INTERNATIONAL SOCIETY FOR NEUROETHOLOGY

Newsletter

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PRESIDENT ELECT: PLEASE VOTE!

FROM PRESIDENT ALBERT FENG

Dear Colleagues

I would like to take this opportunity to thank the outgoing officers (Malcolm Burrows, Arthur Popper and Sheryl Coombs) who have done a marvelous job over the past three years. During their term, the professionalism that John Hildebrand had established for the ISN was strengthened significantly. We are all indebted to them and their hard work. I hope to continue to lead the society in the direction they have set, as well as new directions that you would wish to pursue. I very much look forward to hearing from you on things we should be doing to promote our discipline.

The Sixth congress in Bonn was a great success! The congress attendance and the scientific presentations were super, and the congress location was ideal. I hope you enjoyed the meeting as much as I did. The Congress organizers led by Horst Bleckmann and the student helpers did a splendid job organizing the meeting. The Congress Program Committee, under the stewardship of Hermann Wagner, put together a very exciting scientific program. We very much appreciate their fine work! Of course, your s

strong participation in the congress was the ultimate recipe for the success. The organizers and chairs of the symposia and plenary lectures of the Bonn congress have kindly prepared summaries of highlights of these sessions - these reports are presented in this *Newsletter* for your perusal.

Many of you have responded to the congress questionnaire that I sent out to you earlier, and some have made excellent suggestions for further improvements for future congresses. To them I wish to express my sincere thanks. I have recently appointed an ad hoc Long Range Planning Committee (Arthur Popper as chair, Ansgar Büshges, Ichiro Fujita, Ron Harris-Warrick, Cathy Rankin), with specific charge and duties. One of the duties is to evaluate the members' responses to congress questionnaire, and to prepare a report based on the findings. This report will be presented in an upcoming newsletter.

The post-congress election is now underway! The mail ballots have been sent to you by surface mail. We have a slate of excellent nominees/candidates. ***Please take a moment to vote***!

Finally, there are seven councilors (Kioshi Aoki, Avis Cohen, Sten Grillner, Ed Kravitz, Peter Narins, Gerhard Neuweiler, and Catherine Rankin) whose term of office has expired. On behalf of the society, I wish to thank them for their important contributions.

With best wishes, Albert Feng

ELECTION OF OFFICERS

You will shortly receive, or may already have gotten, a ballot for the new officers for ISN along with a biographical sketch of each candidate. The list of officer candidates is below. Please be sure and make your selections and return your ballot right away. The future of the Society is in your hands and so it is important that all members contribute to the voting.

President_elect: Ed **Kravitz** USA, Axel **Michelsen** Denmark
Secretary: Brian *Mulloney* USA, Janis *Weeks* USA
Treasurer: Sarah **Bottjer** USA, Sheryl **Coombs** USA

Council: Shelley A. **Adamo** Canada, Horst **Bleckmann**, Germany, Alison **Doupe** USA, Martin **Giurfa** France, Ryohei **Kanzaki** Japan, Harvey **Karten** USA, Eric **Knudsen** USA, Frederic **Libersat** Israel, Dorothy **Paul** Canada, Claire **Rind** UK **Sakai** Japan, Mandyam **Srinivasan** Australia, Annemarie **Surlykke** Denmark, Hermann **Wagner** Germany, Harold **Zakon** USA

PESENTATIONS AT 6th CONGRESS

In order to help those who attended the 6th Congress remember the many symposia, and in order to provide members who could not attend with some overview of the many exciting symposia and talks at the meeting, we have asked each of the organizers to provide a short description of the highlights of the organized program. Needless to say, there were also numerous wonderful posters at the meeting, but there is no way that we can include a description of each in the newsletter, as much as we would have liked to have done this. We hope, however, that this “taste” of the meeting will be useful, and wet appetites for attendance at the meeting that will take place in Denmark in 2004.

Plenary lectures 8-9
(Session chair: C. Rind, Newcastle, UK)

Alexander Borst (Berkeley, USA) delivered an impressive lecture on Neural Computation of Visual Motion Information in the Fly. He provided a clear and insightful account of the way the fly is able to extract and use motion over its eyes for course guidance. The direction of motion is not explicitly represented at the level of the retina but rather motion information has to be calculated by the nervous system from the changing images on the retina. Axel Borst examined this process in the fly, a fast-flying vision specialist in which it is possible to study the performance of single cells and small networks of cells as the fly makes visual discriminations. The neurons Borst and his lab have examined are located only a few synapses away from the photoreceptors of the eye and yet they respond in a selective way to motion of the fly in a particular direction. Borst described his experiments using calcium sensitive dyes to image segments of the flies motion detecting neurons to test if processing in a small segment was dependent on the structure of the image, as predicted by the model of directional selectivity proposed by Reichardt and Hassenstein. The dependence of the signal on the structure of the image was found at the level of a small segment of dendrite however it did not appear in the output of the neuron as a whole. This was because the dendrites of the cell were oriented along the direction of motion ensuring integration removes any ripple visible at the local level. Borst and co-workers have also used information theory and discovered that the information rate carried by a motion detecting neuron is limited either by the noise of the visual pattern (photon noise) or the neural hardware, but not the stimulus entropy rate (e.g. stimulus frequency). The neurons were found to adapt to particular stimulus conditions so that they were able cover the dynamic range of a given stimulus. This adaptive rescaling of their response acts to keep information transmission constant in the face of dynamically changing visual inputs.

Small networks of neurons extract motion cues and interactions between neurons enhance the tuning of the cells for particular movements of the fly- for example rotation versus translational movements. Axel predicted that the cellular organization of the flies motion circuitry would be understood in his lifetime. Luckily for us he is still in his prime!

In his lecture on Fly Memories-What, Where and How, Martin Heisenberg (Würzburg, Germany) gave an overview of research on learning and memory in flies. He began by revealing that a male *Drosophila* can remember being rejected in love for up to 10 days after the event. Flies can remember unprecedented consequences of their actions (operant conditioning) as well as novel groupings of cues in the world (classical conditioning). Both types of memory have been shown to improve their ability to make decisions. The cells responsible, at least for olfactory memory are the 700 neurons in the mushroom bodies within the fly brain. Flies do not remember if activity in the 700 neurons are blocked, and it is only in these cells that cAMP dependent synaptic plasticity is necessary for the laying down of short-term olfactory memory. An important point made by Martin Heisenberg is that memory is not dependent on circuitry but can be manifest in single cells. Memories can be stored in an instant and can last for many days. In visual memory, features that are close together are stored as a single figure. *Drosophila* visual memory can hold at least four figures in parallel. Surprisingly visual memories can initially be erased by changes in the context the fly finds itself in. Martin Heisenberg detailed how visual memory, in contrast to olfactory memory is not stored in the cells of the mushroom body but the mushroom bodies contribute to the robustness of visual memories so that the memory is no longer dependent on the context in which they were acquired. Memory is not simple even in a fly the size of *Drosophila.*

Plenary lectures 13-14
(Session chair: C. Rankin, Vancouver, Canada)

The first plenary talk on Friday morning was by Dr. John Hildebrand (Tuscon, USA) who spoke on Neural Processing and plasticity underlying odor-modulated behavior in moths. The data from this talk ranged from the level of behavior to neuroanatomy to neurophysiology. John gave us a marvelous story about how the moths' brain processes pheromones. The story was one of a dynamic neural complex with the temporal firing pattern of afferent cells providing information for higher centers to process changing olfactory inputs.

The second plenary talk was by Dr. Barbara Webb (Scotland, UK) who spoke about using robots to model animals. Barbara gave an informative history of robots built to resemble animals. She talked about ways that robots could help us to understand biology and offered us videos of several fascinating robots that are modeled on biology, including her own robot cricket. This was an excellent talk to introduce people to the area of robot modeling.

Symposium #1 – Venom Cocktails and the Orchestration of Prey Paralysis
Organizers: M. Adams (U.S.A.) & F. Libersat (Israel)

Venomous animals employ diverse biochemical strategies to subdue and exploit their victims. Predators generally aim to immobilize prey rapidly for direct consumption, whereas parasitoids exploit PREY for extended nourishment of developing progeny. This symposium examined venom cocktails from predator scorpions, spiders, and snakes, as well as parasitoid insect wasps. Scorpions have evolved several classes of toxins targeting different binding sites on sodium channels and consequently different prey specificity. How does this diversity of toxins evolve? Michael Gurevitz (Israel) described C-terminal tail wiggling, whereby the C-terminus varies considerably in its attachment to the toxin surface via the 4th disulfide bond. The variable location of this attachment has led to a striking diversity of binding faces optimized for different ion channel receptor architectures. Michael Adams (USA) described simple vs. complex spider venom cocktails and synergism between components. The orb weaver spiders inject a cocktail, which consists of polyamine-like antagonists with high concentrations of the neurotransmitter L-glutamate. The presence of glutamate maximizes availability of toxin binding sites, enhancing the efficacy of the polyamine toxins. Funnel web spiders also employ use-dependent polyamine toxins, but with sodium channel activator toxins, which lead to excessive release of endogenous glutamate. A third class of toxins induces slower, but irreversible antagonism of presynaptic calcium channels, thus blocking transmitter release. Alan Harvey (UK) described joint actions of krait, cobra and mamba venom toxins. Asian kraits combine alpha-bungarotoxins, blockers of nicotinic receptors, with beta-bungarotoxins, which act presynaptically to decrease transmitter release. The two classes of toxin produce a more rapid onset of flaccid paralysis than either one alone. African mambas instead produce excitatory paralysis through the actions of dendrotoxins targeting presynaptic potassium channels and fasciculins, blockers of acetylcholinesterase. Fred Libersat (Israel) wove a story of voodoo rituals and zombies. The main protagonists are a parasitoid wasp and a cockroach host. The wasp injects a cocktail of dopamine and protein toxins directly into the central nervous system, the desired effect being behavior modification instead of paralysis. Two stings are observed, one into the thorax to produce a temporary paralysis, the second into the subesophageal ganglion and the brain to induce frantic grooming followed by lethargy of the host for 5 weeks. The compliant host cooperates with the wasp, allowing itself to be led into a burrow, whereupon it acquires a single wasp egg and subsequently serves as the sole food source of the developing parasitoid. Libersat showed a stupendous movie of the entire sequence - it was a hit. Overall, the symposium covered a number of themes, including toxin evolution, joint actions of venom toxins, and behavior modification by venoms.

Symposium #2 – Visual Ecology and Physiology of Invertebrate Color Vision

Organizers: K. Arikawa (Yokohama, Japan) and D. Stavenga (Groningen, Netherlands)

The theme of the symposium was covered by five presentations on a few exemplary cases where recently considerable progress has been achieved on the relationship between ecology and color vision of invertebrates.

In the first talk by Cronin it was shown that the strongly varying chromatic environment of marine animals correlates with the spectral characteristics of the receptors. The visual system of mantis shrimps appears to be spectrally adapted to the local habitat. Hempel de Ibarra demonstrated with intricate behavioral experiments on the honeybee, using colored patterns, that processing of chromatic and achromatic contrast depends on the distance of the pattern and the spatial distribution of the contrast in the patterns. This will play a crucial role in flower detection by honeybees. Behavioral experiments on nocturnal hawkmoths presented by Kelber demonstrated that color vision is present at extremely low light intensities, where humans are completely color blind. Arikawa discussed the amazing complexity of the retina of papilionid butterflies. The modular array of the retinal ommatidia is composed of three classes, with unique combinations of photoreceptors and screening pigments, yielding highly tuned sensitivity spectra. Some photoreceptors express more than one type of rhodopsin. The papilionid butterflies have now shown to possess excellent color vision, including color constancy. Stavenga further emphasized the striking heterogeneity in the ommatidial characteristics of butterfly eyes, that can be visualized with a novel optical method.

The retinal heterogeneity and its possible function was also highlighted in a perfect sequel to the Bonn meeting: a conference on ‘Invertebrate Vision’, held near Lund (Sweden) in the week following Bonn. Several of the participants were in both meetings. In his Sweden presentation, White (Boston) revealed by molecular biological techniques that a surprising retinal heterogeneity is present in moths. Briscoe (Arizona) showed related findings in diurnal butterflies. Cronin added to his Bonn presentation an extensive overview of the stunningly colorful eyes of stomatopods.

Although color vision is a classical subject of neurobiology, the neuronal mechanism underlying color vision is hardly understood in any animal including vertebrates. This is largely due to the enormous complexity of the brain. As demonstrated in the symposium in Bonn and the subsequent conference in Lund, we have accumulated a substantial amount of knowledge about the function of the input device, the compound eye, and the basic features of color vision capacity by a number of behavioral experiments. Based on the present state of the field, one of the obvious trends in the next decade would be to ask how and where in the brain wavelength information is processed into the recognition of ‘color’. Such attempts in the small brain of invertebrates would provide a major breakthrough to our understanding about color vision mechanisms in general, and thus would expand our insight in the basic design of brain.

Symposium #3 – Constancy of Perception: Neuroethological and Comparative Aspects

Organizer: V. Bastakov (Moscow, Russia)

For proper spatial orientation, animals utilize information of the physical parameters of external stimuli. However the brightness of an object, its size, shape and color largely depend on the characteristics of the environment. The aim of this symposium is to discuss what is known about mechanisms of constancy perception in various sensory systems and at in animals of various evolutionary levels of development. Justin Marshall and Tom Cronin presented both electrophysiological and microspectrophotometric evidence showing that the stomatopod eye has 16 anatomically distinct types of photoreceptor. They discussed whether these photoreceptors are connected with color constancy or not. Vadim Maximov and Oleg Orlov described color-dependent mate choice in common toads *Bufo bufo* and experiments that indicate that relative attractiveness of color stimuli was independent of illumination color in a wide range of tested conditions and a linear function of color coordinates (R, G and B) of the light reflected from

ISN members enjoying a comfortable evening on the Rhine

them. Galina Rozhkova discussed the space constancy mechanism in cricket cercal system - this system provided adequate processing of inputs from hair receptors in consideration of positional information that could be used to provide an invariant estimation of signal direction. The theme of constancy of perception was developed further by Vladimir Bastakov, who discussed size constancy mechanisms in frogs and toads and described that, without visual structural background, prey-catching or escape responses of frogs and toads to stimuli moving around on fixed distances were triggered depending on the perceived size of the object and perceived distance. Inappropriate reactions (i.e. escape of a prey-size object and trying to catch a very large one) were the consequences of the wrong estimation of moving object distance, i.e. functionally corresponding to human visual illusions. Constancy perception tasks could be solved in the nervous systems of simple animals (cricket cercal system, stomatopod eye) and vertebrates (frog, toad, man). The comparative method of constancy perception studies is considered to be perspective due to similarity of constancy perception mechanisms in animals of different classes.

Symposium #4 – Avian Models of Complex Information Processing
Organizers: M. Bateson (Newcastle, UK) and S. Healy (Edinburgh, Scotland)

Birds have provided us with some of the best paradigms for understanding the connections between brain and behavior, especially in the realm of complex information processing tasks that involve perception, learning, memory and decision-making. Our speakers were chosen to represent four different problems in bird behavior, and to reflect the different levels of analysis at which behavioral mechanisms can be explored.

Candy Rowe (UK) proposed that the evolution of complex, multimodal animal signals might best be understood by studying their psychological impact on signal receivers. Her experimental evidence highlighted the importance of studying sensory integration at all levels in receivers in order to appreciate fully the design of multisensory communication.

Anna Gagliardo (Italy) reviewed the evidence for an odor-based navigational map in homing pigeons. She described the ontogeny of this map and presented evidence that it can only be acquired if pigeons are exposed to odor information during a sensitive period in development. Lesion studies suggest that the avian hippocampal formation is involved in learning the navigational map, although young hippocampal birds can still learn a map if they are subjected to training flights following surgery.

Melissa Bateson (UK) presented the hypothesis that the computation of rate of energy intake while foraging requires an internal clock capable of timing short time intervals in the seconds to minutes range. She presented evidence that foraging starlings have such a timing ability. Pharmacological manipulations have revealed that the neurotransmitter dopamine is involved in the control of the speed of the pacemaker underlying this clock.

The relationship between variation in the size of a brain region and its putative cognitive output was discussed by Susan D. Healy (Scotland). She described recent behavioral experiments that show that the large hippocampus of food storing tits may be specifically associated with increased duration of memory rather than improved accuracy of memory or higher number of locations remembered.

Symposium #5 – Multi-modal sensory guidance of complex behaviors
Organizers: S. Coombs (Chicago, USA) & J. New (Chicago, USA)

Animal behaviors rely upon the integration of information from a number of sources of sensory information. The assembly of this information into a coherent and useful “gestalt” upon which appropriate behavioral responses can be generated is a fundamental role of the brain. This symposium brought together investigators who have used a variety of approaches to address questions of how sensory systems extract different kinds of information and how the relative contributions of different systems might change during the time course of a given behavior.

At least five, overriding principles have emerged from this symposium. One, different submodalities of the same sensory system can underlie different behaviors. For example, the ability of fish orient to uniform flow fields (rheotaxis) or to sources (e.g. prey) of spatially non-uniform fields, is mediated by separate classes of lateral line receptors. Two, different sensory systems simultaneously extract fundamentally different types of information to accomplish a single behavioral objective. The ability of many invertebrates and fishes to track odor plumes involves a mechanosensory-based rheotaxis to air or water currents. Three, the contributions of different sensory systems to a behavior can change as a function of distance to the stimulus. The prey capture behavior of some fishes can be divided into two phases: an initial approach phase that is guided by visual cues and a strike phase guided by either visual or lateral line cues. Four, the relative contributions of sensory systems may depend on changing environmental factors: electroreception dominates the prey capture behavior of weakly electric fish at low water conductivities, but at higher conductivities the mechanosensory lateral line may play a significant role. Five, simultaneous use of different sensory modalities can enhance information transfer and content. In wolf spiders, for example, females are most receptive to courtship by males when both visual and vibratory cues are present.

It was apparent from these presentations that animal models provide a rich source for examining multimodal information processing and integration in nervous systems. This field of investigation offers great promise for a better understanding of the means by which brains guide behaviors.

Symposium #6 – Auditory Information Processing and Echolocation: From Neurons to Robot Bats
Organizers: E. Covey (Seattle, USA) & C. Moss (College Park, USA)

Echolocation in bats is one of the foremost areas in which it is possible to link neural circuitry to specific behavioral patterns. Although neuroethological studies of echolocation have traditionally emphasized sensory processing of echolocation signals, this symposium presented information about aspects of the neural basis of echolocation that have not received extensive publicity. Elisabeth Kalko discussed the relative contributions of phylogeny and environmental conditions to echolocation call design in species that hunt in open versus cluttered space, and those that engage in aerial prey capture versus those that glean prey from surfaces. Thomas Park and Achim Klug showed that single neurons in the midbrain of the free-tailed bat respond to both echolocation and communication calls, and proposed that these responses are largely based on frequency tuning combined with the temporal properties of monaural and binaural excitatory and inhibitory inputs. Nick Fuzessery presented evidence that the pallid bat uses echolocation for general orientation, but relies on passive sound localization to detect prey. It must therefore attend simultaneously to two streams of acoustic information while hunting. Its auditory system contains a high percentage of neurons selective for its echolocation pulse, a feature not observed in dedicated echolocators like the free-tailed bat. These results suggest that this response selectivity helps segregate the parallel, dedicated pathways required for this dual-stream processing. Walter Metzner discussed the neural circuitry used for auditory control of vocal output in bats that adjust their vocalizations to compensate for Doppler-shifts in the returning echoes. Ghose and Moss presented animated data from studies of bats taking tethered insects in a laboratory flight room. They described the temporal patterning, direction and focus of the bat's sonar beam during target selection and interception, and proposed that echolocation signals can be used as an index of attention and selective tracking. Timothy Horiuchi described neurobiologically detailed VLSI circuit models of the bat echolocation system tested in a flying bat robot. Behaviors simulated include target localization in three dimensions, tracking of targets using head movements, and control of vocalization.

Symposium #7 – Polarization Vision
Organizers: T. Cronin (Baltimore, USA) & C. Hawryshyn (Victoria, Canada)

It has been recognized for more than half a century that animals are sensitive to and respond to the polarization properties of natural light fields. Recent research on this polarization sensitivity has progressed well beyond the historical perspective, where its utility has primarily been recognized as contributing to orientation and navigation. In this symposium, we featured a variety of presentations illustrating new results in the developing field of polarization vision (PV).

Marie Dacke presented work done at the Univ. of Lund, Sweden, on PV in the spider *Drassodes cupreus.* This animal has eyes with polarization sensitive receptors that integrate over a large part of the sky. The spiders are primarily active after sunset and that they use polarization cues to find their way back to the nest. Justin Marshall (Univ. of Queensland) followed, discussing the use of specialized polarization signaling systems in the stomatopod crustaceans. These animals have numerous polarization receptor classes, and may even be capable of the analysis of circular polarization as well as of visualizing species-specific signals only used during intraspecific encounters. The theme of polarization signaling was developed further in the next talk, by Nadav Shashar (InterUniv. of Eilat), in his powerful presentation on cephalopod PV. Squids and cuttlefishes also identify prey using this visual modality.

The symposium then turned to vertebrate PV, concentrating on the salmonid fishes. Daryl Parkyn (Univ. of Florida) presented a suite of results on the use of polarized-light cues for orientation, as well as covering properties of visual and central neurons that are specialized for polarization analysis. Craig Hawryshyn continued this theme by introducing new results on multidimensional polarization analysis by the visual systems of marine damselfishes.

Attendees of this symposium were treated to a new window into the ways animals view their worlds, as the symposium provided strong evidence for the incorporation of PV and polarized-light cues into visual domains traditionally assigned to spatial and color vision. The extension of this research avenue into new phyletic groups and new environments suggests that exciting new aspects of PV are yet to be discovered.

Symposium #8 – Dendritic Computation in Neuroethological Relevant Systems
Organizer: R. Eaton (Colorado, USA)

Dendritic computation is of critical importance in understanding all cellular and network functions from the simplest reflex to the most advanced cognition. Technical advances in imaging, electrophysiological recording, and powerful numerical simulation methods have led to a rapid expansion of knowledge and interest in this area. This symposium covered dendritic processing in four different systems:

A. Borst and J. Haag: In most neurons dendrites process the incoming signals of presynaptic nerve cells by converting them into a single, time varying signal that is passed along the axon onto one or many postsynaptic partners. In addition, the dendrites of some neurons, mostly involved in local processing, have been found to possess output synapses, too. In their talk, Borst and Haag described in a fly visual interneuron a type of dendrite with a dual mode of operation: for neurons postsynaptic to the axon terminal the dendrite operates as an integrator, while for neurons postsynaptic to the dendrite it acts as a spatial filter preserving the retinotopic information of the motion image.

G. Cummins, J. Casagrand and R. Eaton: Mauthner neurons of the fish brainstem process acoustic information and trigger sudden avoidance maneuvers. High levels of input convergence to these cells, and other neurophysiological data, suggest that the Mauthner lateral dendrite can compute sound source localization. This process requires a non-linear phase comparison of the sound pressure and acceleration of the sound wave. The talk by this group presented data from modeling studies that suggest testable cellular mechanisms for the discrimination. These mechanisms involve voltage-sensitive conductance changes paired with appropriate location of afferents on the dendritic membrane.

D. Edwards: A lateral excitatory network was found to exist among the terminals of primary mechanosensory afferents that mediate excitation of the lateral giant command neuron for escape in crayfish. When a critical density of afferents is excited, the network recruits unstimulated afferents to provide additional excitation of lateral giant and of mechanosensory interneurons that excite the lateral giant. Depolarization of lateral giants by current injection facilitates the recruitment of afferents, and thereby of the mechanosensory neurons and the lateral giant itself. Edwards suggested that the depolarizing EPSPs would have the same effect, thus creating a situation where the lateral giant enhances its own excitation when its input exceeds a critical value.

G. Jacobs: In the cricket cercal sensory system, primary sensory interneurons are tuned to both the direction and frequency of air currents. Sensory input creates spatio-temporal patterns of activity within a neural map of stimulus direction formed by the sensory neurons. Jacobs presented evidence suggesting that interneurons decode these patterns of activity by virtue of the shape and position of their dendritic trees within the neural map. The decoding mechanism involves a shape-matching algorithm in which the cells respond preferentially to those patterns of activity that most closely match the shape of their dendritic trees. It was hypothesized that frequency tuning could emerge from frequency-dependent phase alignment of synaptic inputs from different classes of afferents.

Jacobs showed that at low stimulus frequencies (30Hz) the spatio-temporal patterns among the sensory neurons were in-phase, providing the maximum amount of synaptic input to some sensory interneurons. In contrast, higher stimulus frequencies (100Hz) produced spatio-temporal patterns among the afferents that were significantly out-of-phase with each other, providing a lower synaptic drive to the interneurons.

Symposium #9 – Auditory Brain Maps and their Relation to Sound Perception
Organizer: G. Ehret (Ulm, Germany)

What else is mapped besides sound frequency (tonotopic map) in centers of the auditory system of animals, from orthopteran insects to vertebrates up to humans? How do further maps relate to and are adjusted by specific requirements of acoustic communication and the acoustic environment of a given species? How may biologically significant information be generated by and extracted from neural activity distributions in maps? How plastic are the maps? The seven contributors to the symposium presented exciting evidence about a map of sound intensity in the cricket CNS (Gerald Pollack), a map of periodicity pitch in the primary auditory cortex of the Mongolian gerbil (Holger Schulze), place maps for sound objects calculated from interaural time differences (Albert Feng), adjustment of space maps in the midbrain of owls and rats by attention (Bernhard Gaese), approaches to maps of combination sensitivity of neurons in the primate higher-order auditory fields to represent phonemes (Josef Rauschecker), circuits of corticofugal modulation of auditory brain maps in bats (Nobuo Suga), and the general significance of auditory maps for sound perception and recognition (Günter Ehret).

Fourteen types of maps (orderly or clustered spatial representations) of sound properties or neural response properties have been described to exist in centers of the mammalian auditory system so far, most in the auditory midbrain and/or fields of the auditory cortex. Auditory maps, similar to maps in the visual system, reflect general strategies to process and represent acoustic information in the brain. It appears that auditory perceptual maps, such as maps of auditory space, are all based on combination sensitivity of neurons in centers of the midbrain or of higher levels of the auditory pathways (of vertebrates). We have just begun to recognize that auditory maps are plastic and subject to modulation and adjustment during the ontogeny of an animal and by mechanisms of attention and learning. Auditory brain maps in adult animals will tell us not only about adaptations of species to their acoustical niches but also about individualized brains reflecting adaptations to individual acoustic experiences and to specific constraints of the acoustic environment.

Symposium #10 – Cognitive Abilities in Invertebrates Robot Bats
Organizers: M. Giurfa (Toulouse, France) & E. Capaldi (Lewisburg, PA, USA)

The main aim of this symposium was to illustrate the most recent research demonstrating that invertebrates are capable of rather complex learning tasks that go beyond elementary associations. Research on invertebrate learning and memory has focused mainly on this kind of associations, that is, on the building of simple associative links between, say, two stimuli or between a stimulus and a response. Recent research demonstrates new ways of thinking about the study of invertebrate behavioral plasticity. In particular, it has been shown that invertebrates are capable of complex spatial learning and of non-elementary, configural learning. In addition, some invertebrates can categorize stimuli and learn identify complex relationships between stimuli.

The talks of Carolyn Sherff (UC Irvine) and Daniel Tomsic (Univ. of Buenos Aires) addressed the problem of memory dynamics in *Aplysia* and in the crab *Chasmagnathus*, respectively. Makoto Mizunami (Hokkaido Univ.) and Stimson Wilcox (Binghamton Univ.) reported new findings showing non-elemental associations in crickets and spiders, respectively. Finally, Paul Graham (Univ. of Sussex) focused on learning visual cues for route guidance in ants.

One of the main conclusions of the symposium is that there are indeed learning performances in invertebrates that cannot be explained on the sole basis of simple associations. The mechanistic basis of such complex learning forms is still unknown but as invertebrates have accessible and relatively simple nervous systems, there is a fair chance in addressing this question at the cellular level. The main highlight of the symposium was caused by a technical difficulty encountered in the symposium room, which affected the delivery of the last two talks. This problem had, however, an unexpected advantage: the symposium was the only one in the conference in which a 45 min general discussion took place. In such a discussion some of the points raised above where intensively discussed by the audience. The use of the term “cognition” was subject of debate. It was concluded that a possible dividing line is not one between cognitive vs. not cognitive abilities, but one between elementary vs. non-elementary forms of learning.

Symposium #11 – Neural Mechanisms of Sound Production: A Comparative Approach
Organizers: B. Hedwig (Cambridge, UK) & U. Jürgens (Göttingen, Germany)

Sound production and acoustic communication systems have evolved in vertebrate and invertebrate taxa and play a major role in the behavior and lifestyle of many animals. For this reason the symposium presented a comparative approach to the neural mechanisms underlying sound production. For the first time it brought together speakers working on completely different model systems, from invertebrates to primates. Besides the general concepts, the species-specific neural mechanisms of vocalization and sound production and the different methods to approach them were emphasized.

Matthias Henning and Paulo Fonseca (Berlin/Lisboa) and Berthold Hedwig (Cambridge) discussed neuronal pattern-generating mechanisms and their control by single identified higher order interneurons in cicadas and in crickets/grasshoppers, respectively. In these invertebrate model systems by intracellular recording and stimulation the functional significance of single identified motoneurons and interneurons for sound production can be demonstrated.

Wolfgang Walkowiak (Cologne) reported on the emerging principles of the central neural organization of vocalization in amphibians, which is closely coupled with respiration. Vocalization related moto- and interneurons can be characterized by intracellular recording even in isolated brainstem preparations. The importance of learning and of auditory feedback to acquire song patterns was addressed by Daniel Margoliash (Chicago) demonstrating the precise temporal activity patterns of neurons in awake and sleeping zebra finches. The data suggest a model whereby efference copy during singing and rehearsal premotor activity during sleep contribute to song learning.

The mapping of auditory feedback on the motor pattern in bats was addressed by Gerd Schuller (Munich). He showed that audio-vocal feedback behavior can be modulated by prevocal structures, which may reflect specific adaptations of bats. Finally Uwe Jürgens (Göttingen) discussed the neuronal organization of vocalization in monkeys. Single unit recordings in awake monkey provide strong evidence for the existence of vocalization-initiation and vocalization-pattern generation in different brain areas.

Symposium #12 – Modulatory Signaling: Conveying Information is Not Always Exciting (or Inhibiting), but Can Be Mind-Altering
Organizer: P. Katz (Atlanta, USA)

This symposium dealt with the implications that modulatory signaling may have for how information is transferred between neurons and even how information is transferred between animals. In the nervous system, neuromodulatory signaling is often mediated by G protein-coupled receptors and has widespread effects, changing the *cellular or synaptic properties of neurons. The roles of neuromodulation in sensory systems, motor systems, and complex social behavior were presented in the symposium.

Using biogenic amine neuromodulation in insects as an example, Alison Mercer discussed the plasticity that confers richness and complexity on modulatory messages. She made the point that one of our greatest challenges is not that there are multiple forms of neural plasticity, but that the mechanisms underlying neural plasticity are themselves are remarkably plastic.

Vladimir Brezina discussed how modulatory signals such as neuropeptides allow a simple neuromuscular system in the mollusc, *Aplysia*, to optimize multiple parameters, giving the animal a greater repertoire of movement amplitude and frequency.

Paul Katz showed that modulatory signals could play more than a subsidiary role; the dynamics of second messenger signaling may form the basis for motor pattern generation in the escape swim of the mollusc, *Tritonia*. Modulatory signaling may also be a target of natural selection in the generation of species-specific behavior.

Thomas Insel discussed how differences in the promoter region of the vasopressin receptor gene may underlie its differential distribution in two closely related species of vole and how this may contribute to differences in affiliative behavior in those species; a small change in the distribution of this G protein-coupled receptor may cause a species to exhibit pair-bonding.

Finally, Stanley Schneider introduced the notion of a modulatory behavior: a vibration signal produced by worker bees produces a contingent action on the state of other bees that depends upon the location of the workers in the hive and the nature of the task they were involved in.

Thus, modulatory signaling may be a ubiquitous means of communication in systems that require complex action. This symposium was the first of three symposia at the meeting that dealt directly with the neuromodulation, suggesting a rising awareness of its importance in the control of behavior.

Symposium #13 – Modulating the Neuromodulators
Organizer: K. Mesce (Minnesota, USA)

In this symposium, participants discussed how potent chemical modulators of behavior are themselves 'modulated' by a variety of influences including: social and developmental events, steroid hormones, and network configurations. By addressing how the physiology and external world of an animal shape the suite of neuroactive substances within the nervous system, the view was promoted that a clearer and more comprehensive understanding of behavioral mechanisms can be achieved. Karen A. Mesce (Univ. of Minnesota) in collaboration with Herman K. Lehman (Hamilton College, NY) discussed how the insect steroid hormone 20-hydroxyecdysone (20-E) was shown to influence octopamine (OA), a biogenic amine similar to norepinephrine. In the insect *Manduca sexta*, 20-E was demonstrated to affect the developmental plasticity of OA synthesis and the production of new OA-immunoreactive (ir) neurons not previously identified. These newly described OA-ir neurons likely contributed to the steroid-induced elevations of OA observed at the end of metamorphosis. The developmental and hormonal regulation of newly identified dopamine-ir neurons was briefly discussed and suggested also to be linked to fluctuations in 20-E during metamorphosis.

The neuromodulator OA was also reported by David S. Schulz (Univ. of Illinois) in collaboration with Gene E. Robinson (Univ. of Illinois) to influence the transition of honey bees from hive workers to foragers. Social factors that influenced this shift also influenced levels of OA in antennal lobes of worker bees, suggesting an interaction between social environment and the neuromodulation of behavior. However, flight experience did not affect OA in antennal lobes; octopamine increased as bees developed towards foraging regardless of whether they were allowed to fly. These results demonstrate that brain amine systems in the honey bee are sensitive to a range of both intrinsic and extrinsic influences.

A continued discussion of social interactions and how they alter the biogenic amines was conducted by Donald H. Edwards (Georgia State). Don outlined how the abrupt decision of one of two fighting crayfish to escape determines the social hierarchy of two crayfish, with the escaping animal identified as the new subordinate and its opponent as the new dominant. Maturation of the hierarchy was shown to be marked by a reduction in the frequency of aggressive interactions as the subordinate comes to avoid the dominant. These behavioral changes appeared to result from neuromodulatory changes that altered the relative excitability of neural circuits that mediated discrete behaviors. Two serotonergic neuromodulatory changes were identified in crayfish: changes in patterns of serotonin release that affected walking and changes in serotonin receptor distribution that affected escape.

The presentation by Michael P. Nusbaum (Univ. of Pennsylvania) brought the focus of neuromodulation to the level of identified circuits. It was stressed how not much information is available regarding the extent to which there is uni- or bi-directional communication between descending projections and the neural circuits they control. Using the stomatogastric nervous system of the crab *Cancer borealis*, it was documented that neuronal circuits do indeed provide functionally important synaptic feedback that regulates the activity, and therefore the influence, of modulatory projection neurons. Michael found that one function of this feedback was to enable one neural circuit (the pyloric circuit) to regulate and coordinate the activity of a distinct but behaviorally-related neural circuit (the gastric mill circuit). Specifically, this feedback enabled the pyloric circuit to control the speed of the gastric mill rhythm and its coordination with the pyloric rhythm.

Symposium #14 – Perception of Nearfield Flow and Its Importance for Animal Behavior
Organizer: J. Mogdans (Bonn, Germany)

Near-field medium flow provides important sensory information which allows animals to detect and localize prey, to avoid predators and to find and communicate with mates and other conspecifics. Thus, animals from many different phyla have developed sophisticated sensory system for flow perception. The principal mechanisms of flow detection are similar in air and water. This became evident in the first talk given by Friedrich G. Barth who showed that some spiders species can have about 900 delicate so-called trichobothria on their bodies which are the most sensitive movement detectors among a broad spectrum of cuticular hair sensilla in arthropods. The interaction between the air and the hair follows to a large degree the principles that are known in fluid mechanics. That air movement detectors are enormously sensitive was further elucidated by Tateo Shimozawa. He showed that the cricket wind receptor achieves a sensitivity which is limited only by Brownian motion of single molecules and is thus comparable to the sensitivity of hair-cells in the inner ear of vertebrates. Among aquatic animals, one of the most striking sensory capabilities is found in copepods, small crustaceans of only 1-10 mm body length. Jeannette Yen demonstrated in a spectacular video presentation that copepods can use their highly sensitive setal arrays to detect, analyze and track hydrodynamic signals produced by conspecifics. The fish lateral line is perhaps the best-known example among hydrodynamic receptor systems. Joachim Mogdans presented electrophysiological data indicating that the lateral line consists of at least two subsystems which can only be distinguished when the system is exposed to running water. That hydrodynamic reception is also found among mammals was demonstrated impressively by Björn Mauck who showed that seals, using only their vibrissae, can find and track the water motions generated by a miniature submarine. Thus seal vibrissae can function as hydrodynamic receptors. The presentations given at this symposium were highlighting behavioral capabilities that depend on flow perception and addressing neural mechanisms that underlie the processing of nearfield flow. The examples presented clearly demonstrate the importance of flow perception, whether in air or in water, for the daily life of animals.

Symposium #15: Designs for signaling: from sense to action
Organizer: P. Simmons (Newcastle, UK)

The main aim of this symposium was to make sense of the various types of signals that neurons use, starting with the encoding of sensory stimuli and progressing through the nervous system to consider motor control. First, John Birmingham described how a stretch-sensitive sensory cell in the crustacean stomatogastric system can switch between two different modes of code, regular spiking and bursting, which enables it to signal extremely slow changes in stretch as well as fast changes. Next, Bernhard Ronacher (with Astrid Franz) revealed new features of a Neuroethology Classic, how grasshoppers identify songs of conspecifics. Surprisingly, at least in one species, successful recognition requires as few as two sound bursts to be heard, and even in the presence of background noise is accomplished in less than half a second. By the feat of recording from pairs of receptors, he showed that this is probably accomplished by an array of parallel receptors producing distinct signals. Deeper in the nervous system, Peter Simmons described intrinsic variability in transmission at two types of synapse in flight control pathways in the locust, and proposed that insect synapses can be clever at minimising noise, but profligate with neurotransmitter. Ansgar Büschges (with

Turgay Akay and Gabriel Knop) considered the ways that sensory signals from different types of proprioceptor can influence walking in locusts and stick insects. He proposed that each joint is controlled by its own central rhythm generating mechanism. Finally, Brian Mulloney talked about modelling studies that compared the effects of input from graded potential neurons with the effects of input from impulse producing neurons onto swimmeret motor neurons in crayfish. These demonstrated that smooth regulation of spike frequency in the motor neurons can be is achieved by the smoothly graded input provided by non-spiking interneurons, coupled with a short membrane time constant. The symposium showed that, in the post-genomic era, there are plenty of long-standing issues about signalling in the nervous system still requiring research. All the talks were about arthropods, which are excellent animals for this, because signals in identified neurons can be related directly to the control of behaviour.

Symposium #16 – Timing is Everything: The Behavior and Modulation of Neural Oscillators
Organizer: H. Zakon (Austin, TX, USA)

Behaviors must be temporally regulated on many time scales. In this symposium we considered oscillators underlying rhythmic behaviors in vertebrates and invertebrates. The periodicites of these oscillators vary from milliseconds (pacemaker neurons of electric fish), to hundreds of milliseconds/seconds (STG/Leech heart/thalamocortical circuits), to days (circadian pacemakers). Talks focused on how oscillators were constructed, how much flexibility or plasticity they show, and how mechanisms of plasticity or intrinsic variation is regulated in systems that must be highly precise in their output.

Participants in Neurobiology of Electrosensory Organisms

The stomatogastric system of crustacea is a simple network which switches among different behavioral outputs. Eve Marder showed that neurotransmitters modulate this circuit in complex ways: similar transmitters may act on multiple ionic currents or, conversely, different transmitters act on the same current. She emphasized the importance of maintaining output stability in a complex circuit and showed that there may be various paths to reach the same point of stablity. Mark A. Masino, showed that in a circuit oscillator that controls heartbeat in the leech, one of the cells switches between being rhythmically active and inactive, how this reconfigures the heartbeat circuit, and how this state change might occur. Such plasticity at the circuit level might be expected in vertebrate circuits. Thierry Bal discussed the influence of cortical feedback showing how activation of descending cortico_thalamic axons is gated by the ascending activity of thalamocortical relay neurons, allowing dynamic, endogenous reorganization of the artificially coupled network. The pacemaker neurons of electric fish, which control the electric organ discharge, are the most precise oscillators known. Yet, Joerg Oestreich showed that their oscillation frequency may be shifted to a new value following synaptic input that occurs during a social interaction called the jamming avoidance response. On a completely different time scale Gene Block illustrated how circadian rhythms in invertebrates and vertebrates are similar: single cells may act as cellular oscillators with crude rhythmicitiy with the precision of the whole circadian oscillator depending on the interactions of the cells in a "neuronal democracy" as Walter Heiligenberg used to say.

NEUROBIOLOGY OF ELECTROSENSORY

ORGANISMS

27- 29. August 2001, Bonn/Germany

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From an informal beginning in Thomas Szabo's lab in Gif sur Yvette in 1989, it has become a tradition to hold an electrosensory satellite forum accompanying the tri_annual International Congress of Neuroethology : Gif_sur_Yvette 1989, Montreal 1992, San Diego 1998. All have been exciting and rewarding events, providing a much appreciated opportunity to bring together those interested in electrosensory systems. This year's meeting held in Bonn on July 27_29th, immediately preceding the 6th ICN congress, was organized by Gerhard von der Emde, Kirsty Grant, and Hans Meek and brought together more than 90 participants from 14 different countries and 5 continents.

The 17th century Poppelsdorfer Schloss and botanical gardens made a beautiful setting for 2 1/2 days of lectures, poster sessions, and discussion and thanks are gratefully extended to our hosts Prof. Horst Bleckmann and the University of Bonn Department of Zoology for their hospitality, and to Dr. Michael Hofmann for his help with onsite organization.

Twenty_two lectures and 50 posters covered all aspects of electrosensory systems from molecular mechanisms served at the cellular level, peripheral electroreceptors, central electrosensory and electromotor networks, the sensorimotor interface and multisensory integration, to theoretical modeling and fish behavior. Such a range of approaches around a common theme gives an exceptional opportunity to formulate an integrative overview of a whole brain system and to obtain a better understanding of fundamental brain mechanisms, how they might govern behavior and in what ways they are useful to the animal. This field of research has always been pleasantly cooperative and the satellite forum was the occasion for many exchanges between laboratories and planning of future collaborative projects.

A number of major advances showed significant progress since the meeting in San Diego three years ago. A great effort has been made in the field of evolution: what can the classification of species tell us about how, and how many times, the electric senses and active electric organs have appeared? Carl Hopkins showed how the discovery of new species and modern molecular analysis is generating a number of surprises in our perception of phylogenetic trees. Ad Kalmijn's overview of the physical mechanisms of electroreception and orientation within electric fields provided an excellent base for a better understanding of how fish (both marine and freshwater species) use their electric sense and several speakers dealt with the extraction of weak sensory signals from background noise and the advantages brought by multisensory integration in orientation tasks. Our guest speaker, Sheryl Coombs, gave a stimulatingly thoughtful (and graphically beautiful) analysis of the similarities and differences between hydrodynamic lateral line and electrosensory systems, dealing in particular with the problems of depth perception and the various neuronal mechanisms available for eliminating unwanted sensory reafference generated by body movement or self_generated noise interference linked to different behavioral contexts. The need for the study of sensory systems in a natural context was also underlined by Horst Bleckmann, who illustrated the very different responses of lateral line mechanoreceptive system neurons evoked in static and flowing water. The physical nature of stimuli seen at the electrosensory surface, generated by objects in the near environment, was a subject that required many of us to stretch our imagination in an effort to see as the electrosensory system sees, and it became evident that the 'Mexican hat' profile of the stimulus was a property common to external, peripheral, and central levels of the image formation process, and essential to perception of spatial contrast and depth. This was beautifully illustrated in a poster of "*Gnathonemus petersii's* electric image gallery."

Study of the dynamic properties of sensory neuronal networks is an on_going area of important progress, now successfully bringing together experimental approaches and theoretical modeling. It is clear that the theoretical approach will be increasingly necessary to understand in greater depth the algorithms used by the nervous system for sensory image representation. Several studies are currently exploring the neuronal mechanisms of temporal and spatial contrast, oscillatory behavior and dendritic integration, and the functional description and role of synaptic plasticity.

Finally, much progress has been made since the last meeting in the area of neuronal networks governing motor control. Bruce Carlson's elegant dissection of midbrain pre_motor network in mormyrid fish, coupled with in depth study of electromotor signaling behavior has brought knowledge of this system close to that of the gymnotid fish. The latter is now being extended by major contributions to the study of long_term hormonal or sensory_induced modulation of electromotor behavior, both at the synaptic and cellular level and in the environmental context associated with reproductive behavioral.

The proceedings of the satellite meeting will be published as a special volume in the Journal of Physiology _ Paris (Elsevier) in Spring 2002. We hope that this will serve as the current reference until a future meeting in Denmark in 2004!

LISTSERV ANNOUNCEMENT

We have found that our membership e-mail list is not completely accurate. Keeping up a list is difficult since people sometimes move or change e-mail addresses without notifying all their correspondents, and especially the listservs they may be using. Thus, we would like to ask that all ISN members check their ISN E-mail addresses directory at http://www.neurobio.arizona.edu/isn/isn.memdir.htm. If you have any corrections, please send them to JohnHildebrand at jgh@neurobio.arizona.edu
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"FIELD" BEHAVIOR

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SCIENCE, SOCIAL CONSCIENCE AND SOCIAL POLICY

PART 1-CBW

Prologue: How is one to reconcile the magnitude of the events of September 11, 2001 in New York, Washington and rural Pennsylvania with the day to day routines of our scientific lives? Shouldn't we be doing something more important? Shouldn't we be doing something to ensure that things like this will never happen again? How can we go into our laboratories and watch flies and lobsters fight, or try for the 80th time to record from that difficult to find neuron, or go after that elusive gene we have been trying to clone for the past six months? The issue for me on the morning of the eleventh was how can I and my co-organizers go on with the scheduled conference on "Pathologies of Mind" that we had assembled for Harvard undergraduates. Little did we realize in our planning sessions six months earlier, how relevant the theme was to be to the events of that day. But go on we did, all the while feeling strongly that we were doing the right thing--to ensure that madmen and fanatics cannot dictate how we spend our lives.

The science we do is important, and can impact dramatically on society. We can cure diseases and *unravel the "Pathologies of Mind" that allow people to carry out actions like those of September 11. We train the next generations of scientific leaders and influence the course of the institutions we are part of. The society we directly impact on may be small but the consequences of our actions can be large. These were to be the themes and ideas of a several part essay I had planned to write concerned with the social consequences of our activities as scientists before the events of the 11th. I feel an even greater urge to write on these themes now.*

I am often asked "why do you study aggression"? My answer invariably has three parts to it. First I say, the study of animal behavior is a trap. Once you start observing animals, and truly watching what they do, you cannot stop. I add that I am continually amazed by what animals are capable of in their lives and am fascinated with and challenged by trying to understand that capability. I sometimes tell a story I heard from Ed Wilson of a woman, who after one of his lectures, came up and asked "Dr Wilson, I have a serious problem with ants in my kitchen. I can't get rid of them. Do you have any suggestions of what I should do"? Supposedly Ed replied "Watch them!" Second, I say, aggression is a fundamental component of the behavior of all animals (well, I've asked my colleagues whether nematode worms like *Caenorhabditis elegans* fight, and they claim they do not). Aggression is necessary for access to territory, food and mates in what for most animals is a hostile world. While manifested in forms given names like maternal aggression, territorial aggression, or predator/prey aggression, all forms of aggression may actually involve closely related or identical final common pathways. To me, sorting out and understanding those pathways is an enormous challenge, and I enjoy enormous challenges. And finally I comment that violence is a serious problem in our society. It's a problem with a biological basis, I note, but we have little knowledge or understanding of the underlying mechanisms. Therefore, I finish with, our hope is that we can contribute something to helping people understand and deal with the origins of violence and possibly, just possibly, contribute to its treatment.

The question that almost always follows, however, is "If you do gain knowledge of the biological basis of aggression, couldn't that be used by governments to control people, or by the military to generate super-soldiers"? To this my reply *used to be* that the more public and widely disseminated information is, the less likely it is to be useful for the generation of weapons. I say "*used to be*" because much has changed since September 11, and now we must ask whether those changes of necessity influence the ways in which science is and should be used in the future. It's interesting that precisely the same argument I *used to* offer was used in justifying the publication of a six-volume series of books in 1973 called "The Problem of Chemical and Biological Warfare" by the Stockholm International Peace Research Initiative.[1] The authors of these volumes state that "A difficult dilemma has confronted us in this task. In collecting together and publishing material necessary for a clear understanding of the problems of CB disarmament, might we not be compromising our objective by disseminating information that could promote proliferation of CB weapons"? They add, however, "Elsewhere we have argued that the service we could do by improving the level of public discussion would be greater than any disservice in transmitting dangerous knowledge." In fact these authors too felt that nations were less likely to produce weapons that could just as easily be used against them and threaten them with extinction. That fear and a small moral compunction against the use of these weapons led to the generation and signing of a comprehensive international treaty in 1975, The Biological Weapons Convention,[2] banning the production and use of weapons of biological warfare. Article one of the Biological Weapons Convention reads *"Each State Party to this Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain: (1) Microbial or other biological agents or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes."* While the Convention was a clear statement of intent to ban these materials as sources of weapons, no means of verification was included in the original document and modern technology has produced new categories of organisms that nations and individuals argue are not included. In the present climate, however, the most important new element introduced by the events of September 11 and its aftermath are that we no longer are dealing with States and well defined borders and we no longer are dealing with individuals concerned about self-preservation. In 1993 a Chemical Weapons Convention banned the development, production and possession of chemical weapons, and this has been ratified by 135 countries including the United States.

My first introduction to what chemical and biological warfare was all about began innocently enough. In the mid-1960s I was visited by four generals from the United States Army Chemical Corps, just at the time our work on GABA as a transmitter compound was beginning to be recognized. Frank (F. O.) Schmitt[3] had called me from MIT that morning to ask whether these officers could visit me. Frank was familiar with our work on GABA as a transmitter compound and the single cell approaches we were taking to explore neuronal function, as I had presented the work at several Neurosciences Research Program workshops in the early 1960s. I had no idea why military people wanted to talk with me, but being young and easily flattered by the attention, I agreed to the visit. A short time later, four distinguished, highly braided individuals showed up in my shared little office. They asked first about my work and then started questioning me about people who might be doing similar work in vertebrate systems. It slowly dawned on me what this was all about. They were there to find out whether there was military potential in the work I was doing for we were working on what turned out to be the major inhibitory transmitter compound in the nervous system of all species, including man.

A few years later, at the time of the Vietnam War, I would have refused to see these military officers. But would I have been right in doing so? After all, my research was entirely supported by U. S. government funding, these men dedicated their lives to the protection of our nation, and here, they felt, was a possible new source of weapons to defend our nation. Even more - what would I do now, in the face of horrific terrorist actions that threaten the entire civilized world? Would I now be willing to meet with a contingent of military officers intent on using information I supplied them with to develop anti-terrorist weapons based on my research?

My lectures to Harvard Medical students in the late 1960s and early 1970s focused on acetylcholine as a transmitter compound, and included pointed comments about the development of nerve gases, their stockpiling and their potential use as weapons in new kinds of wars envisioned by military minds in books like "Tomorrow's Weapons."[4] Since the commonly available nerve gases were substrates for, and then covalently-linked essentially irreversible inhibitors of acetylcholinesterases, the enzymes required for inactivation of acetylcholine at neuromuscular junctions, they had the potential to serve as highly potent weapons of war killing people within minutes of exposure. In "Tomorrow's Weapons," the author J. H. Rothschild discusses the wonders of using weapons of this type to incapacitate or kill people without damaging property, a concept that chilled me. In one scary scenario Rothschild describes tests using the drug LSD-25 on a military command center and incapacitating the human subjects involved. His comment on this result was "Think of the effect of using this type of material covertly on a higher headquarters of a military unit, or overtly on a large organization. Some military leaders feel that we should not consider using these materials because we do not know exactly what will happen and no clear cut results can be predicted. But imagine where science would be today if the reaction to trying anything new had been 'Let's not try it until we know what the results will be'."

The journal Military Review in 1970 featured an article by Carl A. Larsen entitled "Ethnic Weapons"[5] dealing with polymorphisms that naturally exist in enzymes within different ethnic groups and the possibility of exploiting these differences to produce selective vulnerabilities to drug attack. Then there was the plan by the military, uncovered in 1969, to make a "routine" shipment by freight train of 27,000 tons of chemical warfare agents across the United States for dumping in the ocean, because the weapons were leaking and becoming dangerous to stockpile. Half of that shipment, that was to go through major population centers like Indianapolis, Dayton, Knoxville, Cincinnati, Philadelphia and Elizabeth, N.J., contained the nerve gas GB. An army officer supposedly told a newsman at the time that "the gas from a single bomb the size of a quart fruit jar could kill every living thing within a cubic mile, depending on the wind and weather conditions."[6] The army also initially claimed they were not responsible, and then admitted responsibility in the death in 1967 of 6400 sheep in Utah, in farmland close to the Dugway Proving Grounds where secret airborne tests of chemical warfare agents were being carried out. Was it any wonder that I was lecturing to future doctors about the horrors of chemical warfare and about the callous way these materials were being discussed and handled by the military? What also was distressing to me at the time was that scientists had to be involved in all of these activities since many scientific, technical and technological problems had to be solved to make effective weapons of chemical and biological agents.

And now we have anthrax -- weapons-grade anthrax. While the United States relentlessly bombs an invisible enemy in a far-away country, a very few envelopes containing a deadly form of what originally was a bacterial pathogen of animals have caused great concern, even panic within the population at home. It impacts on all of us and on our daily lives in ways that would have been inconceivable just a few short weeks ago. To illustrate, I received an envelope yesterday from Santa Barbara, California without a return address. I don't know anyone in Santa Barbara, nor was I expecting mail from that part of the country. Should I throw the letter out unopened? Deciding instead to open the letter, I put on gloves and a face mask and carefully slit the envelope open at the top. Of course, there was nothing of danger in the envelope - it contained an unsolicited reprint sent out in a general mailing. In our departmental business office two days ago an assistant found dust on her desk after opening the mail (the office had received razor blades in an earlier mailing leaving people on high alert) and called the police. This led to a quiet closing of the floor and an examination by the bomb squad and decontamination agents of what turned out to be just dust. The anxiety level is high in the American populace at the present time and it is not reassuring to know that our government's present policies of retaliation are generating even larger numbers of future enemies of our country and its policies. Wouldn't it be better if we were making as much effort at feeding the starving refugees in Afghanistan as we are at destroying the very small amount of infrastructure that exists in a country that has been at war for decades?

The anthrax mailings must involve scientists and engineers who have been trained in the handling of deadly organisms and in generating forms suitable for transmission through the air. There is a reasonably high likelihood that these individuals learned the care and handling of toxic organisms in our own universities and research laboratories. Moreover, from the media and government sites thusfar targeted, the perpetrators could just as well be any of a number of right-wing organizations in the United States as foreign international terrorists. Once again, the question surfaces though: How can scientists act in ways that pervert their science to inhumane actions of these sorts? Is there any way to ensure that, just as doctors have their Hippocratic Oath promising the delivery of their art to all in need of it, scientists could be persuaded to use their science only for the betterment of mankind?

Actually there is no single form of the Hippocratic Oath, as the original is very outdated in a modern world, but most doctors in the United States on receiving their medical degrees swear to some form of Hippocratic Oath (98% of U.S. Schools administer an oath). All versions include phrases dedicated to using medical knowledge for helping, not hurting people and for offering medical aid to all in need of that aid. A recent issue of the Harvard Medical Alumni Bulletin (Summer 2001) featured a section called "What did you do in the war, Doctor?" that brought home the strength of swearing to an oath of this sort in reminiscences of World War II by Harvard Medical School-educated physicians. Most of the articles talked about how battlefield medical stations treated American *and* German wounded soldiers equally as the casualties of war mounted. Surprisingly on researching the Hippocratic Oath on the web, I discovered that there have been numerous attempts to develop a Hippocratic Oath for Scientists as well. The goal is to have all who receive an advanced scientific degree swear an oath to use their scientific knowledge for the betterment of mankind. Here's one version that I particularly like. *"The Hippocratic Oath for Scientists, Engineers and Executives proposed by The Institute for Social Inventions.*[7] *I vow to practice my profession with conscience and dignity; I will strive to apply my skills only with the utmost respect for the well-being of humanity, the Earth and all its species; I will not permit considerations of nationality, politics, prejudice, or material advancement to intervene between my work and this duty to present and future generations. I make this Oath solemnly, freely, and upon my honor."*

Would this work? Would this prevent science and scientists from using their art in perverse ways? I doubt it, but it just might make someone about to embark on a contrary route pause before moving in that direction.

References and footnotes:

1. Almqvist and Wiksell, Stockholm; Humanities Press, NY; and Paul Elek, London.

2. The Biological Weapons Convention was signed in 1972, entered into force in 1975 and ratified by 143 State Parties including the United States. A previous international ban on chemical and biological weapons, called the Geneva Protocol of 1925, was never ratified by the United States.

3. F. O. Schmitt was the founder of the Neurosciences Research Program (NRP), whose board was a group of distinguished investigators from many disciplines who viewed their role as interpreting the implications and future directions of research in the nervous system.

4. "Tomorrow's Weapons-Chemical and Biological", by J.H. Rothschild, retired U.S. Army Brigadier General, published in 1964 by McGraw-Hill Book Company.

5. Military Review (November 1970), pp 3-11.

6. "Germs and Gas as Weapons" by Seymour M. Hersh in the New Republic, June 7, 1969.

7. The Institute for Social Inventions, 20 Heber Road, London NW2 6AA, UK.

MEETINGS AND COURSES

Marine Biological Laboratory Summer Course
Neural Systems and Behavior

June 16 - August 10, 2002
Directors: Catherine Carr, Univ. of Maryland
and Richard Levine, Univ. of Arizona

An intensive eight-week laboratory and lecture course focusing on the neural basis of behavior, from the cellular and synaptic levels to the analysis of complex systems. Intended for graduate students, postdoctoral students, and independent investigators. Limited to 20 students.

The central theme of the course is the investigation of how neurons and neural circuits produce behavior and plasticity. Laboratory and lecture components combine state-of-the-art neurobiological techniques with behavioral and developmental analyses. The lecture series begins with a consideration of electrophysiological and anatomical principles of neuronal function. Topics then move on to how properties of individual neurons come together in simple neural networks for behaviors such as locomotion, escape, and the generation of rhythmic patterns of activity. Modulation of neural activity and neural circuits by transmitter and hormone action, long-term potentiation, and the biophysical basis of sensory transduction are covered. Finally, emphasizing computational approaches, we consider questions such as how animals process complex auditory stimuli or accomplish spatial and vocal learning. Weekly seminars are given by invited lecturers and distinguished Scholars-in Residence.

The heart of the course is the laboratory, where advanced techniques in cellular neurobiology are brought to bear on neural systems. Methods taught include intracellular recording; single cell dye-injection; single and double-electrode, patch, and whole-cell voltage clamp; analysis of synaptic transmission and plasticity;

brain slice; computational and behavioral approaches. A variety of vertebrates and invertebrates serve as experimental systems.

For further information and application forms, see the course web site: http://courses.mbl.edu/

Summer course in "**Chemosensory Neurobiology in the Marine Environment**" at the Bermuda Biological Station for Research, 16 June 5 July 2002 (3 weeks). We will study chemosensory neurobiology in the marine environment at the physiological, biochemical, and molecular levels. This course emphasizes experimental techniques and approaches to the study of chemosensory biology, and is designed to benefit graduate students and advanced undergraduates who have interests in organismal, systems, cellular, or molecular biology. Laboratory exercises and research projects will use the olfactory system of the spiny lobster, Panulirus argus, as the main teaching and research tool. Receptor cell electrophysiology, immunocytochemistry, BrdU labeling of cell proliferation, biochemistry of receptor and perireceptor phenomena, and molecular biology (PCR, sequencing, and other techniques) will be taught. For more information, contact: Charles Derby, Dept. of Biology, Georgia State Univ., P. O. Box 4010, Atlanta, GA 30302_4010; cderby@gsu.edu, (404) 651_3058 (office), http://www.gsu.edu/~biocdd/

NEW BOOKS BY ISN MEMBERS

A SPIDER'S WORLD _ SENSES AND BEHAVIOR. Friedrich G. Barth, 2001, Springer_Verlag (ISBN 3_540_42046_0, Hardcover, approx. 400 pp., 309 figs., 16 color plates, US$ 69.95, BP 48._, DM 129.90, FF 524). In this book the technical perfection of spider sensory systems for different forms of stimulus energy is put into a broad biological and neuroethological context where the senses serve as links between the species specific environment and behavior.

AUDITORY WORLDS: SENSORY ANALYSIS AND PERCEPTION IN ANIMALS AND MAN, edited by Geoffrey A. Manley, Hugo Fastl, Manfred Kössl, Horst Oeckinghaus and Georg Klump. XIX + 359 pages, 76 Figures, 6 Tables, DM 198,_ ISBN 3_527_27587_8, Wiley_VCH Verlag,Weinheim 2000. Design plasticity in the evolution of the amniote hearing organ; Comparative anatomy and physiology of hearing organs; Cochlear frequency maps and their specializations in mammals and birds; Models of the human auditory system; 5 Active mechanics and otoacoustic emissions in animals and man; Neural processing in the brain; Comparative animal behaviour and psychoacoustics; The human aspect I: Human psychophysics; Hearing impairment: Evaluation and rehabilitation

POSITION ANNOUNCEMENTS

ASSISTANT PROFESSOR ARTHROPOD BEHAVIOR/NEUROBIOLOGY Univ. of California, Berkeley. The Division of Insect Biology, ESPM Dept., invites applications for a tenure_track 9_month appointment at the Assistant Professor level in any area of insect or terrestrial arthropod behavior or neurobiology, starting July 1, 2002. The successful applicant must have a Ph.D. in the biological sciences, an excellent record of scientific accomplishment, strong commitment to undergraduate and graduate teaching, and an interest in being part of a community of insect biologists.Applicants should submit a curriculum vitae, copies of recent publications, statements of research and teaching interests and experience and three letters of references sent to:Professor Wayne M. Getz, Chair, Behavior/Neurobiology Search Committee, ESPM_Division of Insect Biology,201 Wellman Hall, Univ. of California, Berkeley, CA 94720_3112. The closing date for applications is January 4, 2001. The deadline for the letters of reference is January 18, 2002.

The Psychology Dept. at the Univ. of Maryland, College Park, has a tenure-track position at the Assistant Professor level for a neurobiologist who uses animal systems, preferably invertebrate, to study learning, neural plasticity, or adaptive changes in the nervous system that occur during development. Research using molecular and genetic techniques is welcome, as long as it remains strongly linked to behavior. Strong history of research productivity and active scientific program required. Teaching will include graduate and undergraduate courses in behavioral neuroscience, neuroethology, and neuropharmacology. For more information visit: http://www.bsos.umd.edu/cebh/INSjob.html. Applicants should send CV, statement of research interests, and arrange for three letters of recommendation to be sent to: Dr. Robert Dooling, Chair, Neuroscience Search, Psychology Dept., Univ. of Maryland, College Park, MD 20742-4411. Univ. of Maryland actively subscribes to a policy of Affirmative Action and Equal Educational Employment Opportunities. For best consideration, materials should be received by 15 November 2001.

Tenure track faculty position in **Cellular and Molecular Neuroscience** in the Dept. of Biology at the Univ. of Maryland. The successful candidate will direct an innovative and competitively funded research program, and be part of the neuroscience program (http://www.life.umd.edu/NACS/). The candidate will also participate in the instructional program at both the graduate and undergraduate levels (http://www.life.umd.edu/biology). UM is the flagship campus of the University of Maryland System, and is located in the heart of the Baltimore_Washington research corridor. Applications should be received by November 15, 2001 to receive full consideration but the search will continue until the position is filled. Materials, including a letter of application, curriculum vitae, statement of research and teaching interests, and the names and E-mail addresses of four references should be directed to: Neuroscience Search, Dept. of Biology, Univ. of Maryland, College Park, MD 20742_4415. The Univ. of Maryland is an Affirmative Action/Equal Opportunity Employer.

The Dept. of Biological Sciences at Vanderbilt Univ. seeks candidates to fill a rank-open, tenure-track or tenured faculty position in **cellular/molecular neurobiology**. It is part of the growing neuroscience community at Vanderbilt with strong graduate and undergraduate programs. Women and minority candidates are especially encouraged to apply. Applicants should send a letter of application together with a *curriculum vitae*, a statement of current and future research interests, and selected reprints to Neurobiology Search Committee, Dept. of Biological Sciences, Vanderbilt Univ., VU Station B 351634, Nashville, TN 37235-1634 U.S.A. Junior faculty applicants should arrange for three letters of recommendation. Senior faculty applicants should provide a list of at least six references. Review of applications will begin October 29 and will continue until the position has been filled.

TRAINING OPPORTUNITIES

Seeking Masters of Science Student. Our current research emphasis is on the mechanisms of water_flow sensitivity in the nudibranch sea slug *Titania diomedea*, the integration of sensory information, and motor control of crawling and turning. Training in brain cell recording, computer analysis of video, microscopy, and underwater animal observation is available. Financial support is available during the academic year and the summer. Applications will be accepted from biology and cross_disciplinary students (physics, chemistry). The Biology Dept. contains faculty including two neurobiologists, a sensory biologist, and another electrophysiologist with advanced courses in animal physiology, molecular biology systematics, and neurobiology. Please send a curriculum vita, unofficial transcript, a 1_page statement of research interest, and the names and contact information (preferably e_mail) of 2 references to: James A. Murray, Ph.D. Assistant Professor of Biology 156 Lewis Science Center Univ. of Central Arkansas Conway, AR 72035, (501) 450_5923,
E-mail: jmurray@mail.uca.edu http://www.uca.edu/divisions/academic/biology/faculty/jmurray.htm

Postdoctoral Position in Sensory Physiology A postdoctoral position to study auditory processing and plasticity in barn owls is available in the laboratory of Prof. Eric Knudsen at Stanford Univ.. We focus on neural mechanisms underlying sound localization and how they are shaped by auditory and visual experience. We use neurophysiological, pharmacological, anatomical and behavioral techniques. Experience with electrophysiology preferred. Please contact Dr. Eric Knudsen, Dept. of Neurobiology, Stanford Univ., Stanford, CA. 94305-5125. e-mail: eknudsen@stanford.edu

Postdoctoral Fellowships in Neuroethology. The Neuroethology Training Program at the Univ. of Maryland is seeking qualified applicants for postdoctoral fellowships to study the relationships between neural circuits, behavior and evolution. Opportunities to conduct research on sound localization (Carr), comparative psychoacoustics (Dooling), locomotion (Cohen), evolution of hearing (Popper), echolocation (Moss), auditory physiology (Yager), visual system (Hodos), reproductive behavior (Ottinger), biological models of learning (Halperin), evolution of developmental mechanisms (Jeffery), development of auditory CNS (Hall), behavioral genetics and sexual selection (Shaw), and song development (Troyer). Specific interests of the faculty and a complete description of the program can be found at http://www.bsos.umd.edu/psyc/neuroethology/. Applicants must be U.S. citizens or permanent residents, and should send their CV, a brief description of research interests and the names of three references to: Dr. Cynthia Moss, Dept. of Psychology, Univ. of Maryland, College Park, MD 20742-4415. Univ. of Maryland is an Affirmative Action and Equal Opportunity Employer

Postdoctoral Fellowships in Auditory Neuroscience. The Comparative and Evolutionary Biology of Hearing Training Program at the Univ. of Maryland seeks applicants for postdoctoral fellowships to study auditory neuroscience. The program (www.life.umd.edu/biology/cebh) has recently expanded and includes 11 faculty on the College Park campus as well as 12 additional faculty from the intramural program of the National Institute on Deafness and Communication Disorders of NIH. Research organisms extend from insects to humans, and research approaches from molecular biology to whole brain imaging. Specific interests of the faculty and a complete description of the program can be found on our web site. Applicants must be U.S. citizens or permanent residents, and should send their CV, a brief description of research interests and the names of three references to: Dr. Arthur N. Popper, Dept. of Biology, Univ. of Maryland, College Park, MD 20742. Univ. of Maryland is an Affirmative Action and Equal Opportunity Employer

Meeting organizer Horst Bleckmann (Bonn) relaxes with Ted Bullock (San Diego).

A **Postdoctoral Research Scientist** position is available immediately to investigate the cellular and molecular control of post-embryonic development in the olfactory system of a model animal, the spiny lobster. Neuronal proliferation, differentiation, and turnover will be studied using techniques that may include in vivo and tissue culture, immunocytochemistry, in situ hybridization, gene expression, and electrophysiology. Salary is $27,000-40,000, depending on experience. GSU is part of a well-equipped, well-funded, and highly interactive Atlanta Neuroscience community that provides opportunities for collaborative investigations, including the NSF-funded Atlanta-wide Center for Behavioral Neuroscience. Visit http://www.gsu.edu/~biocdd for more information about our work. Send your c.v. (including educational background, research experience, and publication list) and the names, addresses, phone numbers and e-mail addresses of 3 references to: Charles Derby, Dept. Biology, Georgia State University P.O. Box 4010, Atlanta, GA 30302-4010; cderby@gsu.edu, tele 404-651-3058, fax 404-651-2509.

THANKS and FAREWELL

This is my last issue as editor of the Neuroethology Newsletter. It was about five years ago that my friend and colleague Catherine Carr, who was then ISN secretary, asked if I could help her out with the newsletter. One thing led to another and I eventually wound up taking responsibility. These years have been great fun, not only in helping the newsletter grow, but also in meeting people, learning a good deal about colleagues from things they have written, and exploring new ideas for making a newsletter more than just a list of announcements, but instead, a document that people, hopefully, find of real interest. I now turn the newsletter over to your new secretary (TBA) with an offer of support, and trust that this person will enjoy doing the newsletter as much as have I.

I want to thank John Hildebrand for letting me try new things, Malcolm Burrows for his strong suppport, and the rest of the Executive Committee for guidance and collegiality. I also want to thank all of the folks who I have badgered over the years to write columns. All (well, most all!) have been on time (generally), within space limits, and cooperative. Mostly, however, I want to thank Ted Bullock for first suggesting that perhaps we should think "outside of the box" in what we should do with the newsletter. As always, Ted's advice was well worth listening to, and I am deeply grateful.

Ted Bullock (San Diego), Axel Michelsen (Odense), Jochen Wagner (Tubingen), Arthur Popper (College Park), and Shaun Collin (Brisbane)

Buffet dinner on Rhine cruise before being descended upon by hungry ISN members

Rod Suthers (Indiana), Axel Michelsen (Odense), David Yager (College Park, George Pollak (Austin)

Adrian Horridge (Cambridge) and former ISN president John Hildebrand (Tucson)

International Society for Neuroethology
c/o Panacea Associates
744 Duparc Circle
Tallahassee FL 32312 USA

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TO: