

## Kenneth W. Horch

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### **Education**

Lehigh University	College of Engineering	B.S. (1965)
Yale University	Department of Biology	M.Phil. (1968)
Yale University	Department of Biology	Ph.D. (1971)

### **Scholastic honor societies**

Eta Kappa Nu (Electrical Engineering)	Pi Mu Epsilon (Mathematics)
Tau Beta Pi (Engineering)	

### **Former memberships**

AAAS	American Society for Engineering Education
American Society for Peripheral Nerve	Biomedical Engineering Society
International Functional Electrical Stimulation Society	New York Academy of Sciences
Society for Neuroscience	Sunderland Society (Nerve Repair)

### **Current memberships**

American Institute for Medical and Biological Engineering (fellow)	
IEEE – EMBS (senior member)	Sigma Xi

### **Professional experience**

2007-present	Adjunct Professor, Dept. Mechanical Engineering, Univ. Utah
2006-present	Professor Emeritus, Dept. Bioengineering, Univ. Utah
2005-present	Research Professor, Center for Adaptive Neural Systems, ASU
1998-2000	coChair, Dept. Bioengineering, Univ. Utah
1994-2007	Agent, Ztech L.C.
1993-2006	Professor, Dept. Physiology, Univ. Utah
1992-2006	Professor, Dept. Bioengineering, Univ. Utah
1991-1998	Associate Chair, Dept. Bioengineering, Univ. Utah
1986-1992	Associate Professor, Dept. Bioengineering, Univ. Utah
1986-1993	Director of Neurological Testing, Topical Testing, Inc.
1986	Visiting Professor, Laboratoire de Biologie Animale, Université Scientifique, Technologique & Médicale de Grenoble, France.
1981-1993	Associate Professor, Dept. Physiology, Univ. Utah
1976-1981	Assistant Professor, Dept. Physiology, Univ. Utah
1973-1975	Research Instructor, Dept. Physiology, Univ. Utah
1971-1974	NIH Postdoctoral Fellow, Dept. Physiology, Univ. Utah
1970-1971	Instructor, Dept. Biological Sciences, Purdue Univ.
1970	Instructor, Catalina Marine Laboratory

## TEACHING

### *Courses currently taught*

N/A

### *Course/lab development*

BIOEN 515, 516 and 517, BIOEN 555, BIOEN 557, BIOEN 655, BIOEN 2000, BIOEN 3801 and 3802, BIOEN 5460, BIOEN 6010, BIOEN 6020, BIOEN 6080 and PHYSL 691 are courses which I created and/or developed. I created BIOEN 562-563, BIOEN 565, BIOEN 595-4, BIOEN 4201 and 4202, BIOEN 6000, and BIOEN 6060 in collaboration with other faculty members. The structure and content of BIOEN 601 was changed significantly when I assumed responsibility for teaching it.

The Physiology Tutoring and Testing educational software I developed was available commercially through Slice of Life®. It is now freely available on the net (<http://medstat.med.utah.edu/kwh>).

### *Other teaching activities of note*

I taught undergraduate courses in invertebrate physiology at the Catalina Marine Lab and at Purdue University. In the early 1980s Suzanne Stensaas (followed later by Tom Parks) from the Department of Anatomy, Ray Kesner from Psychology, and I developed and taught an undergraduate Honors Course in Neuroscience.

I taught part of the sensory neurophysiology section of the Medical Physiology course (PHYSL 602/603) for over 15 years. The medical school curriculum was revised, so this course is no longer offered.

In 1987 I received a John R. Park Teacher's Fellowship. Activities supported by this grant led to my being placed on the Board of Directors of the IMPACT Consortium, a collection of representatives from Physiology Departments of seven major midwestern medical schools interested in improving the teaching of medical physiology. As a member of that consortium, I developed and wrote software for PC-based self tutoring and testing in physiology (and other subjects). The other members of the consortium contributed and edited a large data base of medical physiology test questions and learning responses keyed to the questions. With subsequent financial support from the Educational Computing Committee of the University of Utah School of Medicine, I was able to develop this software and the data base into a commercially marketable system, which is now distributed by Slice of Life (based at Eccles Library). The Web-based version of this program, which I have recently developed, is available on my Web site.

### *Graduate students supervised*

Mark Malagodi, M.S., 1987 *Dr. Andy Schoenberg was Mark's Committee Chairman, but Mark worked in my lab under my direct supervision (see thesis).*

Nicola Nannini, M.S., 1989.

Todd LeFurge, M.S., 1990.

Eleanor Goodall, Ph.D., 1991.

Kichul Cha, Ph.D., 1991.

Susan Schmidt, M.S., 1993.

Ken Yoshida, Ph.D., 1994.

Kashayar Mirfakhraei, Ph.D., 1995.

Vivian Mushawar, Ph.D., 1996.

James Malmstrom, M.S., 1997.

Tim McNaughton, Ph.D., 1998.

James Biggs, Ph.D., 1999.

Steve Lawrence, Ph.D., 2003.

Eric Taday, M.S., 2004.

Sean Snow, Ph.D., 2005.

Ken Olree, Ph.D., 2007.

Gurpreet Dhillon, Ph.D. candidate.

### *Graduate student supervisory committee membership (partial list)*

Michael Parker, Ph.D., 1979, Physical Education.

Jeffrey Schall, Ph.D., 1986, Anatomy.

Stacey Levine, Ph.D., 1986, Nursing.

Jen Yu Wei, Ph.D., 1987, Physiology.

Thomas Giannulli, M.S., 1988, Bioengineering.

Sreekumar Madhavan, M.E., 1989, Bioengineering.

Patrick Campbell, Ph.D., 1990, Bioengineering.  
 Walter Adams, M.S., 1992, Computer Science.  
 William Cimino, Ph.D., 1992, Bioengineering.  
 David Wells, Ph.D., 1993, Bioengineering.  
 Jeff Kendell, M.E., 1993, Bioengineering  
 Anita Bagley, Ph.D., 1994, Bioengineering.  
 Peter Budnick, Ph.D., 1994, Mechanical Engineering.  
 Richard Sailors, M.E., 1994, Bioengineering.  
 Scott Ward, Ph.D., 1994, Physiology.  
 Anne Smith, Ph.D., 1994, Bioengineering.  
 Jeff Burnham, Ph.D., 1995, Physiology.  
 Kelly Jones, Ph.D., 1995, Bioengineering.  
 Timothy Egbert, Ph.D., 1995, Bioengineering.  
 Craig Nordhausen, Ph.D., 1995, Bioengineering.  
 Nick Wilder, M.S., 1995, Bioengineering.  
 Patrick Rousche, Ph.D., 1996, Bioengineering.  
 Dan Paine, Ph.D., 1998, Bioengineering.  
 Deniz Yazar, M.S., 1998, Bioengineering.  
 Brenda Farmer, Ph.D., 2002, Bioengineering.  
 Gillian Brest Van Kempen, M.E., 2003, Bioengineering.  
 Rose Mills, M.S., 2004, Bioengineering.  
 Farrant Sakaguchi, M.S, 2004, Bioengineering.  
 Richard Blomquist, M.E., 2005, Bioengineering.  
 Pratap Khanwilkar, Ph.D., 2005, Bioengineering.  
 David Warren, Ph.D., 2006, Bioengineering.  
 Nishant Gopalakrishnan, Ph.D., 2006, Bioengineering.  
 Suhrud Rajguru, Ph.D., 2006, Bioengineering.  
 Shane Guillory, Ph.D. candidate, Bioengineering.  
 Erik Engeberg, Ph. D., 2008, Mechanical Engineering.

Excluded from the list are students who have not yet had a committee meeting, and who are on leave or who have left the University without receiving a terminal degree. Also excluded are the graduate student committees I served on as an *ex officio* member during my tenure as Director of Graduate Studies for the Department of Physiology.

#### ***Other student supervision***

I have supervised several undergraduate or beginning graduate student projects and research activities. In the following cases these led to publications with the students listed as co-authors:

Nate Coonrod  
 Wendell Gibby  
 Russ Griffiths  
 Clark Lybbert

#### ***Postdoctoral and visiting scholars***

Stephen Lisney, Ph.D., Bristol University, England  
 Rick Koerber, Ph.D., University of West Virginia  
 Bern Boyett, M.D., Louisiana State University  
 Jun-qiang Chen, Shanghai Institute of Physiology, PRC  
 Wei Guo, China Medical University, Shenyang, PRC  
 Rihui Xi, Shanghai University of Science & Technology  
 Zhenmin Zhou, Ph.D., University of Utah  
 Didier Guinard, M.D., Centre Hospitalier Universitaire de Grenoble, France  
 Thilo Krüger, University of Stuttgart, Germany

## RESEARCH AND SCHOLARSHIP

As a graduate student I was supported by NDEA Title IV and NSF predoctoral fellowships.

As a member of the Department of Physiology, I was responsible for supporting myself from research grants.

During that time I was Principal Investigator on grants from NSF, NIH and the National Geographic Society, and was PI on one of the projects of the Department's Program Project Grant. In addition, I have received support from the University of Utah's Biomedical Research Support Grant, the University of Utah Research Committee, the University of Utah Research Corporation, and have conducted contract research for a local biomedical firm (Research Industries).

### *Current extramural grant support:*

NIH: R01 EB 008578, "Neural-Enabled Prosthesis with Sensorimotor Integration." PI: R. Jung.

Role: co-Investigator. Effort: 12%. Annual direct cost: \$463,999. Dates: 04/01/07-03/31/12.

Topic: Development of a totally implanted neural interface for a prosthetic limb.

NSF: BES-0457193, "Towards a Neuroprosthetic Hand." PI :Kenneth Horch.

Role: PI. Effort: 12.5%. Total cost: \$299,911. Dates: 06/01/05-05/31/09.

Topic: Design and construction of a prototype artificial hand to be interfaced directly with an amputee's nerve stumps.

### *Submitted*

NIH: "Promoting Plasticity after Spinal Cord Injury using Neuromuscular Stimulation." PI: R. Jung.

Role: co-Investigator. Effort: 8%. Total direct cost: \$1,000,000. Dates: 04/01/2008-03/31/2012.

### *Previous extramural grant support*

NSF:GB42643/BNS7404826	1974-76	\$40,900	PI
Specificity in regenerating mammalian sensory neurons			
NGS:1715	1976	\$2300	PI
Central processing of acoustic signals by the ghost crab <i>Ocypode</i>			
NIH:R01 NS13283	1977-1979	\$110,960	PI
Specificity in regenerating sensory neurons			
NSF:BNS7916565	1979-84	\$143,430	PI
Specificity in regenerating mammalian sensory neurons			
NIH:?	197?-85	?	Individual Project PI
(Department of Physiology Program Project Grant)			
NIH:R43 NS23656	1986	\$50,000	PI
Automated testing for neurological deficits			
NIH:F32 NS07648	1986-88	\$56,000	Sponsor
NRSA for Dr. Bern Boyett			
NIHR:G008635199	1986-89	\$195,200	coPI
Long term extraction of somatosensory information from peripheral nerves for neural prosthesis applications			
NIH:R43 NS26957	1988-89	\$50,000	PI
Automated evaluation of neurological function			
NSF:EET880885	1989-91	\$358,900	coInvestigator
A silicon based, three dimensional microsystem for stimulation of the visual cortex			
Keck Foundation:881023	1988-91	\$130,000	coDirector
Support for a vision prosthesis research program in the College of Engineering			
NSF:BNS9016288	1990-92	\$30,000	coPI
Recording of neural activity from sensory cortex using silicon based, three dimensional electrode arrays			
NSF:BCS9221313	1992	\$5,000	PI
Perspectives and opportunities in bioengineering			
NIDRR:H133G90031	1989-1993	\$259,000	coInvestigator
Recruitment Properties of Intraneural Electrodes			
NIH:R01 NS27371-01	1989-1993	\$187,652	PI
Information Extraction from Peripheral Nerves			
NSF:BCS9110767	1991-1994	\$260,000	coInvestigator
A Silicon Based, Three Dimensional Microsystem for Stimulation of the Visual Cortex			
Keck Foundation:	1994-1997	\$380,000	coDirector

Visual Prosthesis Program - Phase II				
NIH, 1R01 NS27371-04	1993-1998	\$446,458		PI
Information Extraction from Peripheral Nerves				
NSF, BES-9709654	1997-2000	\$141,858		PI
Finger Proprioception				
NIH, 2R01 NS27371-08	1998-2003	\$853,752		PI
Neural Control of Prosthetic Devices				
NSF, EED-0080452	2000-2003	\$399,822		coPI
Development of an Accelerated Dual BS/MS Program in Bioengineering				

### ***Research interests***

Broadly speaking, my research interests lie in the area of how the nervous system processes information and controls behavior. The main thrust of the work in my lab at present centers around neuroprosthetics - development of devices and methods for restoring or replacing nervous system function in handicapped individuals. The current focus of my work in this area is to develop an interface between the nervous system and prosthetic arms. This work is being supported by funds from NSF.

In addition, I am engaged in an attempt to use magnetic fields to block peripheral nerves. If successful, this system would have various clinical uses such as in treatment of children with cerebral palsy and in hand surgery.

### ***Extramural support abstracts***

Neuroprosthetic Hand: The overall goal of this project is to develop a Neuroprosthetic Arm: an artificial arm that is controlled by motor commands from nerve fibers (or residual muscles) in the amputee's stump that had originally performed the action desired, and that provides distally referred tactile and proprioceptive sensory feedback by stimulation of sensory nerve fibers in the stump. The potential of neural control and feedback from a prosthesis is that it provides the most natural control for the amputee, with minimal training and conscience effort in using the prosthesis. As a significant step towards this goal, based on already completed work in animal models and human amputees, we propose to do the following.

1. Design and construct a prosthetic hand (gripper) with a sensory system that allows proportional control of position, velocity, and force, and that includes sensors for providing feedback about these two parameters.
2. Analyze existing recordings made from human amputee nerve stumps in the course of the subjects attempting to move or control the position of a phantom joint and, from this analysis, develop appropriate control algorithms to be used with the new artificial hand that will provide for "natural" responses of the gripper to such control signals. The algorithms will include the ability to use either single or dual (antagonistic) control signals from the amputee, and, uniquely, to provide position, velocity and force feedback signals to the amputee.
3. Test and evaluate the new gripper using human, lower arm amputees in which control signals will be obtained from electromyographic (EMG) recordings from residual flexor and extensor muscles in the lower arm stump, and in which sensory feedback will be provided by intraneural stimulation of tactile and proprioceptive sensory fibers in the median nerve.

Although directed towards development of a Neuroprosthetic Arm, this work will also have direct applicability to other man-machine neural interfaces. The work will be conducted in two associated labs, the Neuroprosthetics Lab in the Department of Bioengineering, University of Utah (Horch) and the Mechatronics Lab in the Mechanical Engineering Department, University of Utah (Meek). A leading manufacturer of electromyographically controlled artificial arms, Motion Control, Inc., will provide the new generation gripper.

### **Publications**

I have not kept, nor can I readily generate, a list of all the abstracts, extended (two page) abstracts, and review articles I have published. Therefore none of them are listed here. My estimate is that the number of abstracts, extended abstracts and reviews would bring my complete list of publications to over 175 items.

- Waterman, TH & KW Horch (1966) "Mechanisms of polarized light perception." *Science* 154:467-475.
- Horch, KW & M Salmon (1969) "Production, perception and reception of acoustic stimuli by semiterrestrial crabs." *Forma et Functio* 1:1-25.
- Horch, K (1971) "An organ for hearing and vibration sense in the ghost crab *Ocypode*." *Z. vergl. Physiol.* 73:1-21.
- Horch, K & M Salmon (1972) "Responses of the ghost crab, *Ocypode*, to acoustic stimuli." *Z. Tierpsychol.* 30:1-13.
- Salmon, M & K Horch (1972) "Acoustic signalling and detection by semiterrestrial crabs of the Family Ocypodidae." In: *Behavior of Marine Animals*, v. 1 (HE Winn & B Olla, eds.) Plenum Press, New York. pp. 60-96.
- Forward, RB, KW Horch & TH Waterman (1972) "Visual orientation at the water surface by the teleost *Zenarchopterus*." *Biol. Bull.* 143:112-126.
- Salmon, M & K Horch (1973) "Vibration reception by the fiddler crab, *Uca minax*." *Comp. Biochem. Physiol.* 44A:527-541.
- Burgess, PR & KW Horch (1973) "Specific regeneration of cutaneous sensory fibers in the cat." *J. Neurophysiol.* 36:101-114.
- Horch, K & M Salmon (1973) "Adaptations to the acoustic environment by the squirrelfishes *Myripristis violaceus* and *M. pralinus*." *Marine Behav. Physiol.* 2:121-139.
- Burgess, PR, KB English, KW Horch & LJ Stensaas (1974) "Patterning in the regeneration of Type I cutaneous receptors." *J. Physiol.* 236:57-82.
- Horch, KW, D Whitehorn & PR Burgess (1974) "Impulse generation in Type I cutaneous mechanoreceptors." *J. Neurophysiol.* 37:267-281.
- Horch, K (1974) "Barth's myochordotonal organ as an acoustic sensor in the ghost crab, *Ocypode*." *Experientia* 30:630-631.
- Horch, K (1975) "The acoustic behavior of the ghost crab *Ocypode cordimana* Latreille, 1818 (Decapoda, Brachyura)." *Crustaceana* 29:193-205.
- Horch, KW & PR Burgess (1975) "Effect of activation and adaptation on the sensitivity of slowly adapting cutaneous mechanoreceptors." *Brain Res.* 98:109-118.
- Horch, KW, FJ Clark & PR Burgess (1975) "Awareness of knee joint angle under static conditions." *J. Neurophysiol.* 38:1436-1447.
- Horch, KW & PR Burgess (1976) "Responses to threshold and suprathreshold stimuli by slowly adapting cutaneous mechanoreceptors in the cat." *J. Comp. Physiol.* 110:307-315.
- Horch, KW, PR Burgess & D Whitehorn (1976) "Ascending collaterals of cutaneous neurons in the fasciculus gracilis of the cat." *Brain Res.* 117:1-17.
- Horch, KW (1976) "Ascending collaterals of cutaneous neurons in the fasciculus gracilis of the cat during peripheral nerve regeneration." *Brain Res.* 117:19-32.
- Salmon, M & K Horch (1976) "Acoustic interneurons of fiddler and ghost crabs." *Physiol. Zool.* 49:214-226.
- Salmon, M, K Horch & GW Hyatt (1977) "Barth's myochordotonal organ as a receptor for auditory and vibrational stimuli in fiddler crabs (*Uca pugilator* and *U. minax*)." *Marine Behav. Physiol.* 4:187-194.
- Horch, KW, RP Tuckett & PR Burgess (1977) "A key to the classification of cutaneous mechanoreceptors." *J. Invest. Dermatol.* 69:75-82.
- Tuckett, RP, KW Horch & PR Burgess (1978) "Response of cutaneous hair and field mechanoreceptors in the cat to threshold stimuli." *J. Neurophysiol.* 41:138-149.
- Burgess, PR & KW Horch (1978) "The distinction between the short and intermediate ascending pathways in the fasciculus gracilis of the cat." *Brain Res.* 151:579-580.
- Horch, K (1978) "Central responses of cutaneous sensory neurons to peripheral nerve crush in the cat." *Brain Res.* 151:581-586.
- Clark, FJ, KW Horch, SM Bach & GF Larson (1979) "Contributions of cutaneous and joint receptors to static knee-position sense in man." *J. Neurophysiol.* 42:877-888.
- Horch, K (1979) "Guidance of regrowing sensory axons after cutaneous nerve lesions in the cat." *J. Neurophysiol.* 42:1437-1449.

- Horch, KW & PR Burgess (1980) "Functional specificity and somatotopic organization during peripheral nerve regeneration." In: Nerve Repair and Regeneration: Its Clinical and Experimental Basis. (D Jewett & HR McCarroll, Jr, eds.) Mosby, St. Louis. pp. 105-109.
- Horch, K, M Salmon & N Coonrod (1980) "Responses of acoustic interneurons in ghost and fiddler crabs to sounds of conspecifics and sympatric heterospecifics." *Marine Biology Letters* 1:167-173.
- Horch, KW & SJW Lisney (1981) "On the number and nature of regenerating myelinated axons after lesions of cutaneous nerves in the cat." *J. Physiol.* 313:275-286.
- Horch, KW & SJW Lisney (1981) "Changes in primary afferent depolarization of sensory neurones during peripheral nerve regeneration in the cat." *J. Physiol.* 313:287-299.
- Horch, K (1981) "Absence of functional collateral sprouting of mechanoreceptor axons into denervated areas of mammalian skin." *Exp. Neurol.* 74:313-317.
- Horch, K (1982) "The microcomputer and the electrophysiologist." *J. Electrophysiol. Tech.* 9:71-87.
- Horch, K (1982) "The influence of mechanoreceptor structures on regenerating sensory axons after cutaneous nerve transection in the cat." *Neurosci. Lett.* 32:281-284.
- Gibby, WA, HR Koerber & KW Horch (1983) "A quantitative evaluation of suture and tubulization nerve repair techniques." *J. Neurosurg.* 58:574-579.
- Burgess, PR, KW Horch & RP Tuckett (1983) "Boring's formulation: a scheme for identifying functional neuron groups in a sensory system." *Federation Proc.* 42:2521-2527.
- Burgess, PR, J Mei, RP Tuckett, KW Horch, CM Ballinger & DA Poulos (1983) "The neural signal for skin indentation depth. I. Changing indentations." *J. Neurosci.* 3:1572-1585.
- English, KB, D Kavka-van Norman & K Horch (1983) "Effects of chronic denervation in type I cutaneous mechanoreceptors (Haarscheiben)." *Anat. Rec.* 207:79-88.
- Mei, J, RP Tuckett, DA Poulos, KW Horch, JY Wei & PR Burgess (1983) "The neural signal for skin indentation depth. II. Steady indentations." *J. Neurosci.* 3:2652-2659.
- Burgess, PR, RP Tuckett & KW Horch (1984) "Topographic and non-topographic mapping of spatial sensory information. Predictions from Boring's formulation." In: Comparative Physiology of Sensory Systems. (L Bolis, RD Keynes & SHP Maddrell, eds.) Cambridge Univ. Press, London. pp. 611-621.
- Poulos, DA, J Mei, KW Horch, RP Tuckett, JY Wei, MC Cornwall & PR Burgess (1984) "The neural signal for the intensity of a tactile stimulus." *J. Neurosci.* 4:2016-2024.
- English, KB, KW Horch, D Kavka-Van Norman & PR Burgess (1984) "Neurotrophic influences on cutaneous type I mechanoreceptors." In: Sensory Receptor Mechanisms. (W Hamann & A Iggo, eds.) World Scientific, Singapore. pp. 36-45.
- Horch, K (1984) "Specificity in regenerating cutaneous nerves." In: Sensory Receptor Mechanisms. (W Hamann & A Iggo, eds.) World Scientific, Singapore. pp. 47-55.
- Horch, KW, RP Tuckett & PR Burgess (1984) "Rapid displacements of the skin lack clear positional information." *Brain Res.* 309:382-383.
- Horch, K (1985) "Somatosensory function after peripheral nerve regeneration." In: Development, Organization and Processing in Somatosensory Pathways. (M Rowe & WD Willis, Jr, eds.) Neurology and Neurobiology 14:13-21. Alan R. Liss, New York.
- Koerber, HR & KW Horch (1985) "Axonotmesis as treatment for neurotmesis." *Exp. Neurol.* 88:316-326.
- Horch, K (1985) "Introduction to microcomputers: The Cromemco System Three." *J. Electrophysiol. Tech.* 12:209-248.
- Horch, KW & PR Burgess (1985) "Long term adaptation of cutaneous type I and type II mechanoreceptors in the cat." *Chinese J. Physiol. Sci.* 1:54-62.
- Clark, FJ & KW Horch (1986) "Kinesthesia." In: Handbook of Perception and Human Performance v.1 Sensory Processes and Perception. (KR Boff, L Kaufman & JP Thomas, eds.) Wiley, New York. pp. 13-1 - 13-62.
- Burgess, PR, KW Horch & RP Tuckett (1987) "Mechanoreceptors." In: Encyclopedia of Neuroscience. (G Adelman, ed.) Birkhauser Boston, Cambridge, MA. pp. 620-621. Updated 1999 in: Encyclopedia of Neuroscience, 2<sup>nd</sup> edition. (G Adelman & BH Smith, eds.) Elsevier pp. 1121-1123.
- Stensaas, LJ, LM Partlow, PR Burgess & KW Horch (1987) "Inhibition of regeneration: the ultrastructure of reactive astrocytes and abortive axon terminals in the transition zone of the dorsal root." *Prog. Brain Res.* 71:457-468.
- Schoenberg, AA, M Malagodi & K Horch (1987) "Extraction of somatosensory information from peripheral nerves for FNS applications." In: Advances in External Control of Human Extremities IX. (D Popovic, ed.) Proceedings of the IX International Symposium on External Control of Human Extremities. Yugoslav Committee for ETAN, Belgrade. pp. 363-373.

- Horch, K (1988) "Neurospecificity following sensory nerve regeneration." In: The Current Status of Peripheral Nerve Regeneration. (T Gordon, RB Stein, & PA Smith, eds.) Neurology and Neurobiology 38:269-273. Alan R. Liss, New York.
- Malagodi, M, KW Horch & AA Schoenberg (1989) "An intrafascicular electrode for recording of action potentials in peripheral nerves." Ann. Biomed. Eng. 17:397-410.
- Campbell, PK, RA Normann, KW Horch & SS Stensaas (1989) "A chronic intracortical electrode array: Preliminary results." J. Biomed. Mater. Res.: Applied Biomaterials 23:245-259.
- Griffiths, RH, KW Horch & LJ Stensaas (1989) "Method of forming fibrin-collagen nerve and body tissue repair material." U.S. Patent 4,863,668.
- Griffiths, R, K Horch & L Stensaas (1990) "A collagen and fibrin tube for nerve repair." Rest. Neurol. Neurosci. 1:339-346.
- Schoenberg, AA, T Lefurge, E Goodall & K Horch (1990) "Long term recording of action potentials in peripheral nerves using intrafascicular electrodes." In: Advances in External Control of Human Extremities X. (DB Popovic, ed.) Nauka, Belgrade. pp. 299-306.
- Lefurge, T, E Goodall, K Horch, L Stensaas & A Schoenberg (1991) "Chronically implanted intrafascicular recording electrodes." Ann. Biomed. Eng. 19:197-207.
- Horch, KW (1991) "Coding of vibrotactile stimulus frequency by Pacinian corpuscle afferents." J. Acoust. Soc. Amer. 89:2827-2836.
- Horch, KW, JH Fisher & BL Evans (1991) "Apparatus and method for automated tactile testing." U.S. Patent 5,022,407.
- Campbell, PK, KE Jones, RJ Huber, KW Horch & RA Normann (1991) "A silicon-based three-dimensional neural interface: manufacturing processes for an intracortical electrode array." IEEE Trans. Biomed. Eng. 38:758-768.
- Nannini, N & K Horch (1991) "Muscle recruitment with intrafascicular electrodes." IEEE Trans. Biomed. Eng. 38:769-776.
- Goodall, EV, TM Lefurge & KW Horch (1991) "Information contained in sensory nerve recordings made with intrafascicular electrodes." IEEE Trans. Biomed. Eng. 38:846-850.
- Goodall, EV & KW Horch (1992) "Separation of action potentials in multi-unit intrafascicular recordings." IEEE Trans. Biomed. Eng. 39:289-295.
- Cha, K, K Horch, RA Normann & DK Boman (1992) "Reading speed with a pixelized vision system." J. Opt. Soc. Amer. A 9:673-677.
- Cha, K, KW Horch & RA Normann (1992) "Mobility performance with a pixelized vision system." Vision Res. 32:1367-1372.
- Cha, K, K Horch & RA Normann (1992) "Simulation of a phosphene based visual field: visual acuity in a pixelized vision system." Ann. Biomed. Eng. 20:439-449.
- Horch, K, M Hardy, S Jimenez & M Jabaley (1992) "An automated tactile tester for evaluation of cutaneous sensibility." J. Hand Surg. 17A:829-837.
- Hardy, M, S Jimenez, M Jabaley & K Horch (1992) "Evaluation of nerve compression with the automated tactile tester." J. Hand Surg. 17A:838-842.
- Goodall, EV, KW Horch, TG McNaughton & CM Lybbert (1993) "Analysis of single-unit firing patterns in multi-unit intrafascicular recordings." Med. & Biol. Eng. & Comp. 31:257-267.
- Jimenez, S, MA Hardy, K Horch & M Jabaley (1993) "A study of sensory recovery following carpal tunnel release." J. Hand Therapy 6:124-129.
- Yoshida, K & K Horch (1993) "Selective stimulation of peripheral nerve fibers using dual intrafascicular electrodes." IEEE Trans. Biomed. Eng. 40:492-494.
- Schmidt, S, K Horch & R Normann (1993) "Biocompatibility of silicon-based electrode arrays implanted in feline cortical tissue." J. Biomed. Mater. Res. 27:1393-1399.
- Yoshida, K & K Horch (1993) "Reduced fatigue in electrically stimulated muscle using dual channel intrafascicular electrodes with interleaved stimulation." Ann. Biomed. Eng. 21:709-714.
- Mirfakhraei, K & K Horch (1994) "Classification of action potentials in multi-unit intrafascicular recordings using neural network pattern recognition techniques." IEEE Trans. Biomed. Eng. 41:89-91.
- McNaughton, T & K Horch (1994) "Action potential classification with dual channel intrafascicular electrodes." IEEE Trans. Biomed. Eng. 41:609-616.
- Cha, K & KW Horch (1994) "Method and apparatus for determining body composition using bioelectrical impedance." U.S. Patent 5,335,667.



- Normann, RA, PJ Rousche, KW Horch & SP Schmidt (1994) "Impact inserter mechanism for implantation of a biomedical device." U.S. Patent 5,361,760.
- Mortimer, JT, WF Agnew, K Horch, P Citron, G Creasey & C Kantor (1995) "Perspectives on new electrode technology for stimulating peripheral nerves with implantable motor prostheses." *IEEE Trans. Rehab. Eng.* 3:145-154.
- Yoshida, K & K Horch (1996) "Closed-loop control of ankle position using muscle afferent feedback with functional neuromuscular stimulation." *IEEE Trans. Biomed. Eng.* 43:167-176.
- McNaughton, TG & Horch, KW (1996) "Metallized polymer fibers as leadwires and intrafascicular microelectrodes." *J. Neurosci. Methods* 70:103-110.
- Mirfakhraei, K & K Horch (1997) "Recognition of temporally changing action potentials in multi-unit neural recordings." *IEEE Trans. Biomed. Eng.* 44:123-131.
- Mushahwar, VK & KW Horch (1997) "Proposed specifications for a lumbar spinal cord electrode array for control of lower extremities in paraplegia." *IEEE Trans. Rehab. Eng.* 15:237-243.
- Fisher, JH, BL Evans & KW Horch (1997) "Apparatus and method for automated determination of low frequency tactile thresholds." U.S. Patent 5,673,703.
- Malmstrom, JA, TG McNaughton & KW Horch (1998) "Recording properties and biocompatibility of chronically implanted polymer-based intrafascicular electrodes." *Ann. Biomed. Eng.* 26:1055-1064.
- Fisher, JH, BL Evans & KW Horch (1998) "Hybrid electronic and electromechanical device for the production of tremulant sound." U.S. Patent 5,848,166.
- Biggs, J, K Horch & FJ Clark (1999) "Extrinsic muscles of the hand signal finger tip location more precisely than they signal the angles of individual finger joints." *Exp. Brain Res.* 125:221-230.
- Biggs, J & K Horch (1999) "Biomechanical model predicts directional tuning of spindles in finger muscles facilitates precision pinch and power grasp." *Somatosens Mot Res* 16:251-262.
- Biggs, J & K Horch (1999) "A three-dimensional kinematic model of the human long finger and the muscles that actuate it." *Med. Eng. Phys.* 21:625-639.
- Mushahwar, VK & KW Horch (2000) "Selective activation of muscle groups in the feline hindlimb through electrical microstimulation of the ventral lumbo-sacral spinal cord." *IEEE Trans. Rehab. Eng.* 8:11-21.
- Mushahwar, VK & KW Horch (2000) "Muscle recruitment through electrical stimulation of the lumbo-sacral spinal cord." *IEEE Trans. Rehab. Eng.* 8:22-29.
- Popper, AN, M Salmon & KW Horch (2001) "Acoustic detection and communication by decapod crustaceans." *J. Comp. Physiol. A* 187:83-89.
- Biggs, J, K Cha & K Horch (2001) "Electrical resistivity of the upper arm and leg yields good estimates of whole body fat." *Physiol. Meas.* 22:365-376.
- Lawrence, SM, JO Larsen, KW Horch, R Riso & T Sinkjær (2002) "Long-term biocompatibility of implanted polymer-based intrafascicular electrodes." *J. Biomed. Mat. Res.* 63:501-506.
- Horch, K, M Salmon & R Forward (2002) "Evidence for a two pigment visual system in the fiddler crab, *Uca thayeri*." *J. Comp. Physiol. A* 188:493-499.
- Lawrence, SM, GS Dhillon & KW Horch (2003) "Fabrication and characteristics of an implantable, polymer-based, intrafascicular electrode." *J. Neurosci. Meth.* 131:9-26.
- Horch, KW & GS Dhillon, eds. (2004) Neuroprosthetics: Theory and Practice. World Scientific, New Jersey, xxv+1261 pp.
- Horch, KW & PR Burgess (2004) "Peripheral nervous system." In: Neuroprosthetics: Theory and Practice. (KW Horch & GS Dhillon, eds.) World Scientific, New Jersey. pp. 30-47.
- Mushahwar, VK, T Hanania, J Ingram, KE Jones, SK Patrick & KW Horch (2004) "Anatomy and physiology of the central nervous system." In: Neuroprosthetics: Theory and Practice. (KW Horch & GS Dhillon, eds.) World Scientific, New Jersey. pp. 48-136.
- Dhillon, GS & KW Horch (2003) "Autonomic nervous system." In: Neuroprosthetics: Theory and Practice. (KW Horch & GS Dhillon, eds.) World Scientific, New Jersey. pp. 137-157.
- Salmon, M, TT Jones & KW Horch (2004) "Ontogeny of diving and feeding behavior in juvenile seaturtles: Leatherback seaturtles (*Dermochelys coriacea* L) and green seaturtles (*Chelonia mydas* L) in the Florida current." *J. Herpetol.* 38:36-43.
- Dhillon, GS, SM Lawrence, DT Hutchinson & KW Horch (2004) "Residual function in peripheral nerve stumps of amputees: Implications for neural control of artificial limbs." *J. Hand Surg.* 29A:605-615.
- Lawrence, SM, GS Dhillon, W Jensen, K Yoshida & KW Horch (2004) "Acute peripheral nerve recording characteristics of polymer-based longitudinal intrafascicular electrodes." *IEEE Trans. Neural Sys. Rehab. Eng.* 12:345-348.

- Dhillon, GS, TB Krüger, JS Sandhu & KW Horch (2005) "Effects of short-term training on sensory and motor function in severed nerves of long-term human amputees." *J. Neurophysiol.* 93:2625-2633.
- Dhillon, GS & KW Horch (2005) "Direct neural sensory feedback and control of a prosthetic arm." *IEEE Trans. Neural Syst. Rehab. Eng.* 13:468-472.
- Snow, S, KW Horch & VK Mushahwar (2006) "Intraspinal microstimulation using cylindrical multielectrodes." *IEEE Trans. Biomed. Eng.* 53:311-319.
- Snow, S, SC Jacobsen, DL Wells & KW Horch (2006) "Microfabricated cylindrical multielectrodes for neural stimulation." *IEEE Trans. Biomed. Eng.* 53:320-326.
- Olree, KS & KW Horch (2006) "Differential activation and block of peripheral nerve fibers by magnetic fields." *Muscle Nerve* 34:189-196.
- Tuday, EC, KS Olree & KW Horch (2006) "Differential activation of nerve fibers with magnetic stimulation in humans." *BMC Neuroscience* 7:58-64.
- Olree, KS & KW Horch (2007) "Assessing the numerical accuracy of the impedance method." *Bioelectromagnetics* 28:454-462.
- Gwilliam, JC & K Horch (2008) "A charge-balanced pulse generator for nerve stimulation applications." *J. Neurosci. Methods* 168:146-150.
- Horch, KW, JP Gocke, M Salmon & RB Forward (2008) "Visual spectral sensitivity of hatchling loggerhead (*Caretta caretta* L.) and leatherback (*Dermochelys coriacea* L.) sea turtles, as determined by single-flash electroretinography." *Marine and Freshwater Behaviour and Physiology* 41:107-119.

### ***Invited presentations***

The following is a list of invited presentations I have made for which I have a written record. I have also been invited to speak to the American Society for Surgery of the Hand and at various universities here and abroad.

- "A key to the classification of cutaneous mechanoreceptors" (1976) Symposium on the Biology of Skin, Glendenen Beach, OR.
- "Schwann cells and axonal guidance" (1977) Peripheral Nerve Study Group, Airlie House, VA.
- "Functional specificity and somatotopic organization during peripheral nerve regeneration" (1977) Symposium on Nerve Repair and Regeneration, San Francisco, CA.
- "Axonotmesis as a therapy for neurotmesis" (1981) Peripheral Nerve Study Group, Shakertown, KY.
- "Guidance during regeneration in the vertebrate peripheral nervous system" (1983) International Society for Developmental Neuroscience, Salt Lake City, UT.
- "Somatosensory function after nerve regeneration" (1983) IUPS Satellite Symposium, Hunter Valley, Australia.
- "Specificity in regenerating peripheral nerves" (1983) Symposium on Sensory Receptor Mechanisms, Hong Kong.
- "Pacinian corpuscles and polyharmonic vibrations" (1985) Acoustical Society of America, Austin, TX.
- "Specific reinnervation of sensory receptor structures by regenerating peripheral nerve fibers" (1986) IUPS Satellite Symposium, Edmonton, Alberta, Canada.
- "History of the Automated Tactile Tester" (1989) Advances in Sensory Testing of Peripheral Nerves, Jackson, MS.
- "Determination of cutaneous sensory thresholds in the hand with an automated tactile tester" (1990) The Sunderland Society, Louisville, KY.
- "Nerve healing and types of nerve injury" (1990) A Problem-Oriented Approach to Peripheral Nerve Evaluation, Boston, MA.
- "Intrafascicular electrodes" (1991) Neural Prosthesis Workshop, Washington, DC.
- "Automated testing for evaluation of cutaneous sensitivity" (1992) Univ. Wien, Austria.
- "Longitudinal intrafascicular electrodes" (1993) Future Electrodes for Motor Prostheses, Case Western Reserve University, Cleveland, OH.
- "Intraneural and Intrafascicular Stimulation Systems" (1994) Neural Prostheses: Motor Systems IV, Mt. Sterling, OH.
- "New Recording and Stimulating Methods for FES" (1995) Functional Electrical Stimulation Mini-Symposium, EMBC95, Montréal, Qué.
- "Simulation of a Phosphene Based Visual Field: Psychophysics of Pixelized Vision" (1996) RESNA '96, Salt Lake City, UT.
- "Peripheral Nerves and Prosthetic Limbs" (1997) Yale University, New Haven, CT.

- “Microstimulation of Peripheral Nerve with Intrafascicular Electrodes” (1998) BMES, Cleveland, OH.
- “A Brain’s Eye View of the Finger” (1999) Aalborg University, Denmark.
- “Beyond Myoelectric Control” (2000) ISEK 2000, Sapporo, Japan.
- “Building the Bionic Man” (2002) 3<sup>rd</sup> Alberta Biomedical Engineering Conference, Banff, Canada.
- “Neuroprosthetics: Controlling the Bionic Man” (2003) Frontiers in Science lecture, Florida Atlantic University, Boca Raton, FL.
- “Direct Neural Sensory Feedback and Control for a Prosthetic Arm” (2005) Advanced Prosthetics Workshop, Ellicott City, MD.
- “PNS-based control of artificial limbs” (2007) Neurobotics Summer School 2007, Volterra, Italy.

## SERVICE

### *Intramural*

Department of Physiology Director of Computer Facilities  
 Department of Physiology Director of Graduate Studies  
 Department of Bioengineering Graduate Admissions Committee (chairman)  
 Department of Bioengineering Retention, Promotions and Tenure Committee (chair)  
 Department of Bioengineering Undergraduate Major Advisor  
 Department of Bioengineering Undergraduate Program Director  
 College of Engineering Academic Appeals Chair  
 College of Engineering Dean's Advisory Committee  
 College of Engineering Presidential Fellowship Committee  
 College of Engineering RPT Committee  
 University of Utah Academic Freedom and Tenure Committee (vice chair)  
 University of Utah Faculty Hearing Committee  
 University of Utah Academic Senate  
 University of Utah Academic Senate Executive Committee  
 University of Utah Institutional Animal Care and Use Committee  
 University of Utah Institutional Review Board (chairman)  
 University of Utah Neuroscience Steering Committee  
 University of Utah Patent Advisory Committee  
 University of Utah Research Committee  
 University of Utah Chapter of Sigma Xi Secretary/Treasurer  
 University of Utah University Promotion and Tenure Advisory Committee  
 University of Utah Faculty Hearing Committee (chair)  
 University of Utah Undergraduate Council  
 University of Utah Personnel and Elections Committee

### *Extramural*

I am or have been a reviewer, study section member (including serving as chair), and consultant for NIH, NSF, NIDRR, FDA, VA, BIOSIS and several journals.

I was on the Board of Editors of the Journal of Electrophysiological Techniques from 1983 until its merger by the publisher with a larger journal four years later, and have served as a guest editor for the IEEE Transactions on Rehabilitation Engineering.

I was the co-chairman of the Conference Committee for the Biomedical Engineering Society's Fall, 1992 meeting at the University of Utah.

On the community level I have served in a number of capacities, including administrative at local and state levels, in Boy Scout and Youth Soccer programs, edited the *Emigration Canyon Newsletter*, and served on the speakers' bureau of the Nature Conservancy.