PONTIFICIA ACADEMIA SCIENTIARVM

THE AWARD

OF THE

PIUS XI GOLD MEDAL

2020

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The aim of the Pontifical Academy of Sciences, which was founded on 28 October 1936 by the Holy Father Pius XI, is to honour pure science, wherever this may be found, to ensure its freedom, and to support the research essential for the progress of applied science.

On 28 October 1961, on the occasion of the 25th anniversary of the foundation of the Pontifical Academy of Sciences, the Holy Father John XXIII established the Pius XI Gold Medal in honour of the founder of the Academy. The medal should be awarded to a young scientist who has already gained an international reputation.

The Council of the Academy unanimously decided to award the "Pius XI Gold Medal" for the year 2020 to

PROF. DEMIS HASSABIS

in recognition of his great merits as a scholar and the important contribution of his research to scientific progress.


PIVS · XI · PONTIFEX · MAXIMVS · FVNDATOR
ACADEMIA · SCIENTIARVM · PONTIFICIA
DEMIS HASSABIS
A.D.
MMXX

DEMIS HASSABIS

Full Name: Demis Hassabis

Scientific Discipline: Artificial Intelligence

Current Professional Activity: Founder & CEO, DeepMind

Date of Birth: 27 July 1976

Place of Birth: London, UK

Academic Qualifications: 2005-2009: Institute of Neurology, University College London (UCL) PhD in Cognitive Neuroscience; 1994-1997: Queens' College, University of Cambridge BA (Hons) in Computer Science (Double 1 st Class)

SELECTED AWARDS AND ACHIEVEMENTS

- Awarded the Dan David Prize Future Award for work on AI (2020)
- Elected a Fellow of the Royal Society (2018)
- Awarded the honour of Commander of the Order of the British Empire (CBE) (2018)
- Elected a Fellow of the Royal Academy of Engineering (2017)
- Included on the Time 100 list of the world's 100 most influential people (2017)
- Listed by Nature as one of 'top ten scientists who mattered this year' (2016)
- Received WIRED's 'Leadership in Innovation' award (2016)
- Awarded the Silver Medal by the Royal Academy of Engineering (2016)
- Named by the Financial Times as the Digital Entrepreneur of the Year (2016)

– Received the Royal Society's Mullard Award (2014)
– Honorary Fellowships and Doctorates at UCL, Cambridge and Imperial
– Elected as a Fellow of the Royal Society of Arts for my game design work (2009)
– 5-times World Games Champion at the Mind Sports Olympiad (1998-2003)
– Represented England at chess at junior level, reaching master standard at 13 (2300 ELO rating), the second highest rated player of my age in the world at the time

ACADEMIC AND INDUSTRIAL CAREER

2010 – Present: DeepMind, London (now part of the Alphabet group) – Founder & CEO

I'm the founder and CEO of DeepMind, the world's leading AI research company, with a mission to 'solve intelligence' by building Artificial General Intelligence (AGI) using learning algorithms. With a world-class interdisciplinary research team, we rapidly made a series of important research breakthroughs, pioneering the field of Deep Reinforcement Learning, which combines Deep Learning with Reinforcement Learning techniques to allow the latter to scale to complex problems, as demonstrated by the DQN algorithm that was able to learn to achieve superhuman performance on a range of Atari games receiving only the raw pixels as input.

In Jan 2014 DeepMind was acquired by Google in its largest ever European acquisition, and is now an autonomous unit within the Alphabet group, with its own unique research agenda and culture optimised for scientific innovation. We have published over 1000 papers to date including 14 in *Nature* and

Science, and two of the top 10 most cited papers of the past 5 years in any field. Most notably, we developed the program AlphaGo that in 2016 famously defeated the world champion at the complex game of Go, a longstanding grand challenge of AI, and followed that with the more general AlphaZero that can play any 2-player perfect information game starting with no prior knowledge.

With our technology we have helped to improve dozens of Google products for billions of users, and launched high-impact applied projects in areas of science, health and energy such as the program AlphaFold which won CASP13, the main international protein folding competition. The company has now grown to over 900 researchers and engineers, with satellite offices in Canada, Paris and California.

2009-2010: Gatsby Computational Neuroscience Unit, UCL – Wellcome Trust Research Fellow

As an independent research fellow, I worked in close collaboration with Prof. Peter Dayan, one of the world's leading authorities on theoretical and computational neuroscience, primarily on computational models of scene construction, understanding and recognition. I secured a prestigious Sir Henry Wellcome Fellowship to fund my research. I currently have an h-index of 60 (Google Scholar) and published papers in many of the highest impact journals including *Nature*, *Science*, *Neuron*, and *PNAS*.

2009: McGovern Institute for Brain Research, MIT, & Dept of Psychology, Harvard – Visiting Postdoc

I spent several months as a visiting scientist jointly based at MIT and Harvard. At MIT I collaborated with Prof. Tomaso

Poggio, on extending his influential hierarchical neural network algorithms to investigate the boundary between memory and perception. At Harvard I collaborated with Prof. Dan Schacter, conducting an fMRI study investigating how people construct a theory of mind about others and use those models to predict behaviour.

2005-2009: Institute of Neurology, University College London (UCL) – PhD in Cognitive Neuroscience

I conducted my PhD at the Institute of Neurology at UCL under the supervision of Prof. Eleanor Maguire FMedSci FRS. My research focused on understanding the neural mechanisms that support memory and imagination. My work connecting the constructive process of imagination with the reconstructive process of episodic memory systematically for the first time was listed in the top 10 scientific breakthroughs of 2007 by *Science*.

1998-2005: Elixir Studios, London – Founder & CEO

In 1998 I founded Elixir Studios, one of the UK's highest profile independent games developers, growing the company to 70 people working across several game projects for major publishers including Microsoft and Vivendi Universal. I was involved in practically every aspect of the company including both the game mechanics and technical fronts for all our pioneering AI games including the BAFTA-nominated 'Republic: The Revolution' and 'Evil Genius' games. In 2005 the intellectual property and technology rights were sold to various publishers.

1997-1998: Lionhead Studios, Guildford – Lead AI Programmer

Founding member of Lionhead Studios, which became one of the most famous game developers in the world and is now a

subsidiary of Microsoft. I worked as the Lead AI Programmer on the revolutionary game 'Black & White' writing the intelligence routines for an artificial creature that had the ability to learn from the player's actions.

1993-1994: Bullfrog Productions, Guildford – Lead Programmer, Lead Designer.

SELECTED PUBLICATIONS

PI currently have an h-index of 60 and a complete list of my publications can be viewed on Google Scholar. Below are my top 30 publications including #14 and #20 which are in the top 10 most cited papers of the past 5 years in any field.

1. Vinyals O*, Babuschkin I*, Czarnecki WM, Mathieu M, Dudzik A, Chung J, Choi DH, Powell R, Ewalds T, Georgiev P, Oh J, Horgan D, Kroiss M, Danihelka I, Huang A, Sifre L, Cai T, Agapiou JP, Jaderberg M, Vezhnevets AS, Leblond R, Pohlen T, Dalibard V, Budden D, Sulsky Y, Molloy J, Paine TL, Gulcehre C, Wang Z, Pfaff T, Wu Y, Ring R, Yogatama D, Wụnsch D, McKinney K, Smith O, Schaul T, Lillicrap T, Kavukcuoglu K, Hassabis D, Apps C, Silver D "Grandmaster level in StarCraft II using multi-agent reinforcement learning", *Nature* 575, 350–354 (2019)

2. N Tomašev, X Glorot, JW Rae, M Zielinski, H Askham, A Saraiva, A Mottram, C Meyer, S Ravuri, I Protsyuk, A Connell, CO Hughes, A Karthikesalingam, J Cornebise, H Montgomery, G Rees, C Laing, CR Baker, K Peterson, R Reeves, D Hassabis, D King, M Suleyman, T Back, C Nielson, JR Ledsam, S Mohamed "A clinically applicable approach to continuous prediction of future acute kidney injury", *Nature* 572, 116-119 (2019)

3. M Jaderberg, WM Czarnecki, I Dunning, L Marris, G Lever, AG Castaneda, C Beattie, NC Rabinowitz, AS Morcos, A Ruderman, N Sonnerat, T Green, L Deason, JZ Leibo, D Silver, D Hassabis, K Kavukcuoglu, T Graepel "Human-level performance in 3D multiplayer games with population-based reinforcement learning", *Science* 364, 859-865 (2019)

4. M Botvinick, S Ritter, JX Wang, Z Kurth-Nelson, C Blundell, D Hassabis. "Reinforcement Learning, Fast and Slow", *Trends in cognitive sciences* 23:408-422 (2019)

5. D Silver, T Hubert, J Schrittwieser, I Antonoglou, M Lai, A Guez, M Lanctot, L Sifre, D Kumaran, T Graepel, T Lillicrap, K

Simonyan, D Hassabis. “A general reinforcement learning algorithm that masters chess, shogi, and Go through self-play”, *Science* 362:1140-1144 (2018)

6. R Koster, MJ Chadwick, Y Chen, D Berron, A Banino, E Düzel, D Hassabis, D Kumaran “Big-loop recurrence within the hippocampal system supports integration of information across episodes”, *Neuron* 99 (6), 1342-1354 (2018)

7. J De Fauw, JR Ledsam, B Romera-Paredes, S Nikolov, N Tomasev, S Blackwell, H Askham, X Glorot, B O’Donoghue, D Visentin, G van den Driessche, B Lakshminarayanan, C Meyer, F Mackinder, S Bouton, K Ayoub, R Chopra, D King, A Karthikesalingam, CO Hughes, R Raine, J Hughes, DA Sim, C Egan, A Tufail, H Montgomery, D Hassabis, G Rees, T Back, PT Khaw, M Suleyman, J Cornebise, PA Keane, O Ronneberger “Clinically applicable deep learning for diagnosis and referral in retinal disease”, *Nature Medicine* 24 (9), 1342 (2018)

8. A Eslami, DJ Rezende, F Besse, F Viola, AS Morcos, M Garnelo, A Ruderman, AA Rusu, I Danihelka, K Gregor, DP Reichert, L Buesing, T Weber, O Vinyals, D Rosenbaum, N Rabinowitz, H King, C Hillier, M Botvinick, D Wierstra, K Kavukcuoglu, D Hassabis “Neural scene representation and rendering”, *Science* 360 (6394), 1204-1210 (2018)

9. JX Wang, Z Kurth-Nelson, D Kumaran, D Tirumala, H Soyer, JZ Leibo, D Hassabis, M Botvinick “Prefrontal cortex as a meta-reinforcement learning system”, *Nature Neuroscience* 21 (6), 860-868 (2018)

10. A Banino*, C Barry*, B Uria*, C Blundell, T Lillicrap, P Mirowski, A Pritzel, MJ Chadwick, T Degris, J Modayil, G Wayne, H Soyer, F Viola, B Zhang, R Goroshin, N Rabinowitz, R Pascanu, C Beattie, S Petersen, A Sadik, S Gaffney, H King, K Kavukcuoglu, D Hassabis, R Hadsell, D Kumaran “Vector-based navigation using grid-like representations in artificial agents”, *Nature* 557 (7705), 429-433 (2018)

11. Silver D*, Schrittwieser J*, Simonyan K*, Antonoglou I, Huang A, Guez A, Hubert T, Baker L, Lai M, Bolton A, Chen Y, Lillicrap T, Hui F, Sifre L, Van Den Driessche G, Graepel T, Hassabis D "Mastering the Game of Go without Human Knowledge", *Nature* 550, 354-359 (2017)

12. Hassabis D, Kumaran D, Summerfield C, Botvinick M "Neuroscience-Inspired Artificial Intelligence", *Neuron* 95(2):245-58. (2017)

13. Kirkpatrick J, Pascanu R, Rabinowitz N, Veness J, Desjardins G, Rusu AA, Milan K, Quan J, Ramalho T, Grabska-Barwinska A, Hassabis D, Clopath C, Kumaran D, Hadsell R "Overcoming Catastrophic Forgetting in Neural Networks", *Proc Nat Acad Sci* 114(13):3521-26 (2017)

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16. Kumaran D, Hassabis D, McClelland JL "What Learning Systems do Intelligent Agents Need? Complementary Learning Systems Theory Updated", *Trends in cognitive sciences* 20(7):512-34 (2016)

17. Kumaran D, Banino A, Blundell C, Hassabis D, Dayan P "Computations Underlying Social Hierarchy Learning: Distinct Neural Mechanisms for Updating and Representing Self-Relevant Information", *Neuron* 92(5):1135-47 (2016)

18. Chadwick MJ, Anjum RS, Kumaran D, Schacter DL, Spiers HJ, Hassabis D "Semantic Representations in the Temporal Pole Predict False Memories", *Proc Natl Acad Sci USA* 113(36):10180-85 (2016)

19. Balaguer J, Spiers H, Hassabis D, Summerfield C "Neural Mechanisms of Hierarchical Planning in a Virtual Subway Network", *Neuron* 90(4):893-903. (2016)

20. Mnih V*, Kavukcuoglu K*, Silver D*, Rusu AA, Veness J, Bellemare MG, Graves A, Riedmiller M, Fidjeland AK, Ostrovski G, Petersen S, Beattie C, Sadik A, Antonoglou I, King H, Kumaran D, Wierstra D, Legg S, Hassabis D "Human-Level Control through Deep Reinforcement Learning", *Nature* 518(7540):529-33 (2015)

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28. Hassabis D, Maguire EA. "Deconstructing episodic memory with construction", *Trends in Cognitive Sciences* 11(7):299-306 (2007)

29. Hassabis D, Kumaran D, Maguire EA. "Using imagination to understand the neural basis of episodic memory", *Journal of Neuroscience* 27(52):14365-74 (2007)

30. Hassabis D, Kumaran D, Vann SD, Maguire EA. "Patients with hippocampal amnesia cannot imagine new experiences", *Proc Natl Acad Sci USA* 104(5):1726-31 (2007)

* equal contribution

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