b>	Frances (Fran) E. Allen
<b>2006</b>	Arnold M. Spielberg
<b>2006</b>	Mamoru Hosaka
<b>2008</b>	Carl A. Petri

<b>2008</b>	Edward J. McCluskey
<b>2008</b>	Betty Jean Jennings Bartik
<b>2009</b>	Lynn Conway
<b>2009</b>	Jean Sammet
<b>2011</b>	David Kuck
<b>2012</b>	Cleve Moler
<b>2013</b>	Edward Feigenbaum
<b>2013</b>	Stephen B. Furber
<b>2014</b>	Linus Torvalds
<b>2015</b>	Peter M. Kogge
<b>2015</b>	Michael J. Flynn
<b>2016</b>	E. Grady Booch
<b>2018</b>	Bjarne Stroustrup
<b>2018</b>	Barbara Liskov

Source : IEEE Computer Pioneer Award<sup>310</sup>.

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<sup>310</sup><https://www.computer.org/web/awards/pioneer>