

## **Demis Hassabis, CBE, FRS, FEng – Curriculum Vitae (Sep 2023)**

DeepMind, 8 Handyside Street, King's Cross, London, N1C 4DJ

### **Research and Industrial Career**

#### **2010 – Present: Google DeepMind, London**

Co-Founder & CEO

Co-Founder and CEO of Google DeepMind, one of the world's leading artificial intelligence (AI) research groups that aims to solve intelligence to advance science and benefit humanity. Assembled and led a world-class interdisciplinary research team, and 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 in 2013 that was able to learn to achieve superhuman performance on a range of Atari games receiving only the raw pixels as input.

In 2014 DeepMind was acquired by Google in its largest ever European acquisition, but continued to operate independently until 2023 when DeepMind joined forces with Google Research's Brain team to form a single unit within Google under my leadership. DeepMind has published over 2000 papers to date including more than 20 in *Nature* and *Science*, and two of the top 10 most cited papers of the past 5 years in any field. Some of DeepMind's many notable achievements include developing the *AlphaGo* program that in 2016 famously defeated the world champion at the complex game of Go, a longstanding grand challenge of AI, and the more general *AlphaZero* that can play any 2-player perfect information game starting with no prior knowledge and was able to be beat the world's strongest chess program Stockfish at chess, as well as AlphaGo at Go. The company has now grown to over 1000 researchers and engineers, with satellite offices in Canada, Paris and California.

We have successfully translated our technological breakthroughs to improve dozens of Google products used by billions of people, and launched high-impact applied projects in areas of science, medicine, and energy. In 2020 our *AlphaFold* system was recognised as a solution to the 50-year grand challenge of protein structure prediction, and that was followed by the launch of the *AlphaFold Protein Structure Database* with hundreds of thousands of protein structures, including the most complete and accurate picture of the human proteome to date. In 2022 we expanded the AlphaFold database to include more than 200 million structure predictions, covering nearly all catalogued proteins known to science.

#### **2009 – 2010: Gatsby Unit, UCL; McGovern Institute, MIT; Dept of Psychology, Harvard**

Wellcome Trust Postdoctoral Research Fellow

Awarded a prestigious Sir Henry Wellcome Fellowship as a postdoc jointly at UCL, MIT and Harvard. Built computational models of imagination and scene understanding, used hierarchical

neural networks to investigate the boundary between memory and perception, and investigated how people construct a theory of mind and use those models to predict the behaviour of others.

**2005 – 2009: Institute of Neurology, University College London (UCL)**

PhD in Cognitive Neuroscience

Awarded a Brain Trust studentship to undertake a PhD with Prof Eleanor Maguire FMedSci FRS focused on the neural mechanisms underpinning imagination and memory. Investigated the process of imagination (or mental simulation) with the use of highly innovative fMRI and patient studies, showing that the hippocampus was critically involved, and for the first time systematically connecting the constructive process of imagination with the reconstructive process of episodic memory. This work was listed in the top 10 scientific breakthroughs of 2007 by *Science*, and subsequently opened up a whole new subfield in cognitive neuroscience of imagination and planning.

**1998 – 2005: Elixir Studios, London**

Founder & CEO

In 1998 founded and ran Elixir Studios, which went on to become one of the UK's highest profile independent games developers, producing games for major publishers including Eidos, Microsoft and Vivendi Universal. Involved in all aspects of the company including both the game mechanics and technical design for 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, and I returned to academia to study systems neuroscience to find inspiration from the brain for new AI algorithm ideas.

**1993 – 1998: Bullfrog Productions; Lionhead Studios, Guildford**

Lead AI Programmer, Lead Designer

Co-created 'Theme Park' aged 17, a multi-million selling AI simulation game allowing players to design and run their own amusement parks, for Bullfrog Productions (now part of Electronic Arts) then one of the leading games developers in Europe. Theme Park went on to become one of the most successful games ever, achieving 90%+ average review scores and selling over ten million copies worldwide, and inspiring a whole new genre of sandbox simulation games.

After graduating from Cambridge, became a founding member of Lionhead Studios (now part of Microsoft). Worked as the Lead AI Programmer on the revolutionary game 'Black & White' coding the intelligence routines for an artificial creature that had the ability to learn from and adapt to the player's actions, still the most complex use of AI in any game.

## 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<sup>st</sup> Class)

## Selected Awards and Achievements

- Albert Lasker Basic Medical Research Award (2023)
- Canada Gairdner International Award (2023)
- Breakthrough Prize in Life Sciences (2023)
- BCS Lovelace Research Medal (2023)
- BBVA Foundation Frontiers of Knowledge Award (2022)
- Princess of Asturias Award for Technical & Scientific Research (2022)
- Doyne Medal (2022)
- Wiley Prize in Biomedical Sciences (2022)
- IRI Medal (2021)
- International Honorary Member of the American Academy of Arts & Sciences (2021)
- Royal Designer for Industry (2021)
- Pius XI Medal from Pope Francis and the Pontifical Academy of Sciences (2020)
- Dan David Prize Future Award for work on AI (2020)
- Fellow of the Royal Society (2018)
- Commander of the Order of the British Empire (CBE) (2018)
- Fellow of the Royal Academy of Engineering (2017)
- *Time* 100 list of the world's 100 most influential people (2017)
- *Nature's* 'top ten scientists of the year' (2016)
- *WIRED's* 'Leadership in Innovation' award (2016)
- Silver Medal of the Royal Academy of Engineering (2016)
- *Financial Times* Digital Entrepreneur of the Year (2016)
- Honorary Degrees from Cambridge (2015), UCL (2016), and Imperial (2018)
- Mullard Award of the Royal Society (2014)
- Fellow of the Royal Society of Arts (2009)
- 5-times World Games Champion at the Mind Sports Olympiad (1998-2003)
- Captained England junior chess teams, reaching master standard at 13 (2300 ELO rating), the second highest rated player in the world for my age at the time

Research listed in the top 10 Breakthroughs of the Year by *Science* four times:

- 2021 Breakthrough of the Year (Winner) - for solving the protein structure prediction problem with AlphaFold 2
- 2020 Breakthrough of the Year (Top 10) - for winning CASP13 with AlphaFold 1
- 2016 Breakthrough of the Year (Top 10) - for developing AlphaGo
- 2007 Breakthrough of the Year (Top 10) - for my work on the neural basis of imagination

## Selected Publications

h-index of 83 and over 130,000 citations as of Dec 2023 - a [complete list of publications](#) can be viewed on Google Scholar. Top 40 publications listed below, with #24 and #30 in the top 10 most cited papers of the past 5 years in any field (cited over 17,000 and 27,000 times respectively).

1. J Jumper, D Hassabis. Protein structure predictions to atomic accuracy with AlphaFold. **Nature Methods** (2022)
2. J Kirkpatrick, B McMorrow, DHP Turban, et al. Pushing the frontiers of density functionals by solving the fractional electron problem. **Science** (2021)
3. A Davies, P Veličković, L Buesing, et al. Advancing mathematics by guiding human intuition with AI. **Nature** (2021)
4. J Jumper, R Evans, A Pritzel, ..., D Hassabis. Applying and improving AlphaFold at CASP14. **Proteins: Structure, Function, and Bioinformatics** (2021)
5. R Evans, M O'Neill, A Pritzel, ..., D Hassabis. Protein complex prediction with AlphaFold-Multimer. **Biorxiv** (2021)
6. J Jumper, R Evans, A Pritzel, ..., D Hassabis. Highly accurate protein structure prediction with AlphaFold. **Nature** 596, 583–589 (2021)
7. K Tunyasuvunakool, J Adler, Z Wu, ... D Hassabis. Highly accurate protein structure prediction for the human proteome. **Nature** 596, 590–596 (2021)
8. J Schrittwieser, I Antonoglou, T Hubert, et al. Mastering atari, go, chess and shogi by planning with a learned model. **Nature** (2020)
9. AW Senior, R Evans, J Jumper, ..., D Hassabis. Improved protein structure prediction using potentials from deep learning. **Nature** (2020)
10. W Dabney, Z Kurth-Nelson, N Uchida, et al. A distributional code for value in dopamine-based reinforcement learning. **Nature** (2020)
11. O Vinyals\*, I Babuschkin\*, WM Czarnecki, et al. “Grandmaster level in StarCraft II using multi-agent reinforcement learning”. **Nature**. 575, 350–354 (2019)
12. N Tomašev, X Glorot, JW Rae, et al “A clinically applicable approach to continuous prediction of future acute kidney injury”. **Nature**, 572, 116-119 (2019)
13. M Jaderberg, WM Czarnecki, I Dunning, et al. “Human-level performance in 3D multiplayer games with population-based reinforcement learning”. **Science**, 364, 859-865 (2019)
14. 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)

15. D Silver, T Hubert, J Schrittwieser, ..., D Hassabis. "A general reinforcement learning algorithm that masters chess, shogi, and Go through self-play", **Science**, 362:1140-1144 (2018)
16. R Koster, MJ Chadwick, Y Chen, et al. "Big-loop recurrence within the hippocampal system supports integration of information across episodes" **Neuron** 99 (6), 1342-1354 (2018)
17. J De Fauw, JR Ledsam, B Romera-Paredes, et al. "Clinically applicable deep learning for diagnosis and referral in retinal disease", **Nature Medicine** 24 (9), 1342 (2018)
18. A Eslami, DJ Rezende, F Besse, ..., D Hassabis "Neural scene representation and rendering", **Science** 360 (6394), 1204-1210 (2018)
19. JX Wang, Z Kurth-Nelson, D Kumaran, et al. "Prefrontal cortex as a meta-reinforcement learning system" **Nature Neuroscience** 21 (6), 860-868 (2018)
20. A Banino\*, C Barry\*, B Uria\*, et al. "Vector-based navigation using grid-like representations in artificial agents" **Nature** 557 (7705), 429-433 (2018)
21. D Silver \*, J Schrittwieser \*, K Simonyan\*, ..., D Hassabis "Mastering the Game of Go without Human Knowledge". **Nature**, 550, 354-359 (2017)
22. D Hassabis, D Kumaran, C Summerfield, M Botvinick "Neuroscience-Inspired Artificial Intelligence". **Neuron**. 95(2):245-58. (2017)
23. J Kirkpatrick, R Pascanu, N Rabinowitz, et al. "Overcoming Catastrophic Forgetting in Neural Networks". **Proc Nat Acad Sci**. 114(13):3521-26. (2017)
24. D Silver\*, A Huang\*, CJ Maddison, ..., D Hassabis "Mastering the Game of Go with Deep Neural Networks and Tree Search". **Nature**. 529(7587):484-89. (2016)
25. A Graves\*, G Wayne\*, M Reynolds, ..., D Hassabis "Hybrid Computing Using a Neural Network with Dynamic External Memory". **Nature**. 538(7626):471-76. (2016)
26. D Kumaran, D Hassabis, JL McClelland "What Learning Systems do Intelligent Agents Need? Complementary Learning Systems Theory Updated". **Trends in cognitive sciences**. 20(7):512-34. (2016)
27. D Kumaran, A Banino, C Blundell, D Hassabis, P Dayan "Computations Underlying Social Hierarchy Learning: Distinct Neural Mechanisms for Updating and Representing Self-Relevant Information" **Neuron**. 92(5):1135-47. (2016)
28. MJ Chadwick, RS Anjum, D Kumaran, DL Schacter, HJ Spiers, D Hassabis "Semantic Representations in the Temporal Pole Predict False Memories". **Proc Natl Acad Sci**. 113(36):10180-85. (2016)
29. J Balaguer, H Spiers, D Hassabis, C Summerfield "Neural Mechanisms of Hierarchical Planning in a Virtual Subway Network". **Neuron**. 90(4):893-903. (2016)
30. V Mnih\*, K Kavukcuoglu\*, D Silver\*, ... , D Hassabis "Human-Level Control through Deep Reinforcement Learning". **Nature**. 518(7540):529-33. (2015)

31. D Hassabis\*, N Spreng\*, A Rusu, C Robbins, R Mar, D Schacter "Imagine All the People: How the Brain Creates and Uses Personality Models to Predict Behaviour". ***Cerebral Cortex***. 24(8):1979-87. (2013)
32. D Schacter, D Addis, D Hassabis, V Martin, N Spreng, K Szpunar "The Future of Memory: Remembering, Imagining, and the Brain". ***Neuron***. 76(4):677-694. (2012)
33. MJ Chadwick\*, D Hassabis\*, N Weiskopf, EA Maguire. "Decoding individual episodic memory traces in the human hippocampus". ***Current Biology***. 20(6):544-7. (2010)
34. D Kumaran, JJ Summerfield, D Hassabis, EA Maguire. "Tracking the emergence of conceptual knowledge during human decision making". ***Neuron***. 63(6):889-901. (2009)
35. D Hassabis, EA Maguire. "The construction system of the brain" ***Phil. Trans. of the Royal Society B***. 364(1521):1263-71. (2009)
36. D Hassabis, C Chu, G Rees, N Weiskopf, PD Molyneux, EA Maguire. "Decoding neuronal ensembles in the human hippocampus". ***Current Biology***. 19(7):546-54. (2009)
37. D Mobbs, P Petrovic, JL Marchant, D Hassabis, N Weiskopf, B Seymour, RJ Dolan, CD Frith. "When fear is near: threat imminence elicits prefrontal-periaqueductal gray shifts in humans". ***Science***. 317(5841):1079-83. (2007)
38. D Hassabis, EA Maguire. "Deconstructing episodic memory with construction" ***Trends in Cognitive Sciences***. 11(7):299-306. (2007)
39. D Hassabis, D Kumaran, EA Maguire. "Using imagination to understand the neural basis of episodic memory". ***Journal of Neuroscience***. 27(52):14365-74. (2007)
40. D Hassabis, D Kumaran, SD Vann, EA Maguire. "Patients with hippocampal amnesia cannot imagine new experiences". ***Proc Natl Acad Sci***. 104(5):1726-31. (2007)

\* equal contribution