

**Name****Stuart R. Hameroff, MD****Position title**

Emeritus Professor, Anesthesiology  
Emeritus Professor, Psychology  
Director, Co-Founder, Center for Consciousness Studies

**Education/Training**

<b>Institution and Location</b>	<b>Degree</b>	<b>Years</b>	<b>Field of Study</b>
University of Pittsburgh Pittsburgh, PA	B.S.	1965-69	Chemistry, Physics Mathematics
Hahnemann Medical College Philadelphia, PA	M.D.	1969-73	Medicine
Internship, Tucson Medical Center Tucson, AZ		1973-74	

**1977-Present**

Attending Physician/Anesthesiologist, Department of Anesthesiology  
University Hospital, University Medical Center, University Physicians Inc., University of Arizona, Health Sciences Center, UAHN, Banner-University Medical Center, The University of Arizona, Tucson, Arizona

1977-1978

Instructor, Anesthesiology, University of Arizona, College of Medicine, Tucson, AZ

1978-1984

Assistant Professor, Anesthesiology

1979

Certified by the American Board of Anesthesiology

1979-1985

Director, Pain Clinic/Pain Service, University Medical Center

1984 -1995

Associate Professor with Tenure, Anesthesiology

1994

Joint Appointment, Associate Professor, Department of Psychology

1995

Professor, Department of Anesthesiology, College of Medicine

1995

Professor, Department of Psychology, University of Arizona

1999

Associate Director, Center for Consciousness Studies, University of Arizona

1998 Co-Founder

2003-Present

Emeritus Professor, Anesthesiology and Psychology

2004-Present

Director, Center for Consciousness Studies

Stuart Hameroff MD grew up in Cleveland, Ohio, working summers at Republic Steel and Cleveland Stadium. At the University of Pittsburgh in the late 1960s, he studied chemistry, physics, mathematics and philosophy of mind. In medical school in the early 1970s at Hahnemann Medical College in Philadelphia, Hameroff spent a summer in a cancer research lab. Studying mitosis, he became interested in mitotic spindles and centrioles, composed of microtubules, polymers of the protein 'tubulin', and major components of the cytoskeleton within all cells. Comparing their lattice structure to Boolean computer matrices, he proposed that microtubules were the source of biological intelligence, and perhaps consciousness. Choosing an academic career, Hameroff trained in anesthesiology at the new University of Arizona Medical Center in Tucson, mentored by the department of anesthesiology's founding chair, Dr. Burnell Brown Jr, MD, PhD. After residency, Hameroff joined the anesthesiology faculty in 1977, a position he still holds as emeritus professor and practicing anesthesiologist.

Hameroff's research pursues theory - brain mechanisms of consciousness, memory, anesthetic action, quantum processing in microtubules, and clinical applications - transcranial ultrasound (TUS) for various brain disorders.

In the mid-1990s Hameroff teamed with famed British physicist Sir Roger Penrose to develop a quantum theory of consciousness ('orchestrated objective reduction', 'Orch OR') based on microtubule quantum computing. Highly controversial and harshly criticized, Orch OR is now supported by evidence, e.g. that anesthetics act in quantum channels in microtubules, and that microtubules have multi-scalar resonances, e.g. in megahertz. Hameroff and Penrose wrote a 20 year review of Orch OR in 2014.

Megahertz mechanical vibrations are ultrasound, clinically used in anesthesiology, and Hameroff proposed low intensity, non-invasive ultrasound could stimulate microtubule megahertz resonance and improve mental and neurological states in the brain. He and anesthesiology colleagues performed and published the first clinical trial of transcranial ultrasound ('TUS') on mental states in human volunteers, showing mood enhancement from brief, low intensity TUS. Collaborative studies with psychology professor John JB Allen and post-doc Jay Sanguinetti corroborated and elaborated TUS effects, and more TUS clinical studies are planned for Alzheimer's disease, depression, traumatic brain injury (with Dr. Michael Lemole in neurosurgery), Parkinsons (with Dr.Scott Sherman in neurology) and pediatric developmental delay (with Dr. Sydney Rice in pediatrics). The group will test a state-of-the-art TUS headset from Berkeley Ultrasound, sponsored and organized through the Center for Consciousness Studies.

Beginning in 1994, with professor and former department head Al Kaszniak in Psychology, the late professor Alwyn Scott in mathematics, and subsequently philosophy (and Regents) professor David Chalmers, Hameroff started an interdisciplinary, international conference series 'Toward a Science of Consciousness' held in even-numbered years in Tucson, and odd-numbered years elsewhere around the world. April 2014 marked the 20 year anniversary 'Tucson' conference, and the 2015 conference will be in Helsinki, Finland in June.

In 1998, with Kaszniak and Scott, and a 1.4 million dollar grant from the Fetzer Institute, Hameroff co-founded the University of Arizona Center for Consciousness Studies (CCS), served as associate director, and succeeded Kaszniak and then Chalmers, as director in 2004. With CCS moving administratively to anesthesiology, and Abi Behar-Montefiore as assistant director, CCS has subsisted since 2004 entirely on conference registration fees and small grants, and has supported relevant research.

Hameroff also collaborates with professors Jack Tuszynski at the University of Alberta, and Travis Craddock at Nova Southeastern on molecular modeling of microtubules, memory via CaMKII phosphorylation, and non-polar anesthetic and psychoactive drug actions in microtubule 'quantum channels'. Quantum non-locality implied for consciousness has attracted interaction with Deepak Chopra, and the inaugural 'Rustum Roy' award in 2011.

Hameroff has written or edited 5 books, over a hundred scientific articles and book chapters, lectured around the world, and appeared in the film 'WhattheBleep?' and numerous TV shows about consciousness on BBC, PBS, Discovery, OWN and History Channel. See [http://en.wikipedia.org/wiki/Stuart\\_Hameroff](http://en.wikipedia.org/wiki/Stuart_Hameroff), [www.quantumconsciousness.org](http://www.quantumconsciousness.org), and <http://www.consciousness.arizona.edu>.

### **Books Authored or Edited**

1. Hameroff SR, Satsangi PS, (Eds), *Consciousness: Integrating Eastern and Western Perspectives*, New Age Books, (2016)
2. Hameroff SR, Kaszniak AW & Chalmers D, (Eds), *Toward a Science of Consciousness III: The Third Tucson Discussions and Debates*, MIT Press/Bradford Books, Cambridge, MA (1999)
3. Hameroff SR, Kaszniak AW & Scott AC, (Eds), *Toward a Science of Consciousness II: The Second Tucson Discussions and Debates*, MIT Press/Bradford Books, Cambridge, MA, (1998)
4. Hameroff SR, Kaszniak AW & Scott AC, (Eds), *Toward a Science of Consciousness: The First Tucson Discussions and Debates*, MIT Press/Bradford Books, Cambridge, MA (1996)
5. Koruga DL, Hameroff SR, Withers J, Loutfy R, Sundareshan M. *C60 Fullerene--From Nanobiology to Nanotechnology*. Elsevier-North Holland, Amsterdam (1993)
6. Hameroff SR, *Ultimate Computing: Biomolecular Consciousness and NanoTechnology*, Elsevier-North Holland, Amsterdam (1987)

## Peer-Reviewed Articles

1. Hameroff SR, Change the Music: Psychotherapy and Brain Vibrations, *The Neuropsychotherapist*, Vol 4, 4, April 2016.
2. Craddock JA, Hameroff SR, Ayoub AT, Klobukowski M, Tuszynski JA. Anesthetics act in quantum channels in brain microtubules to prevent consciousness. *Current Topics in Medicinal Chemistry*, 2015/3/1, Vol 15:6, 523-533.
3. Craddock J.A. Travis, Friesen D, Mane J, Hameroff SR, Tuszynski JA. The Feasibility of Coherent Energy Transfer in Microtubules. *Journal of the Royal Society Interface*. 2014 Nov 6; 11(100).
4. Hameroff SR, Craddock TJ, Tuszynski JA. Quantum effects in the understanding of consciousness. *J Integr Neurosci*. 2014 Apr; 13(2):229-52.
5. Hameroff S, Penrose R. Consciousness in the universe: A review of the 'Orch OR' theory. *Phys Life Rev*, 2014; Mar 11(1):39-78.
6. Hameroff S, Penrose R. Reply to Seven Commentaries on "Consciousness in the Universe: Review of the 'Orch OR' theory". *Physics of Life Reviews*, 2014; 11:94–100.
7. Hameroff S, Penrose R. Reply to Criticism of the 'Orch OR qubit' - Orchestrated objective reduction is scientifically justified. *Physics of Life Reviews*, 2014; 11(1):104-112.
8. Hameroff S. Quantum walks in brain microtubules-a biomolecular basis for quantum cognition? *Top Cogn Sci*, 2014; Jan; 6(1):91-7.
9. Hameroff S. Consciousness, Microtubules and "Orch-OR": A 'Space-time' Odyssey', *Journal of Consciousness Studies*, Vol. 21, 3-4, 2014, pp 126-153.
10. Hameroff SR. Quantum mathematical cognition requires quantum brain biology: the "Orch OR" theory. *Behav Brain Sci*, 2013; Jun; 36(3):287-90.
11. Hameroff S, Trakas M, Duffield C, Annabi E, Gerace MB, Boyle P, Lucas A, Amos Q, Buadu A, Badal JJ. Transcranial ultrasound (TUS) effects on mental states: a pilot study. *Brain Stimul*, 2013; May; 6(3):409-15.
12. Hameroff S. A tale of two fields: comment on "Dissipation of 'dark energy' by cortex in knowledge retrieval" by Capolupo, Freeman and Vitiello. *Phys Life Rev*. 2013 Mar;10(1):95-6; discussion 112-6.
13. Hameroff S. How quantum brain biology can rescue conscious free will. *Front Integr Neurosci*, 2012; 6:93, Oct 12.

14. Craddock T, St George M, Freedman H, Barakat K, Damaraju S, Hameroff S, Tuszynski J. Computational Predictions of Volatile Anesthetic Interactions with the Microtubule Cytoskeleton: Implications for Side Effects of General Anesthesia. *PLoS ONE*, 2012; June 25 7(6).
15. Hameroff S. Quantum brain biology complements neuronal assembly approaches to consciousness: Comment on "Consciousness, biology and quantum hypotheses" by Baars and Edelman. *Phys Life Rev.* 2012 Sep;9(3):303-5; discussion 306-7.
16. Craddock T, Tuszynski J, Hameroff S. Cytoskeletal Signaling: Is Memory Encoded in Microtubule Lattices by CaMKII Phosphorylation? *PLoS Computational Biology*, 2012; March 8.
17. Craddock TJ, St George M, Freedman H, Barakat KH, Damaraju S, Hameroff S, Tuszynski JA. Computational predictions of volatile anesthetic interactions with the microtubule cytoskeleton: implications for side effects of general anesthesia. *PLoS One.* 2012;7(6).
18. Craddock TJ, Tuszynski JA, Chopra D, Casey N, Goldstein LE, Hameroff SR, Tanzi RE. The zinc dyshomeostasis hypothesis of Alzheimer's disease. *PLoS One.* 2012;7(3):e33552.
19. Ebner, M, Hameroff S. Lateral information processing by spiking neurons: a theoretical model of the neural correlate of consciousness. *Comput Intell Neurosci*, 2011; Oct 23.
20. Hameroff SR, Craddock TJ, Tuszynski JA. "Memory bytes" - molecular match for CaMKII phosphorylation encoding of microtubule lattices. *J Integr Neurosci*, 2010; Sep;9(3):253-67.
21. Hameroff S. The "conscious pilot"-dendritic synchrony moves through the brain to mediate consciousness. *J Biol Phys*, 2010 Jan;36(1):71-93.
22. Hameroff SR. The Brain Is Both Neurocomputer and Quantum Computer. *Cogn Sci*, 2007; Nov 12;31(6):1035-45.
23. Hameroff Stuart. The Good, the Bad and the Octopus, *Journal of Consciousness Studies*, Volume 14, Number 8, 2007, pp. 105-109(5).
24. Hameroff SR. The entwined mysteries of anesthesia and consciousness: is there a common underlying mechanism? *Anesthesiology*, 2006; Aug;105(2): 400-12.
25. Hameroff SR. A new theory of the origin of cancer: quantum coherent entanglement, centrioles, mitosis, and differentiation. *Biosystems.* 2004 Nov; 77(1-3):119-36.
26. Hagan S, Hameroff S, Tuszynski J. Quantum Computation in Brain Microtubules? Decoherence and Biological Feasibility, *Physical Reviews E*, 2002; 65:061901.

27. Hameroff S, Nip A, Porter M, Tuszynski J. Conduction pathways in microtubules, biological quantum computation, and consciousness. *BioSystems*, 2002; 64: 149-168.
28. Woolf NJ, Hameroff S. A quantum approach to visual consciousness. *Trends in Cognitive Sciences*, 2001; 5(11): 472-478.
29. Hameroff S. Consciousness, the brain and spacetime geometry. *Annals New York Academy of Sciences*, 2001; 929:74-104.
30. Hameroff S. Anesthesia: the "other side" of consciousness (Commentary on the papers of E. Roy John and colleagues). *Consciousness and Cognition*, 2001; 10: 217-229.
31. Hameroff SR. The neuron doctrine is an insult to neurons (commentary on target article "The neuron doctrine" by Gold and Stoljar) *Behavioral and Brain Sciences*, 1999; 22(5):838-839.
32. Hameroff SR. Quantum computation in brain microtubules? The Penrose-Hameroff "Orch OR" model of consciousness. *Philosophical Transactions Royal Society London*, 1998; (A)356:1869-1896.
33. Hameroff SR. Anesthesia, consciousness and hydrophobic pockets-a unitary quantum hypothesis of anesthetic action. *Toxicology Letters*, 1998; 100/101:31-39.
34. Hameroff SR. Funda-Mentality: Is the conscious mind subtly linked to a basic level of the universe? *Trends in Cognitive Sciences*, 1998; 2(4):119-127.
35. Hameroff S. Reply to Spier and Thomas from Stuart Hameroff, *Trends in Cognitive Science*, Vol 2, 4, 1 Apr 1998 pp. 125-126.
36. Hameroff SR, Penrose R. Conscious events as orchestrated space-time selections. *Journal of Consciousness Studies*, 1996; 3(1):36-53.
37. Hameroff SR, Penrose R. Orchestrated reduction of quantum coherence in brain microtubules: a model for consciousness? *Mathematics and Computers in Simulation*, 1996; 40:453-480.
38. Lahoz-Beltra R, Hameroff SR, Dayhoff JE, Shellie KC, Mangan RL, Capoyelas V. On the area of the intersection of disks in the plane. *Computational Geometry*, Volume 6, Number 6, November 1996, pp. 393- 396(4).
39. Lahoz-Beltra R, Hameroff SR, Dayhoff JE. Connection weights based on molecular mechanisms in Aplysia neuron synapses, *Neurocomputing*, Vol 11, 2, 1 June 1996 pp. 179-202.
40. Lahoz-Beltra R, Hameroff SR, Dayhoff JE, Shellie KC, Mangan RL. Tolerance of red-fleshed grapefruit to a constant or stepped temperature, forced-air quarantine heat treatment. *Postharvest Biology and Technology*, Volume 7, Number 1, January 1996, pp. 151-159(9).
41. Penrose R, Hameroff SR. What Gaps? Reply to Grush and Churchland. *Journal of Consciousness Studies*, 1995; 2(2):99-112.

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43. Tuszynski JA, Hameroff SR, Satari MV, Trpisov B, Nip MLA. Ferroelectric behavior in microtubule dipole lattices: implications for information processing, signaling and assembly/disassembly. *Journal of Theoretical Biology*, 1995; 174:371-380.
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45. Hameroff SR. Quantum coherence in microtubules: A neural basis for emergent consciousness? *Journal of Consciousness Studies*, 1994; 1(1):91-118.
46. Dayhoff JE, Hameroff SR, Swenberg CE, Lahoz-Beltra R. Cytoskeletal involvement in neuronal learning: a review. *Eur Biophys J*, 1994; 23:79-93.
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49. Dayhoff JE, Hameroff SR, Swenberg C, Lahoz-Beltra R, Samsonovich A. Biological learning with cytoskeletal signaling Neural Networks. *International Joint Conference on IJCNN*. 7-11 Jun 1992.
50. Hameroff SR, Dayhoff JE, Lahoz-Beltra R, Samsonovich AV, Rasmussen S. Conformational automata in the cytoskeleton: Models for molecular computation: *IEEE Computer*, Nov. 1992. 25(11):30-39.
51. Dayhoff JE, Hameroff SR, Lahoz-Beltra R, Swenberg C. Intracellular mechanisms in neuronal learning: adaptive models. Neural Networks. *International Joint Conference on IJCNN* 7-11 Jun 1992.
52. Hameroff S, Dayhoff J, Koruga D. Cytoskeletal conformational automata: intra-neuronal support of neural networks. Systems, Man and Cybernetics. *IEEE International Conference* on 18-21 Oct 1992.
53. Hotani H, Lahoz-Beltra R, Combs B, Hameroff SR, Rasmussen S. Microtubule dynamics, liposomes and artificial cells: in vitro observation and cellular automata simulation of microtubule assembly/disassembly and membrane morphogenesis. *Nanobiology*, 1992; 1(1):61-74.

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55. Verneti LA, Nowlin CLA, Hameroff SR, Gandolfi AJ, Lee, YC, Sarid D. Scanning tunneling microscopy resolution of surface features on cytokeratin protein is enhanced by prolonged exposure of protein to cold temperatures. *Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures*. March 1991.
56. Navabi M, Watt RC, Miller K, Mylrea K, Hameroff SR. Integrated monitoring SMART alarms can recognize critical events and reduce false alarms. *J Clin Mon*, 1991; 16(4):295-306.
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58. Rasmussen S, Karampurwala H, Vaidyanath R, Jensen K, Hameroff S. Computational connectionism within neurons: a model of cytoskeletal automata subserving neural networks. *Physica D*, 1990; 42:428-449.
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60. Navabi MJ, Watt RC, Mylrea KC, Hameroff SR. Classification of CO<sub>2</sub> Waveforms Using Artificial Neural Networks Engineering in Medicine and Biology Society. *Proceedings of the Twelfth Annual International Conference of the IEEE*. 1-4 Nov 1990.
61. Hameroff SR, Navabi MJ, Watt RC, Mylrea KC. Smart Alarms In Anesthesia Heart Rate And ECG Monitoring And Event Recognition Using Neural Network And Algorithmic Methods. Engineering in Medicine and Biology Society. *Proceedings of the Twelfth Annual International Conference of the IEEE*. 1- 4 Nov 1990.
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### **Book Chapters**

1. Hameroff S, Penrose R (2016) "Consciousness in the Universe: An Updated Review of the "Orch OR" Theory," In: *Biophysics of Consciousness: A Foundational Approach*, Eds R. Poznanski, JA Tuszynski, TE Feinberg, World Scientific, Chapter 14.
2. Craddock T, Hameroff S, Tuszynski J (2016) "The "Quantum Underground": Where Life and Consciousness Originate, In: *The Biophysics of Consciousness – Foundational Approaches*," Eds R Poznanski, TE Feinberg, JATuszynski, World Scientific, Chapter 13.
3. Hameroff S (2016) *The Quantum Origin of Life – How the brain evolved to feel good*, In *On Human Nature* (Eds M Tabeyranc, F Ayala)
4. Satsangi PS, Hameroff S and Sahni, V (2016) "Does Consciousness Guide the Universe?" In: *Consciousness: Integrating Eastern and Western Perspectives*, New Age Books, Section 2, pp 351-373
5. Ebner M, Hameroff S (2015) Modeling Figure/Ground Separation with a 'Mobile Zone' of Laterally-Connected Spiking Neurons, In: *Simulation in Medicine: Preclinical and Clinical Approach*; Ed. Irena Roterman-Konieczna, de Gruyter, Berlin.
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8. Hameroff S (2014) Consciousness, Free Will and Quantum Brain Biology – The 'Orch OR' Theory, in. *Quantum Physics Meets the Philosophy of Mind*, Eds. A Corradini, U Meixner, De Gruyter, Berlin pp 99- 134.

9. Hameroff S, P. Pylkkanen, R. Gennaro. 'HOT to DOT' – A 'Deeper order thought' theory of consciousness, Chapter 15 in: *Brain, Mind, Cosmos: The Nature of Our Existence and the Universe* (Sages and Scientists Series Book 1) [Kindle Edition] Edited by Deepak Chopra (2014).
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14. Hameroff SR, Tuszynski J. *Search for quantum and classical modes of information processing in microtubules: Implications for the living state*, In: *Bioenergetic organization in living systems*, Eds. Franco Musumeci, Mae-Wan Ho, World Scientific, Singapore (2003).
15. Hameroff SR. *Time, consciousness and quantum events in fundamental spacetime geometry*, in *The nature of time: Physics, geometry and perception – Proceedings of a NATO Advanced Research Workshop*, Ed. R. Buccheri and M. Saniga (2003).
16. Hameroff SR. *Consciousness, Whitehead and quantum computation in the brain: Panprotopsychism meets the physics of fundamental spacetime geometry*, in *Whitehead Process Network Compendium*, Ed. M. Weber (2003).
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### Commentaries

1. Hameroff SR, Roger Penrose - The man who fell to earth in *Science and Spirit* March April (2003).
2. Hameroff S. To the brink of enlightenment? (Review of "The quantum brain" by Jeffrey Satinover) *Cerebrum – The Dana Forum on Brain Science* 3(2), Spring 2001.
3. Hameroff S. Quantum vitalism. *Advances: The Journal of Mind-Body Health* 1997; 13(4):13-22.

### Grants/Awards

- 2014 Bhaumik Foundation - Toward a Science of Consciousness TSC-20th Anniversary Conference
- 2011 Rustum Roy Award, Chopra Foundation
- 2011 Institute of Noetic Sciences, TUS Pilot Study
- 2011 USAF-AFOSR - Toward a Science of Consciousness, 2011 TSC-Stockholm Conference, European Office - Aerospace R-D; Asian Office of Aerospace R&D
- 2005 YeTaDeL Foundation Award for Quantum Approaches to Consciousness
- 2003 Samueli Foundation Award for 2003 Quantum Mind conference
- 1998-01 Fetzer Institute Award to establish the Center for Consciousness Studies at the University of Arizona
- 1990-91 National Science Foundation (NSF) studies of nonlinear dynamics in biomolecular systems; Solitons in biomolecules (Co-PI with Alwyn Scott, PhD)
- 1982 Pfizer-Roerig Pharmaceuticals for the study of Effects of the antidepressant doxepin in chronic pain states, and various clinical drug and equipment studies in anesthesiology.
- 1996-2014 Woodward White Independent Survey, US Pacific Region, Best Doctors in America, (Neuroanesthesia)

## **Editorial Boards**

BioSystems; Journal of Consciousness Studies

## **Professional Memberships**

American Society of Anesthesiologists  
Association of University Anesthesiologists  
Society for Neuroscience  
Association for the Scientific Study of Consciousness

## **Research Interests**

Consciousness, microtubules, memory, quantum biology, anesthetic mechanisms, origin and evolution of life, transcranial ultrasound (TUS)

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