BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: **Ugurbil, Kamil**

eRA COMMONS USER NAME (credential, e.g., agency login): ugurbil

POSITION TITLE: **Professor / Director**

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Columbia University, New York, NY	B.A.	1971	Physics
Columbia University, New York, NY	M.A.	1974	Chemical Physics
Columbia University, New York, NY	Ph.D.	1977	Chemical Physics

A. Personal Statement

My research centers around magnetic resonance (MR) imaging and spectroscopy in general, ultrahigh field (UHF) MR methodology and instrumentation in particular, and the use of these methods in biomedical applications, predominantly in the study of brain function, chemistry and physiology. In this area, the team I lead at the Center for Magnetic Resonance Research (CMRR), the University of Minnesota, is internationally recognized for their leadership role, and has made pioneering contributions, including the introduction of the MR method for imaging brain activity (fMRI), studies aimed at elucidating fMRI mechanisms, the introduction of UHF MR for imaging studies of brain function and neurochemistry in human and animal models, unique applications of UHF techniques in human and animal model studies to achieve for the first time functional maps at the level of neuronal ensembles that represent elementary computational units (e.g. cortical columns and layers), and the development of numerous novel technologies and imaging methods, particularly for very high magnetic field fMRI. A recent example of this activity is the NIH funded Human Connectome Project (HCP) where I have led the technology development effort that has introduced the highly accelerated imaging and image reconstruction approaches that have dramatically altered the way human brain functional and diffusion weighted (dMRI) imaging is currently performed.

In addition, as the director of a large and scientifically successful MR center, the CMRR, I establish, oversee, support, and lead multi-project, multi-investigator, and even multi-institutional grants as the PI (such as NIBIB Biotechnology Research Center (BTRC) P41 grant which was recently renewed for years 20 to 25, an NINDS P30 grant, and the afore mentioned Human Connectome Project (joint PI with David Van Essen from Washington University, St. Louis).

B. Positions and Honors

Positions:

1977 – 1979: Bell Laboratories: Postdoctoral Fellow
1979 – 1982: Assistant Professor, Columbia University: (Biochemistry)
1982 – 1985: Associate Professor, University of Minnesota: (Biochemistry)
1985 – present: Professor, Univ. of Minnesota: (Radiology, Biochemistry, Medicine, and Neurosciences)
1991 – present: Founding Director, Center for Magnetic Resonance Research (CMRR), Univ. of Minnesota
1995 – 2003: Margaret & H.O. Peterson Chair of Neuroradiology, CMRR, Dept. of Radiology
2003 – 2008: Founding Director, Max-Planck Institut, Hochfeld Magnetresonanz Zentrum, Tübingen
2003 – present: McKnight Presidential Endowed Chair Professor, University of Minnesota

Other Experiences and Professional Memberships

2014 - Advisory Editor, *Neural Computation* Journal
2013 - 2014 "BRAIN" Initiative Working Group
2012- National Institute of Mental Health (NIMH), Board of Scientific Advisors
2006 - European Research Council (ERC), Life Science Panel

2000 - 2013 Advisory Board, Stanford University MR Center, Palo Alto, California
2001 - 2006 Editorial Board, Journal of Neurophysiology;
1987 - 2003 Editorial Board, NMR in Biomedicine; Journal
1997 - 2003 Advisory Board; Medical College of Wisconsin, MR Center
1997 - 2002 Program Review Board (Fachbeirat), Max Planck Institute, Leipzig, Germany
1997 - 2000 Scientific Program Committee International Society of Magnetic Resonance Imaging
1996 - 1999 Associate Editor, Journal of Magnetic Resonance (JMR)
1989 - 1994 Journal Editorial Board, Biochemical Journal
1988 - 1994 Advisory Board, National Magnet Lab, Massachusetts Institute of Technology
1988 - 1991 Trustee of the International Society of Magnetic Resonance in Medicine
1987 - 1989 Advisory Board, Center for Nuclear Imaging Research (CNIR), University of Alabama
1986 - present Member, International Society of Magnetic Resonance in Medicine (ISMRM)

Honors:

2016 Vehbi Koç Award
2014 Richard Ernst Medal and Lecture (ETH, Zürich)
2014 Elected into National Academy of Inventors
2013 Erwin Hahn Lecture, Erwin Hahn Institute, Essen, Germany
2013 Elected to Academy of Device Innovators, University of Minnesota
2011 Honorary Doctorate (Doctorate Honoris Causa), University of Maastricht, Netherlands
2010 Centennial Lecture, University of Florida, Gainesville
2010 5th Annual Glen D. Dobben Memorial Lecture, University of Illinois, Chicago
2009 Sir Peter Mansfield Lecture, European Society of Magnetic Resonance in Medicine and Biology
2009 Elected Fellow of the International Society of Magnetic Resonance (ISMAR) Fellow.
2007 Elected into the Institute of Medicine, the National Academies (USA)
2005 Elected into the American Academy of Arts and Sciences
2005 Honorary Doctorate (Doctorate Honoris Causa), University of Utrecht, Netherlands
2003 McKnight Presidential Endowed Chair Professorship, University of Minnesota
2001 Science Day Lecturer, Swiss Federal Institute of Technology (EPFL), Lausanne
1996 Margaret & H.O. Peterson Chair Professorship, University of Minnesota
1997 Inducted as Fellow, International Society of Magnetic Resonance in Medicine (ISMRM)
1996 Gold Medal, the International Society of Magnetic Resonance in Medicine (ISMRM)
1983 NIH Research Career Development Award
1980 Irma T. Hirschl Career Scientist Award
1976 Recipient of Hammett Award for Original and Distinguished Research
1974 Columbia University, Graduate Faculties Alumni Scholar

C. Contribution to Science

1. **Discovery of Functional Magnetic Resonance (fMRI).** The introduction of fMRI was accomplished in two laboratories independently and simultaneously in 1991-1992, one of which was mine at the University of Minnesota. Using manipulations of the physiologic state of the anesthetized animal, such as altering oxygen content of inhaled gas, S. Ogawa from Bell Laboratories described in 1990 the effect of deoxyhemoglobin on MR images of the brain, and named it Blood Oxygenation Dependent (BOLD) contrast. In collaboration with Ogawa, I undertook experiments in my laboratory that aimed at using BOLD contrast to map human brain activity, leading to the successful demonstration of functional mapping in the human brain. This landmark effort was accompanied by the first modeling and experimental papers aimed at elucidating the mechanism underlying the functional imaging signals.
    a. Ogawa S, Tank DW, Menon R, Ellermann JM, Kim SG, Merkle H, **Ugurbil K**. (1992). “Intrinsic signal changes accompanying sensory stimulation: functional brain mapping with magnetic resonance imaging.” Proc Natl Acad Sci U S A 89(13): 5951-5955. PMCID: PMC402116.
    b. Ogawa S, Menon RS, Tank DW, Kim SG, Merkle H, Ellermann JM, **Ugurbil K**. (1993). “Functional brain mapping by blood oxygenation level-dependent contrast magnetic resonance imaging. A comparison of signal characteristics with a biophysical model.” Biophys J 64(3): 803-812. PMCID: PMC1262394.
    c. Menon RS, Ogawa S, Tank DW, **Ugurbil K**. (1993). “4 Tesla gradient recalled echo characteristics of photic stimulation- induced signal changes in the human primary visual cortex.” Magn Reson Med 30(3): 380-386.

2. **Understanding the underlying mechanisms and the charecteristics of Functional mapping signals in fMRI towards developing functional imaging at the level of cortical layers and columns.** The ability to obtain functional maps at the level of minimal architectural units that organize neural populations of similar properties is critical for understanding brain function. The cortical columns of neocortex are prominent examples of such structurally and functionally specialized units and have received extensive attention in studies of brain function using electrophysiology, optical imaging, and computational modeling. In addition, the differences in connectivity and cell types across the few millimeter thick cortical ribbon require that laminar resolution is also critical in deciphering the elementary computations of the brain. However, it is not possible to assume *a priori* that functional mapping signals in fMRI have high fidelity to sites of neuronal activity because the coupling is mediated indirectly through neurovascular coupling and vasculature. Subsequent to the introduction of fMRI, my group made seminal and pioneering contributions towards understanding the mechanisms underlying fMRI signals, the spatial scale of neurovascular coupling, and the nature of mapping signal with different functional contrast encoding approaches; we then exploited this knowledge to develop methods (including ultrahigh field MR technology (see below)) for functional mapping at the level of cortical columns and layers in the human brain.
    a. Duong TQ, Kim DS, **Ugurbil K**, Kim SG. (2001). "Localized cerebral blood flow response at submillimeter columnar resolution." Proc Natl Acad Sci U S A 98, 10904-10909. PMCID: PMC58572.
    b. Shmuel A, Yacoub E, Pfeuffer J, Van de Moortele PF, Adriany G, Hu X, **Ugurbil K**. (2002). "Sustained negative BOLD, blood flow and oxygen consumption response and its coupling to the positive response in the human brain." Neuron 36, 1195-1210.
    c. Shmuel A, Yacoub E, Chaimow D, Logothetis NK, **Ugurbil K**. (2007). "Spatio-temporal point-spread function of fMRI signal in human gray matter at 7 Tesla." Neuroimage 35, 539-552. PMCID: PMC2989431.
    d. Yacoub E, Harel N, **Ugurbil K**. (2008). "High-field fMRI unveils orientation columns in humans." Proc Natl Acad Sci U S A 105, 10607-10612. PMCID: PMC2492463.
3. **Development of high and ultrahigh magnetic fields for magnetic resonance imaging and spectroscopy, particularly for neuroimaging and fMRI**. A common thread in my work has been the effort to exploit high magnetic fields for human studies in order to enhance the biological information content, accuracy, and resolution of imaging and spectroscopy signals. My laboratory was one of the first three academic laboratories that initiated 4 Tesla (T) human imaging at approximately the same time in ~1990; subsequently, justified by a large body of 4T human data and small animal experiments conducted at 9.4T, largely aimed at imaging brain function, we were the first to introduce 7 Tesla for human studies in ~1999, using a magnet developed specifically for us and system development and integration undertaken by my group. This seminal effort in ultrahigh magnetic fields was complemented with fundamental studies on the physics of high field/high frequency imaging in the human body, development of high frequency RF methods and instrumentation (such as parallel transmit concepts and hardware), and introduction of new data acquisition methods, to attain some of the most advanced neuroimaging capabilities. The data coming from this 7T system ultimately led to commercially produced 7 T systems and to the evolution of such high fields as the most advanced neuroimaging and more recently body imaging platform.
    a. **Ugurbil K**, Garwood M, Ellermann J, Hendrich K, Hinke R, Hu X, Kim SG, Menon R, Merkle H, Ogawa S, Salmi R. (1993). “Imaging at high magnetic fields: initial experiences at 4 T”. Magn Reson Q 9, 259-277.
    b. Vaughan JT, Garwood M, Collins CM, Liu W, DelaBarre L, Adriany G, Andersen P, Merkle H, Goebel R, Smith MB, **Ugurbil K**. (2001). “7T vs. 4T: RF power, homogeneity, and signal-to-noise comparison in head images.” Magn Reson Med 46, 24-30.
    c. Adriany G, Van de Moortele PF, Wiesinger F, Moeller S, Strupp JP, Andersen P, Snyder C, Zhang X, Chen W, Pruessmann KP, Boesiger P, Vaughan T, **Ugurbil K**. (2005). “Transmit and receive transmission line arrays for 7 Tesla parallel imaging.” Magn Reson Med 53, 434-445.
    d. Van de Moortele PF, Akgun C, Adriany G, Moeller S, Ritter J, Collins CM, Smith MB, Vaughan JT, **Ugurbil K**. (2005). “B(1) destructive interferences and spatial phase patterns at 7 T with a head transceiver array coil.” Magn Reson Med 54, 1503-1518.
4. **The Human Connectome Project**. The Human Connectome Project (HCP) was a major undertaking funded by NIH Blueprint for Neuroscience Research. HCP aims to map connections in of the human brain in the mm scale in normal adults in their mid-life. This project was awarded to a consortium led by the

Washington University and the University of Minnesota, Center for Magnetic Resonance Research (CMRR) (grant number 1U54MH091657) with David Van Essen from Washington University in St. Louis and I serving as co-PIs. My group was responsible for all the technical developments for image acquisition and reconstructions methods. Starting from developments already in progress in my group, we were able to accomplish major advanced for image acquisition leading to the highest temporal and spatial resolution fMRI and diffusion weighted (dMRI) images of the human brain, and significant improvements in connectomics information derived from such data. These imaging approaches have redefined functional and diffusion weighted imaging. Tom Insel, the former head of the NIMH cited the HCP as a major advance in brain sciences (**http://www.nimh.nih.gov/about/director/2015/brain-awareness.shtml**).

a. **Ugurbil K**, Xu J, Auerbach EJ, Moeller S, Vu AT, Duarte-Carvajalino, et al. (2013). "Pushing spatial and temporal resolution for functional and diffusion MRI in the Human Connectome Project." Neuroimage 80, 80-104. PMCID: PMC3740184.
b. Van Essen DC, Smith SM, Barch DM, Behrens TE, Yacoub E, **Ugurbil K**, WU-Minn HCP Consortium. (2013). "The WU-Minn Human Connectome Project: An overview." Neuroimage 80, 62-79. PMCID: PMC3724347.
c. Smith SM, Miller KL, Moeller S, Xu J, Auerbach EJ, Woolrich MW, Beckmann CF, Jenkinson M, Andersson J, Glasser MF, Van Essen DC, Feinberg DA, Yacoub ES, **Ugurbil K**. (2012). "Temporally-independent functional modes of spontaneous brain activity." Proc Natl Acad Sci U S A 109, 3131-3136. PMCID: PMC3286957.
d. Xu J, Moeller S, Auerbach EJ, Strupp J, Smith SM, Feinberg DA, Yacoub E, **Ugurbil K**. 2013. "Evaluation of slice accelerations using multiband echo planar imaging at 3 T." Neuroimage 83, 991-1001. PMCID: PMC3815955.

5. **In vivo magnetic resonance Spectroscopy and applications to studies in the human brain**. One of the pioneering efforts towards using magnetic resonance spectroscopy (MRS) to extract biological and physiologic information non-invasively in intact biological systems was started in Bell Laboratories Biophysics group where my colleagues and I introduced and demonstrated the use of MRS in intact biological systems. Many years later I used many of these techniques to study bioenergetics of neuronal function in the human brain.

a. **Ugurbil K**, Brown TR, den Hollander JA, Glynn P, Shulman RG. (1978). "High-resolution 13C nuclear magnetic resonance studies of glucose metabolism in Escherichia coli." Proc Natl Acad Sci U S A 75, 3742-3746.
b. Brown TR, Kincaid BM, **Ugurbil K**. (1982). "NMR chemical shift imaging in three dimensions." Proc Natl Acad Sci U S A 79, 3523-3526.
c. Chen W, Zhu XH, Gruetter R, Seaquist ER, Adriany G, **Ugurbil K**. (2001). "Study of tricarboxylic acid cycle flux changes in human visual cortex during hemifield visual stimulation using (1)H-{(13)C} MRS and fMRI." Magn Reson Med 45, 349-355.
d. Mangia S, Tkac I, Gruetter R, Van de Moortele PF, Maraviglia B, **Ugurbil K**. (2007). "Sustained neuronal activation raises oxidative metabolism to a new steady-state level: evidence from 1H NMR spectroscopy in the human visual cortex." J Cereb Blood Flow Metab 27, 1055-1063.

Complete List of Published Work in MyBibliography:

http://www.ncbi.nlm.nih.gov/sites/myncbi/kamil.ugurbil.1/bibliography/45757589/public/?sort=date&direction=descending

D. Research Support

ACTIVE

P41EB015894 (PI: Ugurbil) 06/01/2013 - 05/31/2018 3.00 Calendar Months
NIH $1,349,542
NMR Imaging and Spectroscopy

The central aim of this Biotechnology Research Center (BTRC) grant is to significantly advance MR based measurement capabilities and their biomedical applications in humans and enabling a large number of Collaborative and Service projects to use these capabilities to acquire advanced structural, functional, and physiological information to investigate human organ function in health and disease.

UO1 HL117664 (PI: Gupta) 06/01/2014 – 05/31/2018 0.12 Calendar Months
NIH (Co-Inv: Ugurbil) $1,270,369

Cannabinoid-based Therapy and Approaches to Quantify Pain in Sickle Cell Disease

The major goal of this project is to examine the mechanisms(s) that cause ongoing pain and if Cannabis-based drugs can provide analgesia to treat pain in sickle cell disease

R01MH111447 (Co-PI: Ugurbil) 09/01/2016 – 08/31/2021 1.80 Calendar Months
NIH $699,938

Neurons, Vessels and Voxels: Multi-modal Imaging of Layer Specific Signals

This BRAIN initiative R01 award supports multi-photon optical and MR imaging research on the spatial scale of neurovascular coupling in the living brain across imaging modalities using an animal model system and human subjects.

R24 MH108315 (PI: Ugurbil) 06/01/2015 – 05/31/2020 0.12 Calendar Months
NIH $124,079

Connectome Coordination Facility

The CMRR will provide image acquisition and reconstruction software, and consultation and support services to the research community for the primary purpose of harmonizing image acquisition protocols with those of the Human Connectome Project (HCP).

UO1AG052564 (Co-PI: Ugurbil) 03/01/2016 – 02/28/2020 1.20 Calendar Months
NIH (Sub To Washington Univ) $242,434

Mapping the Human Connectome During Healthy Aging

The CMRR will optimize imaging protocols in year 1 (starting from existing lifespan protocols) to be used for scanning healthy adult and elderly subjects in years 2-4. By the end of year 4, 300 subjects (75 of whom will be followed longitudinally) would have been scanned at the CMRR on a 3T Prisma.

UO1MH109589 (PI: Yacoub) 03/01/2016 – 02/28/2020 0.48 Calendar Months
NIH (Sub to Wash U) (Co-Inv: Ugurbil) $195,558

Mapping the Human Connectome during Typical Development

The CMRR will optimize imaging protocols in year 1 (starting from existing lifespan protocols) to be used for scanning young children and adults (Ages: 8-21) in years 2-4. By the end of year 4, 275 subjects would have been scanned at the CMRR on a 3T Prisma.

UO1 MH110274 (Sub PI: Elison) 09/01/2016 – 05/31/2020 1.20 Calendar Months
NIH (Co-PI: Ugurbil) $1,166,765

UNC/UMN Baby Connectome Project

A total of 500 typically developing children between birth and five years of age will be imaged using novel image acquisition and analysis tools capable of providing quantitative measures of early brain development and a publically available dataset.

P30 NS076408 (PI: Ugurbil) 09/30/2012 – 06/30/2017 0.60 Calendar Months
NIH $379,074

Institutional Center Cores for Advanced Neuroimaging

The general aim of this proposal is to establish NINDS Institutional Center Core facilities for biomedical imaging, so as to maximize utilization and impact of advance neuroimaging capabilities on a large number of NINDS funded research projects on normal brain function and neurological disorders.

R24 MH106049 (PI: Chen) 09/26/2014 – 06/30/2017 0.12 Calendar Months
NIH (Co-Inv: Ugurbil) $376,313

Advancing MRI & MRS Technologies for Studying Human Brain Function and Energetics

This project research aims to develop a novel engineering solution for overcoming the current technical barriers and significantly reinvigorate MRI and in vivo MRS imaging technologies at ultrahigh field towards addressing challenging neuroscience questions on brain physiology and function.

R01MH111413 (PI: Chen) 09/01/2016 – 08/31/2021 0.36 Calendar Months
NIH (Co-Inv: Ugurbil) $600,545

Integrated fMRI Methods to Study Neurophysiology and Circuit Dynamics at Laminar and Columnar Level

The proposed research will overcome the current technical barriers to reinvigorate multimodal electrophysiology and fMRI technologies at ultrahigh field and elucidate electrophysiology basis and neural correlate of fMRI BOLD signal at mesoscopic scale.