Seventeenth Annual Computational Neuroscience Meeting

CNS*2008

July 19th - 24th 2008
Portland, Oregon
USA

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17:00 – 23:00	Opening reception (*Crystal Ballroom*)

SUNDAY JULY 20, 2008

8:15	**Registration** (*Mayfair Ballroom*)
9:00	**Welcome:** Ranu Jung (OCNS President) and Patrick Roberts (Local Organizer)
9:10	**Invited Talk:** *John Rinzel*
10:10	**Break**
10:40	**Oral Session 1**: *System Dynamics*
12:00	**Lunch Break** (*Program Committee meeting, Parliament 1*)
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8:30	**Registration** (*Mayfair Ballroom*)
9:00	**Announcements**: (*Mayfair Ballroom*)
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10:40	**Oral Session 3**: *Cellular Mechanisms*
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8:30	**Registration** (*Mayfair Ballroom*)
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9:00-5:00	Workshops (*Center for Health & Healing, OHSU*)

Welcome and Acknowledgements

The international ***Computational Neuroscience*** meeting (***CNS***) has been a premier forum for presenting experimental and theoretical results exploring the biology of computation in the nervous system for the last 17 years. The meeting is organized by the ***Organization for Computational Neurosciences*** (OCNS), a non-profit organization governed by an international executive committee and board of directors. A separate program committee is responsible for the scientific program of the meeting. Participants at the meeting are from academia and industry. The meeting not only provides a venue for research presentation and discussion by senior scientists, but actively offers a forum for promoting and supporting young scientists and students from around the world.

Welcome to the 17th annual Computational Neuroscience Meeting (CNS*2008) held in Portland, Oregon, USA from Saturday July 19 to Thursday July 24, 2008. The meeting consisted of a welcome reception, three days of oral and poster sessions, a banquet, and two days of workshops. The main meeting is held at the Benson Hotel in downtown Portland. This year the meeting includes several invited talks linking systems biology and computational neuroscience. These talks focus on the use of computational models to examine the role of sub-cellular processes in memory and synaptic plasticity. In addition, Erik De Schutter discusses the relationship between computational neuroscience and systems biology and the future of computational neuroscience in a special lecture "Computational Neuroscience and Systems Biology: the Past, the Now and the Future".

Abstracts for the meeting were submitted in early February. Those authors wanting an oral presentation also submitted an extended summary of their work. The abstracts were reviewed by the Program Committee and each extended summary was additionally reviewed and scored by three independent reviewers. In the end 173 papers were accepted for the meeting. The review comments and scores for the extended summaries were used by the Program Committee to construct the final oral and poster programs.

The abstracts for this year's presentations are published online. These abstracts represent a sampling of some of the exciting work being done today, often by young researchers, in the field of Computational Neuroscience.

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OCNS would like to thank the following sponsors for their support:
NIMH, Springer, Royal Society Publishing, Neuralynx, NINDS, MIT Press, HFSP Journal, Neuralynx, and the National Bernstein Network for Computational Neuroscience of Germany.

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We would like to thank the Department of Biomedical Engineering, OHSU, for their invaluable administrative support: Sandy Baxter (Administrator), Alena Tkacova (Financial Manager), Tamara Hayes (Interim Department Head), Stephen Hanson (Professor).

General Information

Location: The welcome reception will be held on July 19th in the Crystal Ballroom on the lobby floor of The Benson Hotel. The main meeting (both oral and poster sessions) will be held in the Mayfair Ballroom on the 2nd floor of The Benson Hotel, from Sunday, July 20th to Tuesday, July 22nd. The workshops will be held in rooms of the Center for Health and Healing at the Oregon Health & Sciences University on Wednesday, July 23rd and Thursday July 24th.

Registration: Registration will be available from 5 till 7:30 pm outside the Crystal Ballroom on the lobby floor of The Benson Hotel. For the rest of the meeting, registration tables will be set up outside the Mayfair Ballroom on the 2nd floor of The Benson Hotel. During the workshops, registration tables will be set up on the 3rd floor of the Center for Health and Healing at the Oregon Health & Sciences University.

Wireless internet will be available in the Mayfair Ballroom for the duration of the main meeting with a daily password from the registration desk.

Refreshments: Coffee/tea and water will be available during the breaks of the oral sessions with a continental breakfast available in the morning at the back of the Mayfair Ballroom. Drink tickets ar included in the registration packets that can be used at the cash bars setup at the reception and poster sessions. Refreshments will be available at the workshops on the 3rd floor of the Center for Health and Healing.

Oral Sessions: The main meeting room will be equipped with audio visual equipment. An LCD projector will be available for all speakers to use and the main meeting room is supplied with a large screen and microphones. A laptop with standard software (i.e., powerpoint) will be available to load your talks ahead of time via USB or CD. If you have non-standard needs, please plan to provide your own laptop and software.

Poster Sessions: Posters will be displayed in the Crystal Ballroom (lobby level) and the Parliament rooms (lower level). Poster setup starts at 8:30 am on Sunday and Monday and should be taken down by midnight. There will be an official poster session for 3 hours each day, but the posters will be available for viewing and discussion throughout the day and night. Poster boards are 8 ft (wide) by 4 ft. Pins will be available at registration, and some tables and chairs will be setup between poster boards. A cash bar and hors d'oeuvres will be available during each poster session in the Crystal Ballroom.

Abstracts will be available online at <http://www.biomedcentral.com/bmcneurosci/9?issue=S1>.

Lunches, Dinners and sightseeing: In the pages following the workshops, attendees will find a sampling of lunch restaurants. In addition, a map of food cart locations is provided for a quick lunch. We are in the heart of downtown Portland and just south of the Pearl District which have many fine eating establishments. Here are some of the local host's suggestions for dinner:

Clyde Common - Northwest contemporary - SW 11th and Stark
Andina - Peruvian nuevo - 1314 NW Glisan
Deschutes Brewery & Public House - Pub - 210 N.W. 11th Ave
Eleni's Philoxenia - Greek - 112 N.W. Ninth Ave.
The Heathman Restaurant and Bar - French - 1001 S.W. Broadway at Salmon
Higgins Restaurant & Bar - Northwest/Regional - 1239 S.W. Broadway
Jake's Famous Crawfish - Steak and Seafood - 401 S.W. 12th Ave.
McMenamins Crystal Ballroom & Lola's Room - Pub - 1332 W. Burnside
Mother's Bistro & Bar - American - 212 S.W. Stark St.
Saucebox Restaurant & Bar - Asian - 214 S.W. Broadway
Brazil Grill - International - 1201 S.W. 12th Ave.
Carafe - Bistro - 200 SW Market St

There are also several activities that you can enjoy. Walk to the river, or rent a bicycle, or walk in the many parks. Tourist information and maps are provided in the registration packet. A ride on the aerial tram ($3) by the Center for Health and Healing provides a fine view of the city, the Willamette river and two snow capped peaks, Mt. Hood and Mt. St. Helens.

CNS*2008 Party: Following the oral sessions, at 7:00pm on Tuesday, participants are invited to our party at Lola's Room at the Crystal, 1332 W. Burnside Blvd. This is not at the Crystal Ballroom at the Benson Hotel, but 7 blocks to the west. Walk westward on SW Stark St. for 6 blocks until you merge into Burnside St. Then 1 block further and enter on the corner of Burnside and 14th Ave. Free pizza will be provided for the first 100 guests and refreshments can be purchased from the bar. Kukuva Marimba Band will entertain us with the highly dance-able rhythms of Zimbabwe.

Workshops: Workshop details and directions can be found in the workshop section of this program. Please sign up for workshops that you plan to attend so that appropriate room sizes can be allocated. Sign-up sheets will be available at the registration table. Refreshment breaks will take place from 10-11 am and 3-4 pm each day outside rooms on the 3rd floor of the Center for Health and Healing. Projectors and screens will be available in the workshop meeting rooms. If you wish to organize a workshop during the meeting, please talk to the local organizer as soon as possible to ensure room availability.

Downtown Portland, Oregon

(A) **The Benson Hotel**, 309 SW Broadway Blvd.
(B) **Ondine Hall** (student housing), 1912 SW 6th Ave.
(C) **University Place**, 310 SW Lincoln St.
(D) **Lola's Room at the Crystal** (CNS*2008 Party), 1332 W Burnside St.

The location of the workshops, the Center for Health and Healing, OHSU, is further south. Directions are given on page 67.

Meeting Program

SATURDAY JULY 19, 2008

13:00 – 23:00 Registration, lobby

17:00 – 23:00 Opening reception, Crystal Ballroom

SUNDAY JULY 20, 2008 (Mayfair)

8:15 **Registration**

9:00 **Welcome:** Ranu Jung (President) and Patrick Roberts (Local Organizer)

9:10 L1 **Invited Talk: John Rinzel**
Alternating perceptions of ambiguous scenes: What's out there?

10:10 **Break**

Oral Session: ***System Dynamics***

10:40 O1 **Featured Talk**: Steven Schiff, Tim Sauer
Kalman filter control of a model of spatiotemporal cortical dynamics

11:20 O2 Miriam Zachsenhouse, Mikhail Lebedev, Miguel Nicolelis
Bin-width selected for brain-machine interfaces optimizes rate decoding

11:40 O3 Aonan Tang, Christopher Honey, Jon Hobbs, Alexander Sher, Alan Litke, Olaf Sporns, John Beggs
Information flow in local cortical networks is not democratic

12:00 **Lunch Break** *(Program Committee meeting)*

14:00 L2 **Invited Talk: Upinder Bhalla**
Modules in molecular memory

15:00 **Break**

Oral Session: ***Network Properties***

15:30	O4	**Featured Talk:** David Boothe, Avis Cohen, Todd Troyer *Parameter dependent changes in strength of phase locking in a stochastic simulated central pattern generator*
16:10	O5	Georgi Medvedev *Noise-induced bursting in stochastic models of single cells and electrically coupled ensembles*
16:30	O6	Arthur Leblois, David Perkel *Local inhibition shapes afferent excitatory drive of output neurons in the songbird basal ganglia network*
16:50		**Funding Opportunities (D. Glanzman, K. Whang, Y. Liu)**
17:20-18:20		*Board Meeting*

Dinner Break

19:00-22:00 **Poster Session I (Parliament and Crystal)**

P1-P23	Network Properties
P24-P40	System Dynamics
P41-P58	Cellular Mechanisms
P59-P64	Anatomy and Morphology
P65-P72	Learning
P73-P80	Behavior

MONDAY JULY 21, 2008 (Mayfair)

8:30		**Registration**
9:00		Announcements:
9:10	L3	**Invited Talk: Avrama Blackwell** *Signaling pathways underlying striatal synaptic plasticity and reward learning*
10:10		**Break**

Oral Session: ***Cellular Mechanisms***

10:40	O7	**Featured Talk:** Darrell Haufler, France Morin, Jean-Claude Lacaille, Frances Skinner *Characterizing the transient K+ current contribution to subthreshold membrane potential oscillations in a hippocampal interneuron model*
11:20	O8	Natalia Toporikova, Maurice Chacron *One cell, two bursting mechanisms. In vivo conditions change the in vitro burst in pyramidal cells of the ElectroLateral Lobe (ELL) of electric fish.*
11:40	O9	John Cressman, Ghanim Ullah, Jokubas Ziburkus, Steven Schiff, Ernest Barreto *Ion concentration dynamics: Mechanisms for bursting and seizing*
12:00		**Lunch Break** *(Board meeting)*
14:00	L4	**Special Invited Lecture: Erik De Schutter** *Computational Neuroscience and Systems Biology: the Past, the Now and the Future*
15:00-18:00		**Poster Session II (Parliament and Crystal)**

P81-P94	Databases and Software
P95-P105	Plasticity and Development
P106-P110	Synaptic Mechanisms and Signal Transduction
P111-P130	Information Coding
P131-P152	Synchronization and Oscillation
P153-P158	Functional Imaging and EEG

19:00	**Banquet**

TUESDAY JULY 22, 2008 (Mayfair)

8:30 **Registration**

9:00 Announcements:

9:10 L5 **Invited Talk: Victor Derkach**
CaM kinases and AMPA receptor subunit recomposition in hippocampal synaptic plasticity

10:10 **Break**

Oral Session: ***Synaptic Mechanisms***

10:40 O10 Grier Halnes, Erik Ulfhielm, Jeanette Hellgren Kotaleski, Jean-Pierre Rospars
Modeling of the receptor, G-protein and effector reactions in vertebrate olfactory receptor neurons

11:00 O11 William Gibson, Les Farnell, Max Bennett
A neural-glial network for modeling spreading depression in cortex

11:20 O12 Risa Lin, Svenja Metz, Dieter Jaeger
Synaptic integration in the deep cerebellar nuclei: Comparing dynamic clamp results with a computer model of somatic or distributed dendritic input

11:40 **General Business Meeting**

12:00 **Lunch Break**

14:00 L6 **Invited Talk: Akihiro Kusumi**
Single-molecule tracking of raft-based signal transduction: a system of digital signal transduction?

15:00 **Break**

Oral Session: ***Learning and Plasticity***

15:30 O13 **Featured Talk:** Claudia Clopath, Andre Longtin, Gerstner Wulfram
An online Hebbian learning rule that performs Independent Component Analysis

16:10 O14 Matthieu Gilson, David Grayden, Doreen Thomas, Leo van Hemmen, Anthony Burkitt
Symmetry breaking induced by spike-timing-dependent plasticity in the presence of recurrent connections

16:30 **Workshop Information, Awards, Announcement of next year's meeting, Closing**

19:00-1:00 **CNS*2008 Party with Kukuva Marimba Band at Lola's Room**

WEDNESDAY JULY 23, 2008

(Center for Health & Healing, OHSU, see Workshop section for details)

8:30 **Workshop Registration** (3rd floor, CHH)

9:00-17:00 **Workshop 1**: Interoperability of software for computational and experimental neuroscience
Workshop 2: A dialogue for theoreticians and experimentalists:
What is phase response analysis, and what can it tell us about neurons and networks?
Workshop 3: Molecular Diffusion in Neurons: Theory and Experiment

2:00-17:00 **Workshop 4**: Methods of Information Theory in Computational Neuroscience

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THURSDAY JULY 24, 2008

(Center for Health & Healing, OHSU, see Workshop section for details)

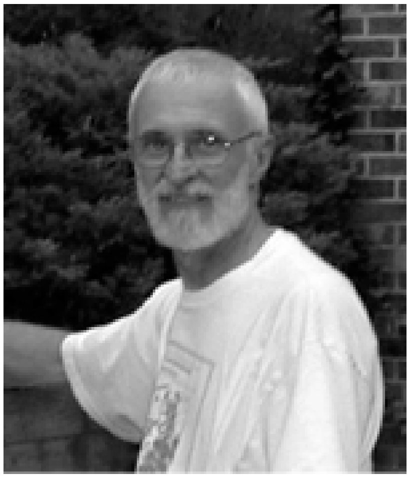
8:30 **Workshop Registration** (3rd floor, CHH)

9:00-17:00 **Workshop 4**: Methods of Information Theory in Computational Neuroscience

9:00-12:00 **Workshop 5**: Neuronal Gap Junctions: Modeling approaches, insights and possible roles
Workshop 6: A tutorial on neuroConstruct

2:00-17:00 **Workshop 7**: NIH Funding Opportunities and Grant Writing Skills:
Dennis Glanzmann (NIMH) and Yuan Liu (NINDS)

Invited Speakers



L1 Invited talk, Sunday July 20, 9:10-10:10

Alternating perceptions of ambiguous scenes: What's out there?

John Rinzel
Center for Neural Science and Courant Institute of Mathematical Sciences, New York University, NY USA

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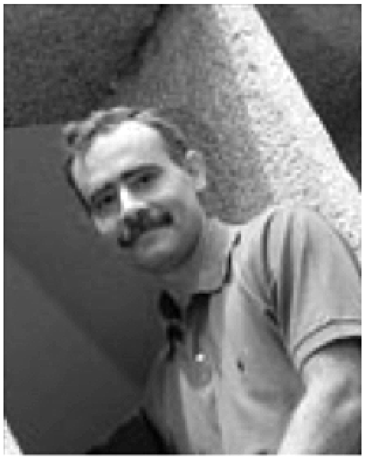
When visualizing an ambiguous scene (such as the Necker cube) one may perceive ongoing random alternations between the possible interpretations. Dynamical models implement competition as reciprocal inhibition between neuronal populations; dominance alternates while slow negative feedback, adaptation, sets the basic time scale (seconds) for switching. When adaptation is strong enough it overcomes dominance and alternations occur intrinsically and periodically; noise perturbs the regularity. In a different framework, with attractor-based dynamics, adaptation is weak and switches are induced by noise operating on a bistable system. We find that statistics of the observed alternations provide constraints that favor an operating range near the transition zone between the parameter regimes for the two mechanisms. In some paradigms one can manipulate stimulus cues to bias the competition away from equal dominance. We have proposed that the percent of time dominant is a measure for the likelihood of valid interpretation of the scene.

Generally, I am interested in the biophysical mechanisms and theoretical foundations of dynamic neural computation. With a background in engineering (B.S., University of Florida, 1967) and applied mathematics (Ph.D., Courant Institute, NYU, 1973) I use mathematical models to understand how neurons and neural circuits generate and communicate with electrical and chemical signals for physiological function. I especially relish developing reduced, but biophysically-based, models that capture a neural system's essence. Before joining the Center for Neural Science and jointly the Courant Institute of Mathematical Sciences at New York University in 1997, I was in the Mathematical Research Branch at the NIH for nearly 25 years. Many of my modeling projects have dealt with oscillatory activity of neurons and in one on-going study we look at mechanisms for alternations in neuronal competition models of perceptual bistability, such as binocular rivalry. In current projects we have been studying the dynamics of auditory processing: the cellular and synaptic biophysical mechanisms for coincidence detection and precise temporal processing in brain stem neurons; adaptation mechanisms and dynamic plasticity in inferior colliculus and cortex.



L2 Invited talk, Sunday July 20, 14:00-15:00

Modules in molecular memory

Upinder S. Bhalla
National Centre for Biological Sciences, Tata Institute of Fundamental Research, Bangalore, Karnataka, 560065, India

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The cell-signaling and biochemical events in memory form an information-processing network to rival the neural circuits in which they are embedded. One of the first molecular modules to be identified was the NMDA receptor, as a key locus of synaptic associativity. In retrospect, this first module was uncharacteristically simple. Increasingly complex signaling models have since then investigated memory maintenance, trafficking of receptors, interactions between synapses, pattern selectivity, and many other functions or modules in synaptic memory. While this growing list is intimidating, I will attempt to make the case that we have a finite number of key modules to work out, and that the outlines of many of these are emerging. I will discuss our work on a new module, that of activity-dependent control of dendritic protein synthesis. While this may seem suspiciously close to cellular housekeeping, this module turns out to act as a hub for many kinds of neuronal signals in memory decisions. I will make so bold as to suggest that several of the hard circuit-level questions about memory may boil down to the computational functions of these molecular modules.

I studied Physics at IIT Kanpur, India, and Cambridge University, UK, before taking the plunge into Biology for my PhD at Caltech. I even did a bit of molecular biology as part of my post-doc work at the Mount Sinai School of Medicine in New York, before deciding that I was more at home with neurons and computers. I am now at the National Centre for Biological Sciences, in Bangalore. I have done experiments on rats and on tissue cultures, and have worked in computational neuroscience and what is popularly called systems biology. I think these are all just labels for whatever approaches happen to work for studying the grand complexity of biology and the brain. I am currently interested in olfactory sensory processing and memory, from molecules to networks.

L3 Invited talk, Monday July 21, 9:10-10:10

Signaling pathways underlying striatal synaptic plasticity and reward learning

Kim T. Blackwell
George Mason University, Molecular Neuroscience Department, The Krasnow Institute for Advanced Study, Fairfax, VA, USA

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Operant conditioning is a form of associative learning in which rewarding an animal's response increases the likelihood of eliciting the response. The ability to use appropriately timed rewards to shape complex behaviour inspires scientists in psychology, neurophysiology, and modeling. Temporal difference models and experimental results agree that reward elicits dopamine release in the striatum and that striatal spiny projection neurons learn the association between the motor response and reward. Nonetheless, critical aspects of operant conditioning behavior have not been replicated. In particular, if synaptic plasticity underlies learning, then the temporal interval between dopamine and cortical inputs should be critical in producing plasticity of cortico-striatal synapses. To investigate the mechanisms whereby glutamate and dopamine interact to produce plasticity, we develop a computer model of the signaling pathways activated by dopamine and glutamate in the spiny projection neuron of the striatum. In the model, dopamine activates adenylyl cyclase, which produces the diffusible molecule, cAMP, which binds to PKA. Glutamate produces an elevation in intracellular calcium, which binds to calmodulin and activates CaMKII. These pathways interact through DARPP32. Model simulations show that simultaneous dopamine and glutamate produce a synergistic increase in PKA activation and DARPP32 phosphorylation consistent with the requirement for both dopamine and glutamate for learning behavior. We are presently developing a multi-compartment model in which the reactions and diffusion implicit in these signaling pathways are simulated stochastically in the spines along a dendrite. Using this model we plan to investigate the spatio-temporal patterns of synaptic input that produce an elevation in critical enzymes, and to test whether plasticity is sensitive to temporal interval.

Kim Blackwell received her V.M.D. in 1986 from University of Pennsylvania, and then, also from the University of Pennsylvania, a Masters in Systems Engineering in 1987 and a Ph.D. in Bioengineering in 1988. In her initial position, Dr. Blackwell worked at a not-for-profit research institute, called Environmental Research Institute of Michigan, developing biologically-motivated artificial neural networks in collaboration with Dan Alkon and Tom Vogl. Subsequently, she began studying how biological neurons store memories in the invertebrate seaslug, *Hermissenda crassicornis*. More recently, the role of the basal ganglia in habit learning has been the focus of her research. In all of these investigations she employs interdisciplinary techniques of software development, computer modeling, and electrophysiology to understand the cellular events underlying the requirement for temporal proximity of stimuli to be associated, and the neural circuits involved in the behavioral expression of memory. Dr. Blackwell created the software Chemesis for modeling reaction-diffusion systems in neurons, and is currently developing software for computationally efficient simulation of stochastic reaction-diffusion systems. Dr. Blackwell is a Professor in the Department of Molecular Neuroscience, Krasnow Institute of Advanced Study, George Mason University, as well as a guest researcher at the National Institute of Mental Health.

L4 Invited talk, Monday July 20, 14:00-15:00

Computational Neuroscience and Systems Biology: the Past, the Now and the Future

Erik De Schutter
Computational Neuroscience Unit, Okinawa Institute of Science and Technology, Japan and Theoretical Neurobiology, University of Antwerp, Antwerp, Belgium

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Despite similar computational approaches, there is surprisingly little interaction between the computational neuroscience and the systems biology research communities. In this talk I reconstruct the history of the two disciplines and show that this may explain why they grew up apart. The separation is a pity, as both fields can learn quite a bit from each other. Systems biology is a better organized community which is very effective at sharing resources, while computational neuroscience has more experience in multiscale modeling and the analysis of information processing by biological systems. In the second part of the talk I will speculate about the future of computational neuroscience, both in its relation with the neuroscience field and with systems biology. I will recommend that where possible we should adapt our practices to current systems biology standards.

Erik De Schutter is a principal investigator at the Okinawa Institute of Science and Technology, where he moved last year. Previously he was a research professor at the Department of Biomedical Sciences of the University of Antwerp, Belgium. Though trained in Antwerp as a medical doctor (1984) and neurologist (1989), he focused his research on the use of computational methods in modeling. Initial work was on simulating invertebrate central pattern generators, but he switched to studying the function of the cerebellum with the development of, at that time, the most detailed neuron model ever of the cerebellar Purkinje cell during a postdoc at the California Institute of Technology (1990-1994). More recent work on Purkinje cells has focused on diffusion in dendrites and the effects of synaptic plasticity. Modeling of neurons and networks is combined with an active interest in simulator development: the compartmental simulators Nodus (developed during his medical training) and GENESIS (Caltech period and afterwards), and more recently the STEPS software for stochastic reaction-diffusion modeling. Each of these simulators played an important role in specific research projects.

L5 Invited talk, Tuesday July 22, 9:10-10:10

CaM kinases and AMPA receptor subunit recomposition in hippocampal synaptic plasticity

Victor Derkach
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It is broadly believed that synaptic plasticity is a neuronal mechanism for learning and memory in the mammalian brain. In the mature hippocampus, the expression of long-term potentiation (LTP) in Schaffer collateral-CA1 synapses requires a postsynaptic Ca^{2+} influx and the GluR1 subunit of the AMPA subtype of glutamate receptor (AMPAR). New findings indicate that the pattern of synaptic activity associated with exploratory behavior can induce LTP by changing the quality of synaptic AMPARs. This process is dynamic and requires activity of Ca^{2+}/calmodulin dependent protein kinases (CaMKs), key transducers of postsynaptic Ca^{2+} changes into LTP. The two CaMKs, CaMKI and CaMKII target AMPARs and regulate synaptic strength differently, however. Under basal conditions, AMPARs in these synapses are heteromers composed of GluR1 and GluR2 subunits. CaMKI enhances synaptic strength by trafficking to synapses more functionally efficient and highly Ca^{2+}-permeable GluR2-lacking AMPARs through a regulated actin dynamics. In contrast, CaMKII can enhance functional properties of these GluR2-lacking AMPARs by a direct phosphorylation of the C-terminus of GluR1 subunit. Taken together, these results argue for two distinct but orchestrated mechanisms in modification of synaptic strength during LTP. Results are discussed in terms of the role of AMPAR subunit recomposition for synaptic plasticity.

Victor Derkach is a Research Assistant Professor and Neuroscience Graduate Faculty member at the Vollum Institute of the Oregon Health and Sciences University. He received his Ph.D. in Biology from the Bogomoletz Institute of Physiology of the Ukrainian Academy of Sciences and holds a B.S. and an M.S. in Physics and Biophysics from Dnepropetrovsk State University. Dr. Derkach is interested in the physiology of synapses and ligand-gated ion channels, and the role synapses play in sensory processing and cognition. His specific focus is on understanding cellular and molecular mechanisms of plasticity in central glutamatergic synapses underlying memory and learning. Calcium-dependent signal transduction to regulate local synthesis, trafficking and functional properties of glutamatergic AMPA receptors in an activity-dependent manner is of particular interest. He is also interested in applicability of this knowledge to understanding abnormalities in synaptic and neuronal function under pathological conditions such as Alzheimer's disease and chronic pain.

L6 Invited talk, Tuesday July 22, 14:00-15:00

Single-molecule tracking of raft-based signal transduction: A system of digital signal transduction?

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The plasma membranes of neuronal cells contain high concentrations of glycosphingolipids and glycosylphosphatidylinositol-anchored receptors (GPI-ARs), as well as cholesterol, which suggests important roles played by hypothetical microdomains, called raft domains in these membranes. Using simultaneous two-color single-molecule tracking of GPI-ARs, as well as intracellular lipid-anchored signaling molecules, Gαi, Lyn, and PLCγ, we have obtained results showing that the plasma membrane is poised for assembly of these molecules, upon the external stimulation that initiates oligomerization of 3-9 GPI-AR molecules.

The receptor-cluster-induced, cholesterol-dependent assembly, termed receptor-cluster raft (RCR), works as a platform for the signal transducton of GPI-AR. Gαi2 and Lyn (GFP conjugates) are recruited to RCRs frequently, but transiently (100-200 ms), based on protein-protein and lipid-lipid (raft) interactions. Gαi2 binding to and its subsequent activation of Lyn are likely to take place within the same RCR, resulting in actin-dependent temporary immobilization (0.57-s lifetime, called Stimulation-induced Temporary Arrest of LateraL diffusion or STALL, every 1.3 s), inducing the temporary (250 ms) recruitment of PLCγ2, for IP_3 production. Therefore, the RCR in STALL is a key, albeit transient, platform for transducing the extracellular GPI-AR signal to the intracellular IP_3-Ca^{2+} signal, via PLCγ2 recruitment.

The bulk activation of IP_3-Ca^{2+} signaling and Src-family kinases persists over several minutes to several 10s of minutes. Meanwhile, single-molecule events, such as STALL and the recruitment of PLCγ2, Gαi2, and Lyn to RCR, lasted only for a fraction of a second. Namely, individual single-molecule events may occur like a digital pulse, and the bulk analogue-type activation of signaling molecules may be the result of superposition of these pulse-like signals. In this sense, the basic signaling mechanism in the raft-based signaling system could be called digital or frequency-modulated.

Akihiro Kusumi received his undergraduate and doctoral training in Biophysics at Kyoto University and then did postdoctoral work at the Medical College of Wisconsin and Princeton University. From there he returned to the Biophysics Department at Kyoto University as an Assistant Professor. He subsequently moved to the University of Tokyo and then to Nagoya University before returning once again to Kyoto University where he is currently Professor and Director of the Research Center for Nano-Medical Engineering at the Institute for Frontier Medical Sciences. His interests are in membrane organization and membrane mechanisms.

Program Listing

Oral presentations O1-O14

O1 Featured talk

Kalman filter control of a model of spatiotemporal cortical dynamics

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O2

Bin-width selected for Brain-Machine Interfaces optimizes rate decoding

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O3

Information flow in local cortical networks is not democratic

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O4 Featured talk

Parameter dependent changes in strength of phase locking in a stochastic simulated central pattern generator

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O5

Noise-induced bursting in stochastic models of single cells and electrically coupled ensembles

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O6

Local inhibition shapes afferent excitatory drive of output neurons in the songbird basal ganglia network

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O7 Featured talk

Characterizing the transient K^+ current contribution to subthreshold membrane potential oscillations in a hippocampal interneuron model

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O8

One cell, two bursting mechanisms. *In vivo* conditions change the *in vitro* burst in pyramidal cells of the ElectroLateral Lobe (ELL) of electric fish.

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O9

Ion concentration dynamics: mechanisms for bursting and seizing

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O10

Modeling of the receptor, G-protein and effector reactions in vertebrate olfactory receptor neurons

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O11

A neural-glial network for modeling spreading depression in cortex

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O12

Synaptic integration in the deep cerebellar nuclei: Comparing dynamic clamp results with a computer model of somatic or distributed dendritic input

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O13 Featured talk

An online Hebbian learning rule that performs independent component analysis

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O14

Symmetry breaking induced by Spike-Timing-Dependent Plasticity in the presence of recurrent connections

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Posters Network Properties P1-P23

P1

Cerebellar timing and negative patterning

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P2

Investigating the effect of cortical discharge variability on the accuracy of population decoders

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P3

Inhibition dominates in shaping in vitro spontaneous hippocampal network rhythms

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P4

Temporal spike pattern learning

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P5

Network effects of age-related NMDA reduction in a model of working memory

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P6

On the propagation of firing rate and synchrony in a model of cortical network

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P7

Capturing correlation structure within a simplified population density framework

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P8

Electric field modulation of theta and gamma rhythms: probe into network connectivity

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P9

Synchrony-asynchrony transitions in neuronal networks

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P10—withdrawn

P11—withdrawn

P12

Study of additional mechanism of short time delay detection in input signal by the homological neural network

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P13—withdrawn

P14

Sparse network models reproduce experimentally observed spike timing jitter during

inspiratory population rhythms in the pre-Bötzinger complex

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P15

Optimal neural connection mechanism in cortical network

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P16

Analysis of stochastic integration with a network of bistable units

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P17

Information transmission between recurrent neural networks by sparsely electrical connections

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P18

Functional structure from dynamic clustering of spike train data

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P19

Inferring neuronal functional connectivity using dynamic Bayesian networks

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P20

Large-scale synapse-level neuronal wiring diagrams in silico and in vitro.

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P21

Intrinsic current generated, omnidirectional phase precession and grid field scaling in toroidal attractor model of medial entorhinal path integration

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P22

Is hippocampal phase precession a useful temporal code?

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P23

Neural network model of the lateral accessory lobe and ventral protocerebrum of *Bombyx mori* to generate the flip-flop activity

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Posters System Dynamics P24-P40

P24

Approximating the phase response curves of square wave bursting neurons

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P25

System identification of the crab cardiac neuromuscular transform by a new method

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P26

Mathematical modeling of isoflurane action on lamprey spinal neurons

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P27

Effects of muscle strength and activation profile on foot drag in a simulated SCI rat

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P28

Temporal variability in a synfire chain model of birdsong

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P29

A memoryless, stochastic mechanism of timing of phases of behavior by a neural network controller

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P30

Measuring spike train reliability

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P31

Transcriptional regulation network analysis of the hypertension-perturbed nucleus tractus solitarius

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P32

Probabilistic Models and Inference Algorithms for Neuronal Decoding of UP and DOWN States

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P33

The reverse connectivity pattern between Broca's area and the left visual word form area in the processing of Chinese words and English characters

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P34

Effective connectivity analysis of global and local mental imagery by dynamic causal modeling

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P35—withdrawn

P36

Roles of prefrontal cortical GABAergic interneurons in psychosis and cognitive deficits in schizophrenia

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P37

Dynamics of self-sustained microcircuits examined with regular-spiking readouts

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P38

Biologically plausible statistics from a Markov model of spiking cortical networks

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P39

A novel method for modelling nonlinear dynamical systems applied to the Hodgkin-Huxley neuron

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P40

Information dynamics in dopaminergic networks

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Posters Cellular Mechanisms P41-P58

P41

Effects of the axonal leak conductance on energy and information

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P42

Calcium sensor properties for activity-dependent homeostatic regulation of pyloric network rhythms in the lobster stomatogastric ganglion

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Using axon models to interpret electrodiagnostic nerve tests

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Active dendritic conductances enhance processing of plastic synaptic stimuli

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K_A channels reduce dendritic depolarization from synchronized synaptic input: Implication for neural processing and epilepsy

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Nicotine and the dopaminergic output of the ventral tegmental area

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Multi-scale modeling of angiotensin II induced neuronal regulatory mechanisms in the brain

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Topological ion channel noise and its implications for the neuronal dynamics

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Non-conductive vs. conductive cell membranes--a reassessment of this assumption when modeling cells under magnetic field stimulation

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Wiener kernel estimation and frequency domain analysis of cortical pyramidal cells

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Why are pyramidal cell firing rates increased with aging, and what can we do about it?

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Cost of linearization for different time constants

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Systematic selection of model parameter values matching biological behavior under different simulation scenarios

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The self-sustained regulation of PKMζ activity during the maintenance of L-LTP

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Voltage attenuation in reconstructed type-identified motor neurons as a constraint for reduced models

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Effect of membrane property modulations by dopamine on synchronous/asynchronous activity in a network of globus pallius externus

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Modulation of synaptically induced burst strength and spike onset timing by inactivating K_{IR} currents in medium spiny neurons

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Investigating the interaction of transcranial magnetic stimulation with a model cortical neuron

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Signal processing in posterior-canal bouton vestibular primary afferents

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Integration of anatomical and physiological connectivity data sets for layered cortical network models

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A computational model of the basal ganglia as a rewarded activity selection circuit with non-specific output

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Self-sustaining non-repetitive activity in a large scale neuronal-level model of the hippocampal circuit

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Optimizing artificial neurons to be successful Reichardt detectors

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Assesment of tamoxifen effects on nitric oxide synthase (nNOS) in rat developing hippocampus

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Modeling of potentiation as cascaded gated processes; relevance to learning and seizure
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Computation by neural and cortical systems
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Determinants of pattern recognition by cerebellar Purkinje cells
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Automatic recognition and statistical quantification of spatial patterns of gene expression in zebra finch brain in response to auditory stimulation
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Properties of synaptic plasticity rules implementing actor-critic temporal-difference learning
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From multiple neural cortical networks to motor mechanical behavior: The importance of inherent learning over separable space-time length scales
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Learning Bayesian network structure based on the classification and regression tree

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Spike-based reinforcement learning of navigation

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A new synthetic face generation method for gender discrimination

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Structured Control from Self-Organizing Arm Movements

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Operant behavior controlled by position of a moving object – a reinforcement learning model

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Neurocomputational modeling of imitation deficits
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Nonlinear diffusion models of detection
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Emergence of sensory selection mechanisms in Artificial Life simulations
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Theoretical derivation of EMOTION-I model for emotional feel of sensation
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Theoretical derivation of EMOTION-II model for happy and unhappy emotions
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Improved automatic midline tracing of neurites with neuromantic
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Database analysis and visualization of simulated and recorded electrophysiological data with PANDORA's Toolbox in Matlab

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A general method for creating realistic reduced compartmental models from electrophysiological traces

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Using Neurofitter to fit a Purkinje cell model to experimental data

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Reaction-diffusion in complex 3D geometries: mesh construction and stochastic simulation with STEPS

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Modeling stochastic calcium dynamics in the dendritic spines: A hybrid algorithm

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The role of the Neurospaces project browser in the GENESIS 3 software federation: Design and targets

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The CBI architecture for computational simulation of realistic neurons and circuits in the GENESIS 3 software federation.

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A new software center for the neuroinformatics community

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Genetic algorithm modification to speed up parameters fitting for multicompartment neuron model

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NeuroCAD - the Modular Simulation Environment for Effective Biologically Plausible Neuromodeling

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Brian: a simulator for spiking neural networks in Python

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A general biological simulator: the multiscale object oriented simulation environment, MOOSE

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Spike overlap resolution of eletrode and tetrode data from primary visual cortex

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Axon guidance simulation: a multi-agent approach

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Modeling the development of maps of complex cells

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A mechanism for temporal sequence learning and recognition in neural systems

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Role of plasticity in coincidence detection in the avian auditory brainstem

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The effect of Hebbian plasticity on the attractors of a dynamical system

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Synaptic symmetry breaking by spike timing dependent synaptic plasticity

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Can calcium ion contribute to morphological plasticity of a spine?

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Translational switch for long term maintenance of synaptic plasticity

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Spatiotemporal molecular dynamics and synaptic plasticity.

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Modeling structural plasticity in dendrites with multiple spine types

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GABAergic control of backpropagating action potentials in striatal medium spiny neurons

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Cellular Dynamic Simulator: An event driven molecular simulation environment
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Results from a novel Cellular Dynamics Simulator reveal a quantitative mechanism for Ca^{2+}-CaM activation in dendritic spines
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Neurogranin provides a kinetic proof reading mechanism for decoding Ca^{2+} signals that may govern the induction of synaptic plasticity
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A computational model of dopamine and tyramine interactions in striatal storage vesicles
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Modeling the GABA and ephaptic feedback mechanisms in cat outer retina
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A hierarchical predictive coding model of visual processing

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Simulating mirror-neuron responses using a neural model for visual action recognition

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Evaluating feedforward spiking neuron networks using a novel decoding strategy

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Adaptation in the anuran auditory system contributes to nonlinear response properties of peripheral and midlevel neurons

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How gamma-band oscillatory activity participates in encoding of naturalistic stimuli in random networks of excitatory and inhibitory neurons

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Independence of space-based and feature-based attention in the determination of figure direction

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Optimal sigmoidal tuning curves for intensity encoding sensory neurons with quasi-Poisson variability

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Computing linear approximations to nonlinear neuronal responses

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Amplitude modulation discrimination in a model of the electrically stimulated auditory nerve

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Effects of passive dendritic properties on the dynamics of an oscillating neuron

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What you show is what you get: sampling biases in determining biological sensory function

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Spike sorting should be biased for optimal neural control prostheses

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Fuzzy interval representation of olfactory stimulus concentration in an olfactory glomerulus model

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Computing a generative model for neural codes

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Responses of primary visual cortical neurons to natural movies in anesthetized cat

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Modeling the transformation from LGN to V1 color-opponent receptive fields

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Modeling spike-count dependence structures with multivariate Poisson distributions

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Multidimensional patterns of neuronal activity: how do we see them?

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Neural representations of visual salience in primary visual cortex

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A simple spiking retina model for exact video stimulus representation

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Comparison of methods to calculate exact spike times in integrate-and-fire neurons with exponential currents

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The effect of rectifying gap junctions on phase-locking in neuronal networks

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Predicting phase-locking in excitatory hybrid circuits

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Predicting excitatory phase resetting curves in bursting neurons

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Phase response curves determine network activity of all to all networks of pulse coupled oscillators.

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Predicting n:1 locking in pulse coupled two-neuron networks using phase resetting theory

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A neurobiological model of the human sleep/wake cycle

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Signal discrimination performed by population of spiking neurons enhanced by background gamma oscillations

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Noise-induced transitions in slow wave neuronal dynamics

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A simplified model of dopaminergic neuron

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Correlation susceptibility and single neuron computation

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Phase and frequency synchronization analysis of NMDA-induced network oscillation

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Theory of neuronal spike densities for synchronous activity in cortical feed-forward networks

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The Type II phase resetting curve is optimal for noise-induced synchrony: A mathematical proof

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Modeling the interplay between interneuron and pyramidal cell during seizures.

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Predicting synchrony and asynchrony in basket cell networks coupled by multiple dendritic gap junctions

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Interaction of membrane dynamics with network structure and its effects on spatio-temporal network patterning

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A new measure for the detection of directional couplings based on rank statistics

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Loss of synchrony in an inhibitory network of type-I oscillators

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Intermittent patterns of synchronous activity in human basal ganglia

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The role of burst duration in inhibitory synchronization

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Modeling perceptual multi-stability with Hodgkin-Huxley neurons

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Multichannel analysis of neural oscillations in a simple model network – towards a better understanding of the spatiotemporal structure of brain oscillations

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Bicoherence and synchrony characteristics of sleep, wakeful and seizure electroencephalogram

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The cerebellum connectivity in mathematics cognition

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The dual route model in Chinese-English bilinguals

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Functional connectivity of brain network during character imagery

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Investigating the interaction of transcranial magnetic stimulation with a model cortical neuron

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Workshop Schedule

Wednesday, July 23 (Coffee, tea, snacks: 8:30 - 9:00)

9:00 – 12:00 (coffee break: 10:00 - 11:00)
Workshop 1, One day, Part 1: Interoperability of software for computational and experimental neuroscience
Organizers: Padraig Gleeson, Sharon Crook

Workshop 2, One day, Part 1. A dialogue for theoreticians and experimentalists:
What is phase response analysis, and what can it tell us about neurons and networks?
Organizers: Astrid Prinz and Nathan Schultheiss, Emory University

Workshop 3, One day: Part 1: Molecular Diffusion in Neurons: Theory and Experiment
Organizer: Yoshihisa Kubota, Department of Neurobiology and Anatomy, University of Texas Medical School, 6431, Fannin, Houston, TX 77030

14:00 - 17:00 (Coffee break: 15:00 - 16:00)
Workshop 1, One day, Part 2: Interoperability of software for computational and experimental neuroscience

Workshop 2, One day, Part 2. A dialogue for theoreticians and experimentalists:
What is phase response analysis, and what can it tell us about neurons and networks?

Workshop 3, One day: Part 2: Molecular Diffusion in Neurons: Theory and Experiment

Workshop 4, One-and-a-half day Part 1: Methods of Information Theory in Computational Neuroscience
Aurel A. Lazar, Department of Electrical Engineering, Columbia University and Alex Dimitrov, Center for Computational Biology, Montana State University

Thursday, July 24 (Coffee, tea, snacks: 8:30 - 9:00)

9:00 – 12:00 (coffee break: 10:00 - 11:00)

Workshop 4, One-and-a-half day Part 2: Methods of Information Theory in Computational Neuroscience

Workshop 5, Half day: Neuronal Gap Junctions: Modeling approaches, insights and possible roles
Organizers: Frances Skinner (Toronto Western Research Institute and University of Toronto, Canada), Tim Lewis (University of California, Davis, USA)

Workshop 6, Half day: A tutorial on neuroConstruct
Presenters: Padraig Gleeson and Volker Steuber, London
14:00 - 17:00 (coffee break: 15:00 - 16:00)

Workshop 4, One-and-a-half day Part 3: Methods of Information Theory in Computational Neuroscience

Workshop 7, Half day: NIH Funding Opportunities and Grant Writing Skills.
Presenters: Dennis Glanzmann (NIMH) and Yuan Liu (NINDS)

Rooms in the Center for Health & Healing (CHH):
All workshop rooms are fully equipped with AV and white boards.
(Room assignments will be made as the number of participants is determined)

CHH 3171 (Room 1A)	3rd floor	50 pers
CHH 3181 (Room 1B)	3rd floor	50 pers
CHH 3170 (Room 2)	3rd floor	10 (+5) pers
CHH 3172 (Room 3)	3rd floor	10 (+5) pers
CHH 12181	12th floor	24 (+10) pers
CHH 13030 (BME conference room)	13th floor	20 pers

Workshop Descriptions

Molecular Diffusion in Neurons: Theory and Experiment

Organizer: Yoshihisa Kubota, Department of Neurobiology and Anatomy, University of Texas Medical School, 6431 Fannin, Houston, TX 77030

Diffusion and transport of signaling molecules play a crucial role in neuronal function. For example, AMPA receptor trafficking in dendritic spines is emerging as a major mechanism for the expression of synaptic plasticity. The activation of AMPA or NMDA receptor requires a diffusion of neurotransmitter in the synaptic cleft, which in turn leads to Ca2+ entrance and subsequent diffusion-mediated Ca2+-calmodulin signaling in the postsynaptic spines.

Molecular-level understanding of neuronal function therefore requires quantitative measurement and concurrent theoretical or computational analysis of molecular diffusion in neurons. In this one-day workshop, theoreticians and quantitative experimental biologists will discuss various aspects of molecular diffusion in neurons and talk about potential interactions between theory, computational modeling, and experiment. The topics include membrane protein diffusion, intra-cellular dynamics of ligand-receptor complex, protein trafficking and anomalous diffusion in dendrites, receptor trafficking in the dendrite spines, neurotransmitter diffusion in the synaptic cleft, and postsynaptic Ca2+-CaM-CaMKII diffusion.

One of our participants, Dr. Kusumi (see below) will also give a talk at the main conference as an invited speaker. The title of his talk at the main conference is: Single-Molecule Tracking of Raft-Based Signal Transduction: A System of Digital Signal Transduction.

List of presenters

Dr. Akihiro Kusumi (Institute for Frontier Medical Sciences, Kyoto University): High-Speed Single-Molecule Tracking of Hop Diffusion and Signal Transfer Processes in the Plasma Membrane.

Dr. Tania Q. Vu (Department of Biomedical Engineering, Oregon Health and Science University): Tracking the intracellular Dynamics of Discrete Ligand-Receptor Complex in Neural Cells Using Quantum Dot Probes.

Dr. Erik De Schutter (University of Antwerp & Okinawa Institute of Science and Technology); Anomalous Intracellular Diffusion in Spiny Dendrites of Pyramidal Neurons and Purkinje Cells

Dr. Paul C. Bressloff (Department of Mathematics, University of Utah): Mathematical Models of Protein Trafficking in Dendrites.

Dr. Naveed Aslam & Dr. Harel Shouval (Department of Neurobiology and Anatomy, University of Texas Medical School at Houston): How Does Receptor Trafficking Affect Receptor Densities.

Yoshi Kubota (Department of Neurobiology and Anatomy, University of Texas Medical School at Houston): CaMKII Trafficking and Membrane Diffusion of Signaling Molecules in Dendritic Spines.

Dr. David Holcman (The Weizmann Institute of Science): The Degenerated Synaptic Cleft Geometry Strongly Controls Synaptic Transmission.

Interoperability of software for computational and experimental neuroscience

Organizers: Padraig Gleeson, Sharon Crook

Biophysically detailed computational models are increasingly accepted as important tools for the investigation of brain function by the wider neuroscience community. However, there are still a number of issues to address before a clear and practical framework can be created for exchange of ideas and data both between theoreticians working in different areas and between modelers and experimentalists. At present, multiple simulation platforms are used to model cellular and network activity, each of which has its own scripting language and data structures. This can make reuse of model code developed for one environment difficult for users of another platform, despite the fact that the physiological concepts underlying software design are the same in both. Also, software applications for analysis and management of data produced by electrophysiological experiments, and tools and utilities for the analysis of simulation results are normally developed independently, although the same analysis techniques can be carried out on both datasets.

This workshop includes presentations from researchers who are actively involved in the construction of software solutions for various stages of the computational modeling cycle: from obtaining experimental results, to model creation, simulation and analysis, to prediction of experimental results, and back again. The aim is to present an overview of initiatives in the field to allow greater interaction between these elements and increased usability of results from each stage.

After the main talks, an open discussion session will a) identify "gaps" in the tool chain and b) identify desired extensions/updates to existing standards that allow for greater biophysical detail in models.

List of presenters

Sharon Crook (Arizona State University) Introduction to model interoperability and usability
Pierre Yger (Centre National de la Recherche Scientifique) PyNN: a common Python interface for network simulators
Padraig Gleeson (University College London) Enabling interoperability and transparency of models of biophysical neurons and networks with NeuroML
Hugo Cornelis (University of Texas Health Science Center at San Antonio) A technical overview of the CBI simulation framework: examples of instances and applications
Cengiz Gunay (Emory University) Standardizing acquired electrophysiological data: A Matlab-loadable HDF5 file format annotated with recording conditions, units and scaling factor attributes A technical overview of the CBI simulation framework: examples of instances and applications
Darren Myatt (University of Reading) Neuromantic: A freeware tool for semi-automatic reconstruction of neuronal morphologies
Subhasis Ray/Upinder Bhalla)National Centre for Biological Sciences, Bangalore) MOOSE, the Multiscale Object-oriented Simulation Environment

Ivan Raikov (Okinawa Institute of Science and Technology) Neuroscience modeling languages: practice and theory
Dan Goodman (École Normale Supérieure, Paris) Brian: a simulator for spiking neural networks in Python
Phillip Lord (Newcastle University) The CARMEN Project: Towards a common data format for electrophysiological data exchange and analysis

Open Discussion, A number of topics related to interoperability and standardization will be discussed including:

Identification of gaps in the toolchain
Integration with SBML
Incorporation of Kinetic scheme/Markov model descriptions of channels/synapses

A dialogue for theoreticians and experimentalists: What is phase response analysis, and what can it tell us about neurons and networks?

Organizers: Schultheiss, Prinz

In the computational neurosciences, phase response (PR) analysis is used to describe how neurons' responses to stimuli depend on the phase of stimulus delivery. At the interface of mathematics and neuroscience, PR analysis is increasingly popular among theoretical and experimental neuroscientists alike, because it offers insights into the relationship between the dynamics of individual neurons and of neuronal networks. This workshop provides a forum for computational neuroscientists from diverse specializations to consider the utility of PR analysis in the study of neural systems at multiple levels of complexity, e.g. cellular mechanisms underlying PR dynamics of single neurons and the prediction of population dynamics. Speakers will use experimental, modeling, and mathematical results to illustrate the application of phase response analysis to a variety of current neuroscientific questions of interest.

Note* One of the major discussion topics at last year's CNS pre-meeting satellite was the tendency for computational neuroscientists to self-organize into experimental/biological and mathematical/theoretical camps. These camps are perpetuated in part by a language gap which can even exist between experts applying similar methods or addressing similar questions. Motivated by the belief that bridging this divide will strengthen and accelerate the field of Computational Neuroscience at large, those speakers who self-identify as theoreticians have been strongly encouraged to target the biological contingent of their audience and vice versa.

List of presenters

Michiel Remme Weakly coupled oscillators as a framework for ongoing dendritic activity

Tay Netoff Multiscale effects of ion channels in epilepsy

Nathan W. Schultheiss Phase response analysis of a morphologically realistic globus pallidus neuron model subjected to ongoing synaptic background inputs.

Farzan Nadim Flattening the PRC: Inhibitory feedback to pacemaker neurons promotes oscillation stability

Ole Paulsen Experimental phase response properties of hippocampal neurons during network oscillations

Tim Lewis Phase response curves and phase locking in networks of neocortical inhibitory interneurons

Hugh Robinson Studying synchronization amongst fast-spiking cortical interneurons using conductance injection and phase response analysis

Astrid Prinz Predicting phase locking in circuits of bursting neurons from the phase response curve

Carmen Canavier Clustering, harmonic locking, and delays in populations of pulse coupled oscillators

Sorinel Oprisan From isolated neurons to networks with phase resetting

John White Dynamical mechanisms of synchronization in the hippocampal formation

Neuronal Gap Junctions: Modeling approaches, insights and possible roles
Organizers: Frances Skinner (Toronto Western Research Institute and University of Toronto, Canada), Tim J. Lewis (University of California, Davis, USA)

Gap junctions are essential coupling components of neuronal networks in young and adult animals. They provide direct, fast electrical communication between cells, allowing current to flow down the electrical gradient between cells. For this reason, it is likely that they play a synchronizing role in neural systems. However, theoretical and modeling studies have shown that attributing only a synchronizing role to gap junctions neglects the richness of network dynamics that these protein molecules can support. The talks in this workshop will explore this rich behavior, which includes wave propagation, pattern formation and non- synchronous activities, thus elucidating the many possible roles that gap junctions can play in the nervous system.

Speakers (in alphabetical order): F. Gurel-Kazanci (Emory), T.J. Lewis (UC Davis), E. Munro (Tufts), F. Nadim (NJIT/Rutgers), F.K. Skinner (TWRI/Toronto)

Talk abstracts:
Role of gap junctions in pattern formation in a network of weakly coupled neural oscillators
Fatma Gurel Kazanci, Department of Biology, Emory University, Atlanta, GA, 30322 Bard Ermentrout, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA, 15260

Networks of coupled neural oscillators exhibit a variety of activity patterns according to the properties of the coupling. There is clear experimental evidence for the existence of electrical and chemical synapses in neocortical inhibitory networks . The effect of each type of coupling in isolation is well studied. Depending on the nature of the neural oscillation, inhibition can be either synchronizing or desynchronizing. In numerous computational and theoretical studies, it has been shown that electrical coupling can promote either synchrony or anti-synchrony depending on the shape of the action potential and the nature of the oscillator. Recently, the combined effects of these couplings have been an area of theoretical interest, however in these studies both the inhibition and the gap junctions encouraged synchronization. In a recent paper, we studied a spatially structured network of coupled neural oscillators in which there was local synchronizing coupling (mediated by electrical or gap junction coupling) and long range “desynchronizing” coupling mediated by synaptic inhibition [2]. The motivation for this work is the appearance of traveling waves and synchronous oscillations in the olfactory lobe of the garden slug [1]. The neurons which generate these patterns are coupled with both gap junctions and synaptic inhibition. Starting with a synchronous locally coupled network, we showed that the addition of global inhibitory coupling leads to a symmetry breaking bifurcation and ultimately to traveling waves. In another paper, we considered the same system (local synchronization and long-range desynchronization) from a different perspective. Starting with a globally coupled network of oscillators, we introduced local synchronizing coupling and asked what kinds of behaviors arise [4]. Our work for the inhibition only case is motivated by [3] where they show a heteroclinic connection between unstable two-cluster states for a different set of coupling functions. We used a slightly altered version of the coupling functions from our previous study to accommodate stable clustered states. With the addition of nearest neighbor synchronizing coupling , we studied the network behavior. Local coupling (as opposed to all-to-all) requires that we specify a geometry of the network; here we consider the simplest case, a one-dimensional ring of oscillators. We showed that for sufficiently strong gap junctions, there are stable traveling waves and that as the gap junction coupling decreases, there is a loss of stability of the traveling waves. For a structured network, the ordering of the oscillators matters and there are many arrangements for a clustered state. We showed that these have different stability behavior when local synchronizing coupling is added and that many new patterns bifurcate.

[1]B. Ermentrout, J. W. Wang, J. Flores, and A. Gelperin, Model for transition from waves to synchrony in the olfactory lobe of Limax, J. Comput. Neurosci., 17 (2004), pp. 365–383.
[2]F. Gurel Kazanci and B. Ermentrout, Pattern formation in an array of oscillators with electrical and chemical coupling, SIAM J. Appl. Math. , 67 (2007), pp.512-529
[3]D. Hansel, G. Mato, and C. Meunier, Clustering and slow switching in globally coupled phase oscillators, Phys. Rev. E, 48 (1993), pp. 3470–3477.
[4]F. Gurel Kazanci and B. Ermentrout, Wave formation through the interaction between clustered states and local coupling in array of neural oscillators, SIAM J. Applied Dynamical Systems, 7 (2008), pp. 491- 509.

The effects of rectifying gap junctions on phase-locking in neuronal networks

Tim J. Lewis (1) with Donald French (2), Tamara J Schlichter (1), (1) Department of Mathematics, University of California, Davis (2) Department of Mathematics, University of Cincinnati

Gap junction mediated electrical coupling is ubiquitous in neuronal systems. Electrical coupling is almost always modeled as a linear ohmic resistance between cells, where the coupling current is proportional to the transjunctional potential. However, many gap junctions exhibit rectification with trans-junctional voltage (Bukauskas & Verselis, 2004). The rectification process can evolve at different time scales. Because gap junctional rectification alters the strength of coupling between cells in a way that depends on the intrinsic states of the cells, it can affect network dynamics in a significant and complicated manner. However, the effects of rectification are largely unstudied. In this talk, I will discuss our recent efforts to understand the effects of gap junction rectification on phase-locking in model neuronal networks.

The axonal plexus: A description of the behavior of a network of axons connected by gap junctions

Erin Munro, Christoph Börgers Mathematics department, Tufts University, Medford, MA

Gap junctions have been indicated in very fast oscillations (VFOs, 80 Hz) in the neocortex and hippocampus. Gap junctions among pyramidal axons have been identified in the hippocampus (Hamzei-Sichani et al. 2007), and are clearly indicated in VFOs within gamma oscillations in the hippocampus (Traub et al. 2003). Previous modeling studies have shown that an axonal plexus (network of axons connected by gap junctions) can produce a VFO (Traub et al. 1999), and that this VFO can be caused by expanding waves forming topological target patterns (Lewis and Rinzel 2000, Lewis and Rinzel 2001).

Using the axon of the model in Traub et al. 1999, we find that the axonal plexus can exhibit three different behaviors depending on the somatic voltage (VS) and gap junction conductance (ggj): (1) noisy non-oscillatory activity, (2) stimulus-driven VFOs as described in Lewis and Rinzel 2000, or (3) re-entrant VFOs where activity forms a spiral wave within the network. While stimulus-driven VFOs stop when external stimulation stops, re-entrant VFOs persist without external stimulation. Moreover, re-entrant VFOs occur for a wide range of VS and ggj in between the regions where we see noise and stimulus-driven VFOs. The behavior of the network is determined by the behavior of axons with the maximum number of connections (4-connected axons). These axons are key because (1) it is harder for them to fire when a neighbor fires relative to axons with fewer connections and (2) 4-connected axons are prevalent in the network. We see noise if 4-connected axons rarely fire, stimulus-driven VFOs if 4-connected axons always fire, and re-entrant VFOs if 4-connected axons fire most of the time but occasionally fail to propagate a spike. We discuss applications of this analysis for VFOs in gamma oscillations, slow-wave sleep, and seizure initiation.

The role of anatomical structure in determining activity in electrically- coupled neuronal networks ***Farzan Nadim*** NJIT/Rutgers

Gap junctions are involved in transfer of ions and small molecules between cells in many tissues. Electrical signaling via gap junctions (electrical coupling) has been implicated in the generation of synchronous electrical activity. We show that signal transfer between electrically coupled neurons is maximized at an optimal diameter of the coupled processes. We then explore the ramifications of this optimal diameter for signaling in a network of electrically coupled model neurons.

Different roles for gap junctions in the dendrites of different inhibitory cell types?
Frances K. Skinner Toronto Western Research Institute, University Health Network and University of Toronto

There are several known subtypes of interneurons in hippocampus (McBain and Fisahn 2001). This diversity of interneurons likely has functional relevance as different interneuron subtypes fire at particular phases of in vivo theta and gamma rhythms, for example, suggesting distinct and specific contributions to behavioural patterning. Interestingly, gap junctions are known to be present on the dendrites of at least three different types of interneurons (Baude et al. 2007; Fukuda and Kosaka 2000). I will describe our use of phase response curves and weakly coupled oscillator theory to help understand the contribution of non-proximally located dendritic gap junctions in inhibitory networks with different intrinsic properties. In this way, different potential roles can be suggested.

Neuronal Gap Junctions Workshop Schedule

08:30-09:00 – Setup, coffee and snacks

09:00-09:35 – Welcome, GJ Introduction, "The effects of rectifying gap junctions on phase-locking in neuronal networks" (*T. Lewis*)

09:35-10:00 – "Role of gap junctions in pattern formation in a network of weakly coupled neural oscillators" (*F. Gurel Kazanci*)

10:00-10:25 – "The axonal plexus: A description of the behavior of a network of axons connected by gap junctions" (*E. Munro*)

10:25-11:00 – coffee break

11:00-11:25 – "The role of anatomical structure in determining activity in electrically-coupled neuronal networks" (*F.Nadim*)

11:25-11:50 – "Different roles for gap junctions in the dendrites of different inhibitory cell types?" (*F. Skinner*)

11:50-12:00 – Further discussion and questions, wrap up (*F. Skinner*)

Each speaker has 20 min to talk with 5 min for questions.

Methods of Information Theory in Computational Neuroscience
Organizers: Aurel A. Lazar, Department of Electrical Engineering, Columbia University and Alex Dimitrov, Center for Computational Biology, Montana State University

Methods originally developed in Information Theory have found wide applicability in computational neuroscience. Beyond these original methods there is a need to develop novel tools and approaches that are driven by problems arising in neuroscience. A number of researchers in computational/systems neuroscience and in information/communication theory are investigating problems of information representation and processing. While the goals are often the same, these researchers bring different perspectives and points of view to a common set of neuroscience problems. Often they participate in different fora and their interaction is limited.

The goal of the workshop is to bring some of these researchers together to discuss challenges posed by neuroscience and to exchange ideas and present their latest work.

The workshop is targeted towards computational and systems neuroscientists with interest in methods of information theory as well as information/communication theorists with interest in neuroscience.

List of presenters
Wednesday, Afternoon Session (2:00 PM - 5:00 PM)
Information Representation and Neural Coding Chair: Paul Sajda

2:00 PM - 2:50 PM, Information Theory and Neuroscience ***Don H. Johnson and Ilan N. Goodman*** Department of Electrical Engineering, Rice University.
Information theoretic methods offer to provide insight into the coding-fidelity capabilities of simple neural populations. Using rate-distortion theory, we show how well populations can represent information. We also analyze the effect of spike-sorting errors on measuring population activity. Beyond theoretical predictions, new developments in information theory offer ways of analyzing data to discover network connectivity. We review these new techniques and indicate how they might be used to study population data.

2:50 PM - 3:40 PM, Temporally Diverse Firing Patterns in Olfactory Receptor Neurons Underlie Spatio-Temporal Neural Codes for Odors ***Raman Baranidharan***, National Institute of Child Health and Human Development, NIH, Bethesda, MD. Also NIST.
Odorants are represented as spatio-temporal patterns of spiking in the antennal lobe (AL, insects) and the olfactory bulb (OB, mammals). We combined electrophysiological recordings in the locust with well-constrained computational models to examine how these neural codes for odors are generated. Extracellular recordings from the olfactory receptor neurons (ORNs) that provide input to the AL showed that the ORNs themselves can respond to odorants with reliable spiking patterns that vary both in strength (firing rate) and time course. A single ORN could respond with diverse firing patterns to different odors, and, a single odorant could evoke differently structured responses in multiple ORNs. Further, odors could elicit responses in some ORNs that greatly outlasted the stimulus duration, and some ORNs showed enduring inhibitory responses that fell

well below baseline activity levels, or reliable sequences of inhibition and excitation. Thus, output from ORNs contains temporal structures that vary with the odor. The heterogeneous firing patterns of sensory neurons may, to a greater extent than presently understood, contribute to the production of complex temporal odor coding structures in the AL.

Our computational model of the first two stages of the olfactory system revealed that several well-described properties of odor codes previously believed to originate within the circuitry of the AL (odor-elicited spatio-temporal patterning of projection neuron (PN) activity, decoupling of odor identity from intensity, formation of fixed-point attractors for long odor pulses) appear to arise within the ORNs. To evaluate the contributions of the AL circuits, we examined subsequent processing of the ORN responses with a model of the AL network. The AL circuitry enabled the transient oscillatory synchronization of groups of PNs. Further, we found that the AL transformed information contained in the temporal dynamics of the ORN response into patterns that were more broadly distributed across groups of PNs, and more temporally complex because of GABAergic inhibition from local neurons. And, because of this inhibition, and unlike odor responses in groups of ORNs, responses in groups of PNs decorrelated over time, allowing better use of the AL coding space. Thus, the principle role of the AL appears to be transforming spatio-temporal patterns in the ORNs into a new coding format, possibly to decouple otherwise conflicting odor classification and identification tasks.

Acknowledgements: Barani Raman is supported by a joint NIH-NIST postdoctoral fellowship award from the National Research Council. This is a joint work with Joby Joseph (equal contributor), Jeff Tang and Mark Stopfer (NICHD, NIH).

4:10 PM - 5:00 PM, Encoding, Processing and Decoding of Sensory Stimuli with a Population of Spiking Neurons ***Aurel A. Lazar and Etychios A. Pnevmatikakis***, Department of Electrical Engineering, Columbia University.
We investigate an architecture for the encoding, processing and decoding of sensory stimuli such as odors, natural and synthetic video streams (movies, animation) and, sounds and speech. The stimuli are encoded with a population of spiking neurons, processed in the spike domain and finally decoded. The population of spiking neurons includes level crossing as well as integrate-and-fire neuron models with feedback. A number of spike domain processing algorithms are demonstrated, including faithful stimulus recovery, as well as simple operations on the original visual stimulus such as translations, rotations and zooming. All these operations are executed in the spike domain. Finally, the processed spike trains are decoded for the faithful recovery of the stimulus and its transformations.

Thursday Morning Session (9:00 AM - 12:00 noon) TBA Chair: W.B. Levy
9:00 AM - 9:50 AM, Bifurcations with Symmetry in Rate Distortion and Information Distortion Optimization Problems ***Alex Dimitrov***, Center for Computational Biology, Montana State University.

9:50 AM - 10:40 AM, Using Feedback Information Theory for Closed-Loop Neural Control in Brain-Machine Interfaces ***Cyrus Omar, Miles Johnson, Tim Bretl and Todd P. Coleman***, Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign.

We propose a complementary approach to the design of neural prosthetic interfaces that goes beyond the standard approach of estimating desired control signals from neural activity. We exploit the fact that the for a user's intended application, the dynamics of the prosthetic in fact impact subsequent desired control inputs. This closed-loop approach uses principles from stochastic control and feedback information theory. We illustrate its effectiveness both theoretically and experimentally - in terms of spelling words from a menu of characters with a non-invasive brain-computer interface.

11:10 AM - 12:00 AM, NeuroXidence: Reliable and Efficient Analysis of an Excess or Deficiency of Joint-Spike Events ***Gordon Pipa***, MIT and Massachusetts General Hospital, and Diek W. Wheeler, Wolf Singer and Danko Nikoli, Frankfurt Institute for Advanced Studies and Department of Neurophysiology, Max-Planck Institute for Brain Research, Frankfurt am Main.

We present a non-parametric and computationally-efficient method named NeuroXidence that detects coordinated firing of two or more neurons and tests whether the observed level of coordinated firing is significantly different from that expected by chance. The method considers the full auto-structure of the data, including the changes in the rate responses and the history dependencies in the spiking activity. Also, the method accounts for trial-by-trial variability in the dataset, such as the variability of the rate responses and their latencies. NeuroXidence can be applied to short data windows lasting only tens of milliseconds, which enables the tracking of transient neuronal states correlated to information processing. We demonstrate, on both simulated data and single-unit activity recorded in cat visual cortex, that NeuroXidence discriminates reliably between significant and spurious events that occur by chance.

Acknowledgements: The authors wish to thank to Sonja Grün and Emery Brown for the fruitful discussions on this project. Also, Gordon Pipa would like to thank to his wife Gabriela Pipa and her family for the great support. This study was partially supported by Hertie foundation.

Thursday Afternoon Session (2:00 PM - 5:00 PM) TBA Chair: Raman Baranidharan

2:00 PM - 2:50 PM, TBA ***William B. Levy***, Laboratory for Systems Neurodynamics, University of Virginia.

2:50 PM - 3:40 PM, Optimal Computation with Probabilistic Population Codes ***Jeff Beck***, Computational Cognitive Neuroscience Laboratory, University of Rochester. Human behavior has been shown to be optimal in a Bayesian/Laplacian (1) sense. This kind of optimality requires a neural code which represents probability distributions a way which allows for the operations of probabilistic inference to be implemented via biologically plausible operations. Within the Probabilistic Population Coding (PPC) framework it will first be argued that optimal neural computation implies a strong relationship between the neural operations which implement probabilistic computation and the statistics of neural activity. As an example, it will then be shown that when the statistics of stimulus conditioned neural activity are Poisson-like, a recurrent neural network which can implement linear combinations of neural activity as well as quadratic non-linearities (and/or coincidence detection) and divisive normalization is sufficient to implement the three basic operations of probabilistic inference: evidence integration, marginalization of nuisance parameters, and parameter estimation/action selection in a wide variety of behaviorally relevant paradigms. As a concrete example, I will present a spike based neural code which tracks the posterior distribution of a particle in Brownian motion in a quadratic potential (i.e. implements a Kalman filter) and then optimally generates motor commands for smooth pursuit.

(1) Though widely credited for the discovery of the rule which bears his name, no direct reference to that rule can be found in his work. Indeed, there is evidence that Bayes was more concerned with reward maximizing decision making and that the form of probabilistic inference currently labeled as Bayesian was best (if not first) elucidated by Laplace in his Philosophical Treatise on Probability:http://ba.stat.cmu.edu/journal/2006/vol01/issue01/fienberg.pdf

4:10 PM - 5:00 PM, Perceptual Decision Making via Sparse Decoding of Neural Activity from a Spiking Neuron Model of V1 ***Paul Sajda***, Department of Biomedical Engineering, Columbia University.

Recent empirical evidence supports the hypothesis that invariant visual object recognition might result from non-linear encoding of the visual input followed by linear decoding. This hypothesis has received theoretical support through the development of neural network architectures which are based on a non-linear encoding of the input via recurrent network dynamics followed by a linear decoder.

In this talk we will consider such an architecture in which the visual input is non-linearly encoded by a biologically realistic spiking model of V1, and mapped to a perceptual decision via a sparse linear decoder. Novel is that we 1) utilize a large-scale conductance based spiking neuron model of V1 which has been well-characterized in terms of classical and extra-classical response properties, and 2) use the model to investigate decoding over a large population of neurons (>1,000) and diverse biological constraints (e.g. Magno vs. Parvo architectures). We compare decoding performance of the model system to human performance by comparing neurometric and psychometric curves. We see that a recurrently-connected V1-type encoding followed by a sparse linear decoder can achieve supra-accurate decoding relative to human behavioral performance.

A tutorial on neuroConstruct

Presenters: Padraig Gleeson, Volker Steuber

This workshop will be a hands on tutorial for those interested in creating biophysically detailed single cell and network models with neuroConstruct (http://www. neuroConstruct.org). It will provide a broad overview of the range of features available to facilitate development and analysis of complex 3D models on the NEURON, GENESIS (and currently in development, MOOSE) simulation platforms.

It will cover the core features of the application including: importation and validation of detailed neuronal morphologies (e.g., from Neuromorpho.org); creation and use of ion channel and synaptic mechanisms, both in native simulator script and specified in ChannelML (the latest version of all of the NeuroML specifications is available at http://www.morphml.org:8080/NeuroMLValidator); generation of complex 3D network connectivity; inbuilt tools for single cell and population activity analysis. A number of cell and network models which have recently been converted to neuroConstruct/NeuroML format will be shown including cell models from the hippocampus (Migliore et al., 2005) and cerebellum (De Schutter and Bower, 1994), and a thalamocortical network model (Traub et al., 2005).

A number of new and under development features will also be presented, including support for the compact HDF5 file format (for storing network structure or cellular activity) and automatic generation of network simulations for parallel computing environments. The initial implementation of the Python based interface for controlling neuroConstruct via script files (e.g. to generate and analyze large numbers of simulations) will also be demonstrated.

Some basic knowledge of simulators such as NEURON and GENESIS prior to the tutorial would be a big advantage for participants, who are encouraged to confirm attendance to p.gleeson@ucl.ac.uk before the meeting.

De Schutter, E., and Bower, J.M. (1994). An active membrane model of the cerebellar Purkinje cell. I. Simulation of current clamps in slice. J Neurophysiol *71*, 375-400.
Migliore, M., Ferrante, M., and Ascoli, G.A. (2005). Signal propagation in oblique dendrites of CA1 pyramidal cells. J Neurophysiol *94*, 4145-4155.
Traub, R.D., Contreras, D., Cunningham, M.O., Murray, H., LeBeau, F.E., Roopun, A., Bibbig, A., Wilent, W.B., Higley, M.J., and Whittington, M.A. (2005). Single-column thalamocortical network model exhibiting gamma oscillations, sleep spindles, and epileptogenic bursts. J Neurophysiol *93*, 2194-2232.

NIH Funding Opportunities and Grant Writing Skills

Computational Neuroscience Meeting – CNS*2008
Thursday, July 24, 2008

NIH Funding Opportunities Seminar

The NIH offers funding mechanisms targeted for graduate students, postdoctoral fellows, beginning faculty members and established scientists. These include training fellowships and career development awards, training grants and a host of research project grants from small grants to exploratory/developmental grants, regular research project grants, program projects and centers. This presentation will provide useful information on which grant mechanisms are appropriate for each stage of your research career and special initiatives.

Grantsmanship Seminar

Are you a graduate student or postdoctoral fellow seeking an NIH fellowship or a career development award? Are you a newly established faculty member planning to write your first NIH research grant application? Then this workshop is especially for you! Although primarily directed to new investigators, the seminar is open to all interested persons. To write a successful NIH grant application, you'll need to understand the NIH granting philosophy. This presentation will focus on how to write a successful grant application, the grant review process, what a grant review committee looks for in an application, and how to respond to a less-than-favorable review.

Additional Information

There will be time allotted for questions and discussion after the formal presentations. Links to relevant URLs for NIH grant application and for grantsmanship issues in general, common mistakes in NIH grant applications, and a technical checklist for writing a grant application will be available as handouts.

Speakers

The seminar speakers have presented this information at numerous meetings and conferences held at universities and institutions throughout the United States and worldwide. They are both program officers responsible for large portfolios of scientific research grants in the NIH Extramural Programs.

Yuan Liu, PhD, is Chief of the Office of International Activities, and Director of the Computational Biology & Bioinformatics Program at the National Institute of Neurological Disorders and Stroke, NIH, DHHS.

Dennis L. Glanzman, PhD, is Chief of the Theoretical and Computational Neuroscience Research Program, and Coordinator for Multi-Scale and Cross-Disciplinary Research at the National Institute of Mental Health, NIH, DHHS.

Directions & Transit Map

The Benson Hotel to the Workshops

Walk 0.27 mile northwest from The Benson Hotel to NW 11th & Couch

Walk a short distance northeast on SW Broadway.
Turn left on SW Oak St.
Walk 0.18 mile west on SW Oak St.
Bear left on W Burnside St.
Walk a short distance west on W Burnside St.
Turn right on NW 11th Ave.
Walk a short distance north on NW 11th Ave.

Board Portland Streetcar to South Waterfront
Get off at SW Moody & Gibbs (under the aerial tram)
Cross SW Moody to the Center of Health and Healing and take elevator to the 3rd floor.

University Place to the Workshops

Walk 0.19 mile north from University Place to SW 3rd & Harrison

Cross SW Lincoln St. onto SW Pedestrian Tr.
Walk 0.17 mile north on SW Pedestrian Tr.
Turn right on SW Harrison St.
Walk a short distance east on SW Harrison St.

Board Portland Streetcar to South Waterfront
Get off at SW Moody & Gibbs (under the aerial tram)
Cross SW Moody to the Center of Health and Healing and take elevator to the 3rd floor.

Ondine (student housing) to the Workshops

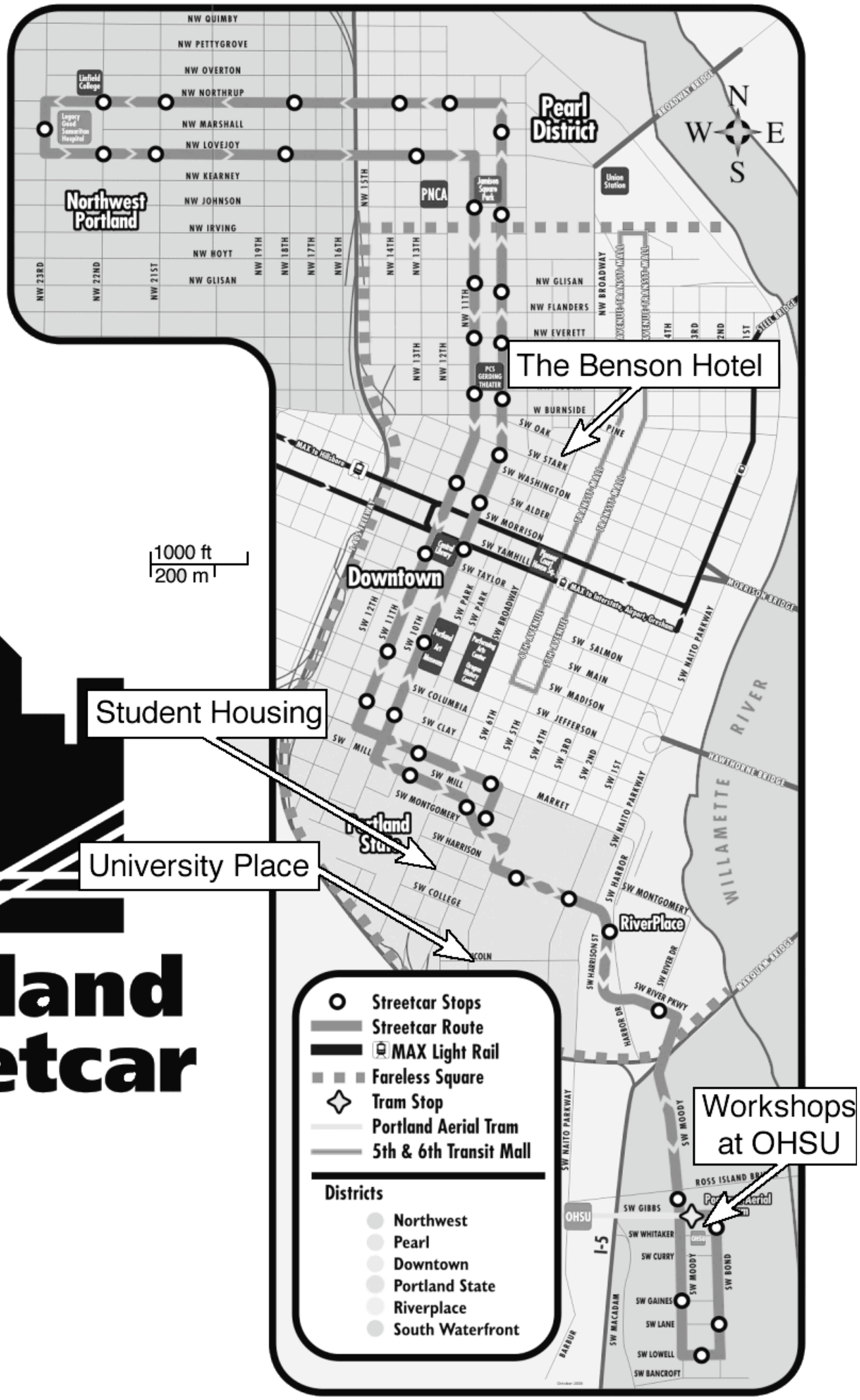
Walk 0.18 mile northeast from Ondine to SW 5th & Montgomery

Walk a short distance north on SW 6th Ave.
Turn right on SW Harrison St.
Walk a short distance east on SW Harrison St.
Turn left on SW 5th Ave.
Walk a short distance north on SW 5th Ave.

Board Portland Streetcar to South Waterfront
Get off at SW Moody & Gibbs (under the aerial tram)
Cross SW Moody to the Center of Health and Healing and take elevator to the 3rd floor.

University Place to The Benson Hotel
Walk 0.19 mile north from 310 SW Lincoln St to SW 3rd & Harrison
Cross SW Lincoln St. onto SW Pedestrian Tr.
Walk 0.17 mile north on SW Pedestrian Tr.
Turn right on SW Harrison St.
Walk a short distance east on SW Harrison St.
Board Portland Streetcar to NW 23rd Ave
Get off at NW 10th & Couch
Walk 0.27 miles to The Benson Hotel
Walk a short distance south on NW 11th Ave.
Turn left on W Burnside St.
Walk a short distance east on W Burnside St.
Bear right on SW Oak St.
Walk 0.18 mile east on SW Oak St.
Turn right on SW Broadway.

Ondine (student housing) to The Benson Hotel
Walk 0.18 mile northeast to PSU Urban Center:
Walk 0.16 mile north on SW 6th Ave.
Turn right on SW Mill St.
Walk a short distance east on SW Mill St.
Board Portland Streetcar to NW 23rd Ave
Get off at NW 10th & Couch
Walk 0.27 miles to The Benson Hotel
Walk a short distance south on NW 11th Ave.
Turn left on W Burnside St.
Walk a short distance east on W Burnside St.
Bear right on SW Oak St.
Walk 0.18 mile east on SW Oak St.
Turn right on SW Broadway.



Portland Streetcar

Portland Lunch Restaurants

Lunch at The Benson Hotel

Palm Court: Lunch Buffet $15.95 Per Person
The London Grill, Located on The Lower Level of the hotel

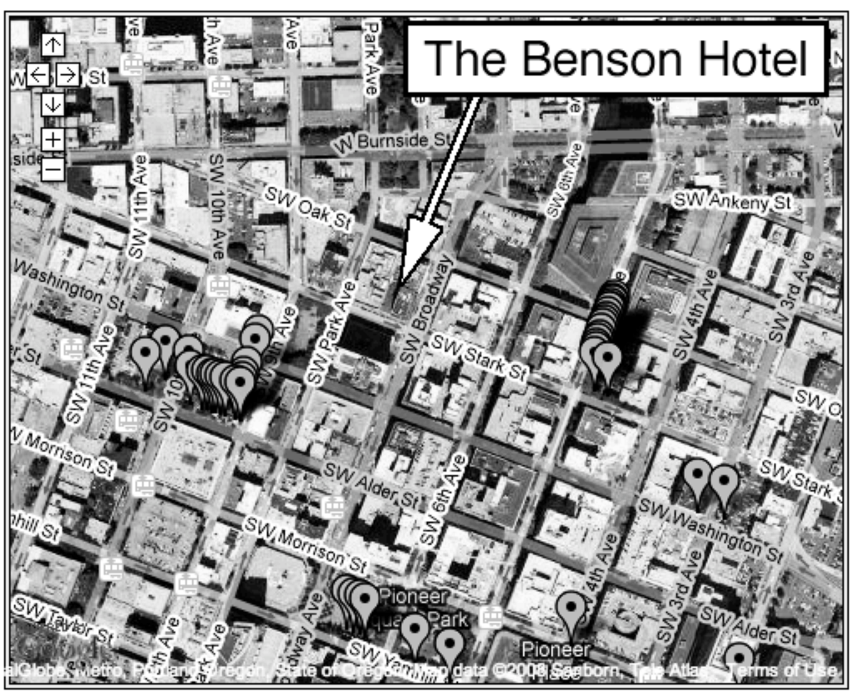
Lunch Outside the Hotel, In 30 minutes…

Pizzacato - 705 SW Alder (On Broadway & Alder Street)
Great Harvest Bread Co. - 540 SW Broadway (On Broadway & Alder Street)
Baja Fresh - 1121 W. Burnside St. (On Burnside & 11th Avenue)
Whole Foods - 1210 NW Couch (On 12th & Couch Street)
Tully's - 845 SW 4th Avenue (On 4th & Washington Street)
Subway - 619 SW Park Ave (On Park and Alder Street)

Lunch Outside the Hotel, In 60 minutes…

Pazzo Ristorante – 627 SW Washington (On Broadway & Washington)
Typhoon – 410 SW Broadway (On Broadway & Stark)
The Greek Cuisina – 404 SW Washington (On Washington & 4th)
Rock Bottom Restaurant & Brewery – 206 SW Morrison (On 2nd & Morrison)
Portland City Grill – 111 SW 5th Ave, 31st Floor

Lunch Food Carts: Each Google pointer locates a unique cart near the Benson.



Lunch Choices

- Barbecue
- Bento
- Bosnian
- Burritos
- Crepes
- Espresso
- Hamburgers
- Hot Dogs or Sausages
- Indian
- Japanese
- Mediterranean
- Mexican
- Peruvian
- Polish
- Sandwiches
- Soup
- Thai
- Vegetarian
- Vietnamese

Author Index

Notes

Notes

Notes

NIMH
National Institute of Mental Health

MIT Press

HFSP Journal
Frontiers of Interdisciplinary Research in the Life Sciences

National Institute of Neurological Disorders and Stroke

Neuralynx
High Density Electrophysiology Recording Systems

Royal Society Publishing
Informing the science of the future

BioMed Central
The Open Access Publisher

Springer
the language of science

nncn

National Bernstein Network for Computational Neuroscience, Germany