Alan Turing at 110 – and Oxford!

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Overview

• **Alan Mathison Turing** OBE FRS (23 June 1912 – 7 June 1954)

• Polymath: mathematician, computer scientist, logician, cryptanalyst, philosopher, theoretical biologist, …

• Centenary meetings at Cambridge, Bletchley Park, Manchester, Oxford, etc., in 2012
Alan Turing: The Enigma


Definitive biography by Andrew Hodges, Wadham College, Oxford
*Turing’s Worlds* (23–24 June 2012)
Department of Continuing Education, Oxford
Turing’s Worlds (23–24 June 2012)
Department of Continuing Education, Oxford

Stephen Wolfram
(Oxford undergraduate)
&
Robin Wilson
(Oxford mathematician)

Me! (computer scientist)

Cliff Jones
(formerly PRG computer scientist)

Philip Maini FRS
(Professor of Mathematical Biology, Oxford)
Happy Birthday Alan Turing! (2012)

Cake at Oxford centenary meeting
The Turing Guide (2017)

A collected set of 42 chapters on Alan Turing. Co-editors (three with Oxford connections)

- **Jack Copeland** (University of Canterbury, New Zealand) – philosopher (DPhil student at Oxford)
- **Jonathan Bowen** (London South Bank University, England) – computer scientist (student and PRG researcher at Oxford)
- **Mark Sprevak** (University of Edinburgh, Scotland) – philosopher
- **Robin Wilson** (Open University / Oxford University, England) – mathematician
Book contents

Foreword by Andrew Hodges

Eight parts:
1. Biography
2. The Universal Machine & Beyond
3. Codebreaker
4. Computers after the War
5. Artificial Intelligence & the Mind
6. Biological Growth
7. Mathematics
8. Finale

Display at Oxford University Press bookshop, High Street, Oxford
UK locations

Alan Turing was at:

- University of Cambridge [education, fellow]
- Bletchley Park [codebreaker, Bombe]
- National Physical Laboratory [ACE hardware]
- University of Manchester [Baby software]

Celebrated by these institutions but …

- University of Oxford? [no written primary evidence] … until now!
Oxford connections

• Father, **Julius Mathison Turing** (1873–1947), scholar at [Corpus Christi College, Oxford](https://www.corpus-christi.ox.ac.uk)
• Turing family visited Oxford in summer 1924
• Turing could have followed his father to Oxford!
Oxford connections

• Security section of Government Code and Cypher School (GC&CS) at Mansfield College, Oxford in World War II

• "Varsity Line": Oxford–Bletchley–Cambridge

• Could Turing have visited from Bletchley Park in WWII?
Oxford visits by Turing?

- Talks on **Alan Turing**, including at SETSS 2016 Spring School on Engineering Software Systems, Southwest Univ., Chongqing, China
- **Jim Woodcock**, ex Oxford, now Professor of Software Engineering at the **University of York** in the audience

Bust of Alan Turing at Southwest University – paid for by students
Oxford visits by Turing?


Oxford visits by Turing?

- Visit to University College, Oxford, for lunch during WWII by General Dwight D. Eisenhower (1890–1969) and others from Bletchley Park…
- …including Alan Turing…
University College visit?

- University College archivist: Robin Darwall-Smith
- Arthur Goodhart: an Anglophile American, and friend of Eisenhower
- Sir William Beveridge (1879–1963), Master of University College (1937–1945) during WWII
University College visit?

- Eisenhower archives and diaries, USA
- Eisenhower visited Oxford on 1 October 1942 …
- … and 16 April 1944 before D-Day

Eisenhower wrote to thank those at Bletchley Park on 12 July 1945
University College visit?

• Beveridge archive, London School of Economics
• Pocket diaries – almost empty!
• Univ Master’s Lodgings visitors’ book…
Master’s lodgings visit?

- 16 April 1944 entry in Master’s Lodgings visitors’ book
- American entries
- And Picture Post
Photos by Hans Felix Sigismund Baumann (1893–1985), aka Felix H. Man; text by Margaret Stewart
University College visit?

- American soldiers visit Beveridge at the Master’s Lodgings for tea on Sunday 16 April 1944
- Beveridge and Eisenhower both in Oxford
- No record of people signing in for lunch in Hall at University College
- Could there have been a secret lunch at the Master’s Lodgings with Eisenhower, Turing, and other Bletchley Park personnel?
- Robin Darwall-Smith, University College archivist, thinks it entirely possible …
- …but sadly no written evidence
Other wartime and post-war visits?

- Weekend visit to Oxford with Joan Clarke (1917–1996)
- At Bletchley Park, briefly engaged to Turing
- Visiting her brother, Martin Clarke, previously a Fellow at King’s College, Cambridge (Hodges)
Other wartime and post-war visits?

- **David Champernowne** (1912–2000), former mathematics scholar with Turing at King’s College
- Professor of Statistical Economics at Oxford (1948–1959)
- Collaborated with Turing on an early chess-playing program, *Turochamp*
- … some visits likely in Oxford (Hodges)

Turochamp v. Kasparov at the 2012 Alan Turing Centenary Conference, University of Manchester
Turing’s academic adviser tree

- Talk on Alan Turing, SETSS Spring School on Engineering Software Systems, Chongqing, China, 2018

- Based on the Mathematics Genealogy Project (MGP) database

* ACM Turing Award (1996)
Robin Gandy  
(1919–1995)  

- British mathematician and logician  
- PhD student of Turing at Cambridge  
- Studied at King’s College, Cambridge (like Turing)  
- Worked on radio intercept equipment at Hanslope Park (north of Bletchley Park) in WWII  
- Turing worked there too on speech encipherment  
- They became lifelong friends and associates
Hyperboloids of wondrous Light;
Rolling for aye through Space and Time;
Harbour those Waves which somehow Might;
Play out God's holy pantomime.
Turing notebook, 1942 (sold April 2015)

- Handwritten during WWII
- Given to Robin Gandy after Turing’s death
- Sold at Bonhams, New York for $1,025,000 (£700,850)!

2.) Wayl. Classical Rep p.3.
A formal expansion

\[ f(x) = \sum_{i=1}^{n} a_i x^i \]

involving the ‘indeterminate’ (or variable) \( x \), whose coefficients \( a_i \) are numbers in a field \( K \), is called a \((K-)\) polynomial of formal degree \( n \).

The idea of an ‘indeterminate’ is distinctly subtle;
I would almost say too subtle. It is not (at any rate as
van der Waerden sees it) the same as variable. Polynomials in
Robin Gandy  
(1919–1995)

- Reader in Mathematical Logic at the Oxford Mathematical Institute
- Robin Gandy Buildings
Robin Gandy  
(1919–1995)

- Centenary celebration at Wolfson College, Oxford (just pre-COVID)
- Many former colleagues …
- … and me! … Samson Abramsky FRS, Oxford
Dana Scott (b. 1932)

- American logician
- Domain theory
- Semantics of programming languages
- Mathematical Institute, Oxford (1972–1981)
- Collaborated with Christopher Strachey (1916–1975), leader of the Programming Research Group, Oxford, in the 1970s
- Scott-Strachey approach to denotational semantics
- 1976 ACM Turing Award for automata theory
Christopher Strachey (1916–1975)

• British computer scientist
• Member of the Strachey family
• Studied at King’s College, Cambridge (like Turing)
• Draughts program for the Pilot ACE at NPL
• Worked with Turing at Manchester
• First computer music on Manchester Mark II
• First director of the Programming Research Group, Oxford (1965–1975)
• First professor of computer science at Oxford
• Distinguished Fellow of the BCS
Earliest computer music

- Recorded in 1951 by the BBC at the University of Manchester
- On Ferranti Mark 1 computer
- Tunes: *God Save the King*, *Baa Baa Black Sheep*, part of *In the Mood*
- Written by Christopher Strachey, colleague of Turing
- Restored in 2016

Scott & Strachey

- Early PRG-6 monograph (1971)
- Mathematical semantics of programming languages
- Scott-Strachey approach to denotational semantics

TOWARD A MATHEMATICAL SEMANTICS FOR COMPUTER LANGUAGES

by

Dana Scott
and

Christopher Strachey

Oxford University
Computing Laboratory
Programming Research Group-Library
8-11 Keble Road
Oxford OX1 3QD
Oxford (0865) 54141

Oxford University Computing Laboratory
Programming Research Group
Jack Copeland (b. 1950)

- British philosopher
- Based in New Zealand
- Oxford DPhil (logic) under Dana Scott
- Turing scholar (many books)
Supervisor of Turing at Princeton University, USA (Sept. 1936 – July 1938)

Turing: PhD in June 1938 (only 1 year 9 months):

*Systems of Logic Based on Ordinals*
The Church–Turing thesis

• Alonzo Church and Turing

• Undecidability of the Entscheidungsproblem ("decision problem")

• Two independently developed approaches

• Turing could have stayed at Princeton, but... WWII
Advisor tree (19th to 20th century)

Siméon Poisson
École Polytechnique (1800)

Michel Chasles
École Polytechnique (1814)

Hubert Newton
Yale (1850)

Hastings Moore
Yale (1885)

Oswald Veblen
Chicago (1903)

Max Newman
Cambridge (1921)

Alonzo Church
Princeton (1927)

Douglas Hartree
Cambridge (1926)

Alan Turing
Cambridge (1934),
Princeton (1938)

33 other students
(4,869+ total
descendants)

Dana Scott
Princeton (1958)

SETSS 2018, from the Mathematics Genealogy Project
Oswald Veblen  
(1880–1960)

- American mathematician and topologist
- Taught at Princeton (1905–1932)
- Helped organize the Institute for Advanced Study (IAS) at Princeton (1932)
- Albert Einstein at the IAS (1933–1955)
- … after visits to Oxford in 1931 & 1933
- Kurt Gödel visited IAS in 1934
- Turing in Princeton for PhD (1936–1938) …
- Could Turing & Einstein have met?
Advisor tree (17th to 18th C.)

SETSS 2018, from the Mathematics Genealogy Project
Further Oxford influences

• Roger Penrose OM FRS, Rouse Ball Professor of Mathematics at Oxford (AI and computability)
• Andrew Hodges, Turing’s biographer (1983/2012)
• Philip Maini FRS, Mathematical Institute (mathematical biology)
• Christopher Strachey (1916–1975), founder of the PRG, colleague of Turing at Manchester
• Samson Abramsky FRS FRSE, Christopher Strachey Professorship (computer science)
• Alan Turing Institute data science researchers (www.oxford-turing.ox.ac.uk)
Roger Penrose (b. 1931)

- British mathematician and physicist
- Emeritus Rouse Ball Professor of Mathematics, Oxford
- Variant of Turing’s halting problem
- Has worked with Andrew Hodges, Turing’s biographer
- Nobel Prize in Physics (2020)
Turing and formal methods

Turing’s legacy – program proving:


• **Cliff Jones** (2014). *Turing and Software Verification*. Technical Report CS-TR-1441, Newcastle University, UK.

* DPhil under Tony Hoare at the PRG, Oxford (1981)
“verification”

“assertions”

“dashed” after states
Checking a large routine

• “In order to assist the checker, the programmer should make assertions about the various states that the machine can reach.”

• “The checker has to verify that the … initial condition and the stopped condition agree with the claims that are made for the routine as a whole.”

• “He has also to verify that each of the assertions … is correct.”

• “Finally the checker has to verify that the process comes to an end.”
An Early Program Proof by Alan Turing

F. L. Morris and C. B. Jones

The paper reproduces, with typographical corrections and comments, a 1949 paper by Alan Turing that foreshadows much subsequent work in program proving.

Categories and Subject Descriptors: D.2.4 [Software Engineering]—correctness proofs; F.3.1 [Logics and Meanings of Programs]—assertions; K.2 [History of Computing]—software

General Terms: Verification

Additional Key Words and Phrases: A. M. Turing

Introduction

The standard references for work on program proofs attribute the early statement of direction to John McCarthy (e.g., McCarthy 1963); the first workable methods to Peter Naur (1966) and Robert Floyd (1967); and the provision of more formal systems to C. A. R. Hoare (1969) and Edsger Dijkstra (1970). The early papers of some of the computing pioneers, however, show an awareness of the need for proofs of program correctness and even present workable methods (e.g., Goldstine and von Neumann 1947; Turing 1949).

The 1949 paper by Alan M. Turing is remarkable in many respects. The three (foolscap) pages of text contain an excellent motivation by analogy, a proof of a program with two nested loops, and a verification of a general proof method very like that of Floyd. Unfortunately, the paper is made extremely difficult to read by the large number of transcription errors. For example, all instances of the factorial sign (Turing used $n$ have been omitted in the commentary, and ten other identifiers are written incorrectly. It would appear to be worth correcting these errors and commenting on the proof from the viewpoint of subsequent work on program proofs.

Turing delivered this paper in June 1949, at the inaugural conference of the EDSAC, the computer at Cambridge University built under the direction of Maurice V. Wilkes. Turing had been writing programs for an electronic computer since the end of 1945—at first for the proposed ACE, the computer project at the National Physical Laboratory, but since October 1948 for the Manchester prototype computer, of which he was deputy director. The references in his paper to 30th are reflections of the 40-bit “lines” of the Manchester machine storage system.

The following is the text of Turing’s 1949 paper, corrected to the best of our ability to what we believe Turing intended. We have made no changes in spelling, punctuation, or grammar.

Turing Text

Friday, 24th June [1949]

Checking a large routine by Dr A. Turing.

How can one check a routine in the sense of making sure that it is right?

In order that the man who checks may not have too difficult a task the programmer should make a number of definite assertions which can be checked individually, and from which the correctness of the whole programme easily follows.
Turing and program proving

A.M. Turing, "Checking a large routine" (1949)


Dashed variables for after states

**Diagram:**

```
A: r' = 1
   u' = 1

B: v' = u

C: TEST r - n
   s' = 1

D: STOP

E: u' = u + v
   s' = s + 1

F: TEST s - r

G

r' = r + 1
```

**Table:**

<table>
<thead>
<tr>
<th>STORAGE LOCATION</th>
<th>(INITIAL) (A) k=6</th>
<th>(B) k=5</th>
<th>(C) k=4</th>
<th>(STOP) D k=0</th>
<th>(E) k=3</th>
<th>(F) k=1</th>
<th>(G) k=2</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>n</td>
<td>r</td>
<td>r</td>
<td>s</td>
<td>s + 1</td>
<td>s</td>
<td>s</td>
</tr>
<tr>
<td>28</td>
<td>n</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
<td>r</td>
</tr>
<tr>
<td>29</td>
<td>r</td>
<td>r</td>
<td>n</td>
<td>s</td>
<td>s</td>
<td>(s + 1)</td>
<td>(s + 1)</td>
</tr>
<tr>
<td>30</td>
<td>r</td>
<td>r</td>
<td>n</td>
<td>s</td>
<td>s</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>31</td>
<td>r</td>
<td>r</td>
<td>n</td>
<td>s</td>
<td>s</td>
<td>(s + 1)</td>
<td>(s + 1)</td>
</tr>
</tbody>
</table>

**Instructions:**

- **TO (B):** WITH r' = 1, u' = 1
- **TO (C):** IF r = n
- **TO (D):** IF r < n
- **TO (E):** IF s ≥ r
- **TO (F):** IF s < r
- **TO (G):** WITH r' = r + 1
Turing and program proving

Modernized flow diagram, with assertions
REFERENCES


Turing’s influence on program proving

• **Aad van Wijngaarden** was at the Cambridge meeting – but no known influence (1949…)

• **Robert Floyd** rediscovered ideas similar to those of Turing (published 1967)

• **Tony Hoare** (later at Oxford) developed these further (published 1969)

• Had Turing lived longer, perhaps formal methods would have developed more rapidly
Turing letter, c.1949 (sold 15 November 2017)

Written to his mathematics teacher, Donald Eperson (1904–2001)

Sold for £75,000!
Blue plaque (27 July 2019)

Joan Clarke (later Murray) moved to 7 Lakesfield, Headington Quarry, Oxford, in 1991
Oxford History of Mathematics Forum (2020)

- **Chris Hollings** (forum co-organizer)
- **Ioan James** mathematics student at Oxford
- **The Queen’s College Record**, December 2017:

  Another Mathematics lecturer worth mentioning was **Alan Turing**, who told us about what became known as the Turing machine.

- **But:**

  My second year ended with another trip to Italy, where of course I ate lots of ice cream. Perhaps as a result of this, I was diagnosed with TB, and was sent to **Cambridge** to recover. I got lots of reading done, thought about my future, and when I returned to Queen’s after a year’s convalescing, it was to concentrate on getting a first and then going on to graduate work.

  **Ioan James (1946)**

- **So was the lecture on Oxford or Cambridge…?**
Ioan James FRS (b. 1928)

- British mathematician (topology)
- Student at Queen’s College, Oxford
- Reader in pure mathematics (1957–1969)
- Research fellow at St John’s College, Oxford
- Savilian Chair of Geometry at the University of Oxford (1970–1995)
- President of London Mathematical Society (1984)
I wrote via St John’s College…

Reply in Feb. 2021: written evidence of Turing in Oxford
Correspondence with Ioan James

- Was a Fellow at St John’s College, Oxford
- Not on email! College closed for the pandemic in 2020!
- Handwritten letter (postmarked 18 February 2021, Oxford), confirming talk by Turing at Oxford, hosted by David Kendall FRS (1918–2007), later a professor in Cambridge
- Subsequently confirmed by email (1 January 2022) to be at Magdalen College, Oxford, in 1950
David Kendall FRS (1928–2007)

- British statistician & mathematician
- University of Oxford (1946–1962)
- Fellow at Magdalen College, Oxford
- Hosted Turing lecture in 1950 at Magdalen
- (Humphry Bowen studying for a chemistry DPhil at Magdalen, 1949–1953)
Article on Alan Turing and Oxford


• [https://www.computerconservationsociety.org/resurrection/res97.htm#e](https://www.computerconservationsociety.org/resurrection/res97.htm#e) (web version)

• [https://www.computerconservationsociety.org/resurrection/pdfs/res97.pdf](https://www.computerconservationsociety.org/resurrection/pdfs/res97.pdf) (PDF version)

• [https://ccsoc.org/turingox.pdf](https://ccsoc.org/turingox.pdf) (full version with references)
Epitaph

“A sort of scientific Shelley.”

Professor of Neurosurgery at Manchester

Shelley Memorial,
University College,
Oxford
Pet Shop Boys – The Proms

• Royal Albert Hall, London, 23 July 2014
• World premiere of “A Man from the Future”
• Tribute to Alan Turing
The Imitation Game
(2014 film)

- Historical drama film on the life of Alan Turing
- Starring Benedict Cumberbatch & Keira Knightley
- Based on the biography Alan Turing: The Enigma by Andrew Hodges

Filming at King’s Cross Station, London October 2013
“Alan Turing law”  
(31 January 2017)

• UK Policing and Crime Act 2017
• General pardon for gay men – 50 years after 1967 legislation
• Imagine if Turing had been born 20 years later…
£50 note

Issued on Turing’s 109th birthday
23 June 2021
Thank you

Alan Turing

110 yesterday!

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