AChemS VII Abstracts

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Seventh Annual Givaudan Lecture

1 Explorations of the Insect Olfactory System.
JOHN G. HILDEBRAND (Columbia University)*

Olfaction plays a major role in the regulation of insect behavior. Thus orientation and movement toward, and interaction with, sources of food, receptive mating partners, appropriate sites for oviposition, and hosts for parisitism usually involve olfactory signals that initiate, sustain, and guide the behaviors. We study insect olfaction both to contribute to understanding of the organization, function, and ontogeny of chemical-sensory systems in general and to advance understanding of the earth's most numerous and biologically successful fauna. Our work with an experimentally favorable insect, the sphinx moth Manduca sexta, probes the anatomy, cellular neurophysiology, neurochemistry, postembryonic development, and behavioral roles of the antennal olfactory system and of other related sensory pathways. These efforts focus on the male-specific olfactory subsystem responsible for detecting and integrating information about the female sexual pheromone and on elements involved in sensing host plants. We are especially interested in the cell-by-cell processing of olfactory signals in the CNS, the transmitters mediating intercellular communication in the system, and the role of afferent inputs in the development of the olfactory pathways in the CNS and of behaviors regulated by olfactory information. This presentation will review earlier work and highlight recent progress on the neurochemical anatomy of the system and the molecular differentiation of its cellular elements.

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Second Stanley K. Freeman Award Lecture

2 Intrinsic Connections And Functional Architecture Of The Visual System. T.N. WIESEL, C.D. GILBERT, D. TS'O, (Laboratory of Neurobiology, The Rockefeller University, New York, NY)

The intrinsic connections of the cortex have long been known to run vertically, across the cortical layers. We have found that individual neurons in the cat striate cortex can communicate over surprisingly long distances horizontally (up to 4 mm) in directions parallel to the cortical surface. This pattern of extensive horizontal projections was revealed by combining the techniques of intracellular recording and injection of horseradish peroxidase with 3-D computer graphic reconstructions. The axons of injected cells had widespread fields of projections with clusters of terminals appearing with a periodicity of about 1 mm. The axonal fields were asymmetric, extending for greater distances along one cortical axis than along the orthogonal axis. When axons projected to more than one layer, the clusters in the deeper layer tended to be located under those in the upper layer, suggesting a relationship between the clustering phenomenon and columnar cortical architecture.

We have begun experiments to investigate the relationship between the physiological connectivity of pairs of cells, as shown by cross-correlation methods, and the cells' receptive fields properties. Results in the cat showed that units separated by .2 mm or more with overlapping receptive fields but differing in receptive field properties such as orientation, ocular dominance or directionality had responses which tended not to be correlated. At these distances, pockets of units exhibiting correlated firing had receptive field properties that matched. These findings provide physiological evidence for a functional contribution of horizontal connections and are consistent with anatomical demonstrations of the clustered nature or horizontal connectivity in the visual cortex.

This work was supported by NIH Grants NS16189, EY05253, EY07042, and NSF Grants BNS8318799 and 8351738.

3

Genetic Analysis of Chemoreception in Drosophila. LAURIE TOMPKINS (Department of Biology, Temple University, Philadelphia, PA 19122)*

Drosophila adults will usually extend their proboscises and feed in response to sugars and water, but they will reject most salt solutions. The chemoreceptors that mediate these responses are on the tarsal segments of the legs and on the proboscis. To elucidate the function of the contact chemoreceptors and parts of the central nervous system (CNS) that are involved in the fly's responses to chemicals in solution, several investigators have isolated mutations that perturb the fly's responses to sugars, water, or salts. With respect to the receptors, analysis of the mutations has revealed the existence of a molecule that interacts with one stimulus and has also provided information about interactions between different receptor types. Chemosensory circuits in the CNS are less well-understood; however, one mutation has defined a gene whose product is necessary for the development of parts of the CNS that function when larvae and adults respond to chemical stimuli. Analysis of this mutation and others in genetic mosaics, flies that express the mutations in some tissues but not others, will eventually allow us to identify such circuits anatomically.

*This work was supported by PHS grant GM33511.

4

Genetics of Chemoreception in the Nematode Caenorhabditis elegans. DAVID B. DUSENBERY (School of Biology, Georgia Institute of Technology, Atlanta, GA 30332)

C. elegans is an attractive animal for genetic studies of chemoreception. It has a few well-defined sensilla that appear to be chemosensory and it is an animal in which mutations are easily isolated. By screening many laboratory chemicals, about a dozen different stimuli have been found to attract or repel them. In addition, there is reason to believe that more potent stimuli remain to be identified from natural sources. A couple of dozen single-gene mutations that alter chemoreception have been isolated by various researchers. Many of these have been characterized with respect to the spectrum of chemical stimuli that are altered. Most of these are defective in response to most known chemical stimuli but still respond to some. A few of the mutations cause the response to certain stimuli to change from attraction to avoidance. Many of the mutants have been studied by electron microscopy and of these about half have observable abnormalities in sensory structures. Most of them cause defects in more than one type of sensilla and some cause abnormalities in all the sensilla studied. These mutations have been used to demonstrate that the response to oxygen is probably mediated internally rather than by external sensory receptors.

5

A Genetic Approach to Mammalian Taste. GLAYDE WHITNEY (Psychology Department, Florida State University, Tallahassee, FL. 32306).

A variety of powerful genetic approaches are available which can be applied to a fundamental analysis of sensory mechanisms. One such approach is illustrated through review of a collaborative research project aimed at discovering mechanisms of taste in mammals. The project began with a behavioral survey among inbred strains of mice of preference-aversion to a variety of tastants. Many strain differences were found. One phenotype chosen for initial investigation was aversion to the bitter tastant sucrose octaacetate (SOA). Given profound differences among inbred strains in aversion to SOA, further psychophysical techniques and electrophysiological nerve recordings were used to establish the sensory (taste) mediation of the aversion phenotype. Genetic segregation analysis by ourselves and others suggested that differences at a single genetic locus might be responsible for the observed differences in behavioral response to SOA. A single locus, two-allele system is readily amenable to genetic manipulation. Through genetic manipulation by taste testing and selective backcrossing, new experimental populations can be created. Congenic lines of mice are being bred which approach identity at all genetic loci except that one which mediates the difference in taste sensitivity to SOA. These new genetic lines should be near ideal experimental groups for identification of basic mechanisms of taste.

6

Genotypic Variation in Mammalian Odor Perception: Phenotypes That May Provide Insight into Olfactory Transduction. CHARLES J. WYSOCKI (Monell Chemical Senses Center, 3500 Market Street, Philadelphia, PA 19104)*

Classical genetic methods have made possible some significant contributions in studies of fundamental neurobiology. For example, much progress has been made in understanding chromatic vision and genetic deafness through the use of these methods. However, with few exceptions, these approaches have not been exploited in the study of mammalian nasal chemoreception. Genes may not account for significant variation in olfactory sensitivity within the normal range, but they do contribute to overall variation. Many people with otherwise normal olfactory acuity cannot perceive some odorants at concentrations that are obvious to most other people. Historically called specific anosmias, these deficits may reflect alteractions in olfactory receptors. Approximately 45% of adults have a specific anosmia to androstenone. Studies of twins implicate a strong genetic component of variation in sensitivity to this volatile steroid: identical and fraternal twins were 100% and 61% concordant for sensitivity. Animal models of human specific anosmias may also be useful in electrophysiological, neuroanatomical and biochemical investigations of olfaction. Two related strains of genetically inbred mice (C57BL/6J and C57BL/10J) did not respond to isovaleric acid at concentrations that normally elicit vigorous responses from other strains. A single gene model did not fit the data obtained from tests of generations derived from a classical genetic cross between C57BL/6J and ARK/J (isovaleric acid sensitive) mice. Screening of 28 strains for sensitivity to other odorants suggests that some strains may be specifically anosmic to androstenone or to Thibetolide, a synthetic musk. Studies of populations possessing specific anosmias may provide additional information regarding olfactory transduction in much the same way that studies of color blind individuals provided a firm foundation for von Helmholtz's trichromatic theory of color vision.

*Supported by NIH Grant NS17580

7

Molecular Biology of the Olfactory System.
F.L.MARGOLIS, K.ROGERS, M.GRILLO, Y.S.GOODALL, M.POONIAN, U.GUBLER (RIMB & Dept. of Molec Genetics, Roche Res Center, Nutley, N.J.)

Biological properties of the olfactory pathway include molecular sensing and transduction; neuronal turnover and differentiation; location, connection and modulation of target neuron phenotype; and, regulation of secretion. These qualities are all manifestations of differential regulation of gene expression. Thus, we must probe the olfactory system to identify those gene products responsible for its specific properties. We used two approaches; first, characterize the olfactory marker protein (OMP), its mRNA and clone it; second, identify and characterize other unique gene products of olfactory tissue. OMP is an 18.5 kD cytosol protein found solely in vertebrate olfactory neurons. It has been purified, sequenced and characterized biochemically and biologically but its function is an enigma. OMP is a developmentally and physiologically regulated neuron-specific gene product. Some neuronal proteins with these properties may be coded for by polyA$^-$mRNA but OMP is coded for by polyA$^+$mRNA. OMP mRNA is 2800-3400 nucleotides in length, much larger than predicted from coding requirements alone and could code for a protein 4-5 times larger. *In vitro* synthesized OMP is indistinguishable in size from isolated OMP. Thus, OMP is synthesized directly, not via a larger polypeptide precursor. OMP mRNA must contain untranslated regions much larger than the coding region. The function of this untranslated RNA is unknown but may play a regulatory role intracellularly. Molecular cloning of OMP message is underway as is creation of an olfactory tissue-specific cDNA library. These will enable us to evaluate, for example, if genes or their transcripts expressed solely in olfactory tissue are denoted by characteristic nucleotide sequences. Coupled with our knowledge of its biology, these studies will provide powerful tools to probe the properties and functions of the olfactory system.

8

Monoclonal Antibodies as Probes of the Structure and Biochemistry of the Olfactory Epithelium.
JAMES I. MORGAN and JAMES L. HEMPSTEAD, Roche Institute of Molecular Biology, Roche Research Center, Nutley, N.J. 07110.

A panel of monoclonal antibodies (MAbs) has been raised to the rat olfactory epithelium. These MAbs variously react with, and are markers for, all the known cell subtypes of the neuroepithelium and adjacent tissues. The MAbs also identify novel cell types and specializations of the neuroepithelium. It can also be shown that basal cells as well as receptor neurons share common antigenic determinants with distinct neuronal subsets in the olfactory bulb. This may be a reflection of functional circuitry, possibly pertaining to the control of basal cell differentiation. Also the expression of a number of neuronal antigenic determinants in the olfactory epithelium is regulated by the olfactory bulb. Thus in unilaterally olfactory bulbectomized (OBX) rats neuron staining with some MAbs is greatly attenuated in the ipsilateral mucosa, while neuron staining with other MAbs shows no difference between control and decentralized neuroepithelium. Such lesioning studies also show the presence of novel neuronal subsets and misplaced axonal bundles suggesting the presence of an axon guidance-adhesion system. One antigenic determinant has been identified using the NEU-5 MAb that may be involved in axon-axon adhesion and fasciculation. The antigen is preferentially associated with the axons of the olfactory and vomeronasal nerves and is abundant in the glomeruli of the olfactory bulb. It is also abundant in misplaced axons but is present at low levels in receptor neuron cell bodies. On western blots of both olfactory epithelium and bulb the antigen is a protein of 200 kD, it is absent in all non-neural tissues. In the rest of brain and in peripheral nerves the antigen has a molecular weight of 120 kD. The NEU-5 MAb has been purified and coupled to Affi-Gel 10 and used to affinity purify the 200 kD antigen from neuroepithelium and the 120 kD species from brain stem.

9

Substance P and its precursor forms in hamster olfactory bulb.
Richard M. Kream (Tufts University School of Medicine, Boston, MA 02111), Thomas A. Schoenfeld, Andrew N. Clancy and Foteos Macrides (Worcester Foundation for Experimental Biology, Shrewsbury, MA 01545)

We recently demonstrated in the hamster that the expression of substance P (SP) and tyrosine hydroxylase by second-order olfactory bulb neurons is dependent on the integrity of primary afferent neurons (Kream et al., J. COMP. NEUROL., 222:140-154, 1984). Chemically authentic SP was shown to be localized in external tufted cells of the main olfactory bulb and in centrifugal afferents of the olfactory bulbs and peduncle. Following peripheral deafferentation, SP was markedly reduced in external tufted cells but not in centrifugal afferents. In subsequent studies we have found that the levels of SP in centrifugal afferents but not in the intrinsic neurons are dependent on the levels of circulating gonadal hormones. The olfactory bulbs thus provide an ideal model system for research on transneuronal or hormonal regulation of peptidergic expression and processing. To pursue such studies, we have generated antisera that are capable of recognizing precursor forms. The antisera are directed against unamidated C-terminal extensions of SP, i.e., SP-gly (SP-G) and SP-gly-lys (SP-G-L), that have been shown to be internal sequences in preprotachykinin molecules. In radioimmunoassays with these antisera, basal levels of precursor are found to be low relative to the level of mature peptide, and to rise after protease treatments. SP-G-L precursor determinants are liberated from heterogeneous larger forms by trypsin treatment, and are converted into SP-G determinants after subsequent treatment with carboxypeptidase B. Immunohistochemical staining of centrifugal afferents using anti-SP-G-L increases considerably after trypsinization. In contrast, external tufted cells are not labeled in these analyses. These data indicate that extended precursor forms of SP are normally present at higher steady state levels in centrifugal afferents than in the second-order neurons, suggesting different rates of processing and turnover. These radioimmunochemical and immunohistochemical analyses should provide a means for measuring and visualizing transneuronal or hormonal influences on precursor expression and processing.

Supported by New England Medical Center grant BRSG19-807419, NIH grant NS12344 and NSF grant BNS81-18767.

10

Olfactory Receptor Neurons As A Route For Chemical Access To The Central Nervous System.
H. BAKER (Cornell Uni. Med.Coll.)

Olfactory receptor (OR) cells in the nasal epithelium are unique because: 1) they can be replaced from precursor cells in the olfactory epithelium and 2) they are in constant contact with molecules in inspired air. At the termination point of OR cell axons, the main olfactory bulb (MOB), these properties may produce profound alterations in function. For example, lesion of OR cells results in the loss of all parameters specific to the dopaminergic phenotype, including decreases in dopamine levels, tyrosine hydroxylase activity and immunocytochemical staining. All changes occur without apparent cell death. To investigate the dynamics of contact between OR axons and cells in MOB the lectin conjugate, wheatgerm agglutinin-horseradish peroxidase (WGA-HRP), was utilized since it displays specific ligand binding, internalization by cells and transneuronal transport. In these experiments WGA-HRP (50-75 ul, 0.1% in saline) was instilled unilaterally into the nares of adult male rats. After two days WGA-HRP visualized by TMB histochemistry was found in the olfactory nerve layer and glomeruli of the ipsilateral, but not contralateral, MOB. Label was heavy and symmetrical. In most animals all glomeruli contained reaction product. In two animals label was predominant in the accessory olfactory bulb, suggesting that WGA-HRP was transported from the vomeronasal organ. Unexpectedly, large number of mitral cells, tufted cells and some periglomerular and internal granule cells were labelled. Furthermore, after a 4-6 day survival, retrogradely labelled neurons were found in the vertical and horizontal limbs of the diagonal band, the lateral nucleus of the horizontal band and substantia innominata. Thus, neurons were found only in those forebrain areas with predominant projections to the glomerular region of the MOB. Anterograde label occurred in the olfactory tubercle, piriform cortex and surrounding the lateral olfactory tract. These data demonstrate that by virtue of their unique properties the olfactory receptor cells can internalize molecules, including toxins, and transport them first to the olfactory bulb and subsequently by transneuronal mechanisms to the basal forebrain. Interestingly, some of the basal forebrain cholinergic neurons which project to the olfactory bulb are thought to be involved in the etiology of Alzheimer's disease.

Supported by NSF grant #BNS 8317552.

11

Fourier analysis of receptor cell field potential waveforms.
G. D. Adamek, H. C. Cejtin & R. C. Gesteland. (Northwestern University, Evanston, IL 60201)

Fourier analysis of a waveshape permits unique identification and quantitative characterization of that waveform. We have been using digitally generated Fourier transforms to study some of the properties of field potentials of single receptor action potentials in the normal olfactory epithelium of the frog. In this tissue, the waveforms of field potentials of single receptor action potentials differ. We are characterizing the normal spontaneous background firing rate which waxes and wanes with time, looking at differences in waveforms recorded at different depths in the epithelium which may be correlated with age differences and at differences between field potentials recorded from a single receptor in response to an odorant and those waveforms produced spontaneously.

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12

Biochemical Characterization of Isolated Cilia from the Olfactory Epithelium of the Bullfrog, Rana catesbeiana.
ROBERT R. H. ANHOLT and SOLOMON H. SNYDER (Department of Neuroscience, The Johns Hopkins University School of Medicine, 725 N. Wolfe Street, Baltimore, Maryland 21205).

Considerable controversy exists regarding the nature, diversity and specificity of odorant receptors. The isolated cilia preparation from frog olfactory epithelium may provide a promising model system to investigate the biochemistry of early events in odor perception. We have modified the isolation technique described by Chen and Lancet (PNAS (1984) 81, 1859-1863) to detach olfactory cilia via a calcium shock procedure without the use of organic solvent. The cilia are further purified on a sucrose cushion. The yield of olfactory cilia from Rana pipiens amounts to 32 ± 10 µg protein per frog (n=6) and from Rana catesbeiana to 205 ± 44 µg protein per frog (n=5). Respiratory cilia from the palate of R. catesbeiana can be obtained at a yield of 53 ± 12 µg protein per frog (n=3). The SDS-polyacrylamide gel electrophoresis pattern of the respiratory cilia reveals primarily the tubulin bands and some minor protein components. In contrast, olfactory cilia display a more complex pattern of proteins of which at least 30 bands can be readily resolved. Adsorption of a Triton-X100 extract of iodinated cilia on a concanavalin A-Sepharose resin allows the identification of at least 8 glycoproteins with apparent molecular weights of 47,000, 52,000, 55,000, 57,000, 74,000, 100-105,000, 118,000 and 185,000 daltons. The glycoproteins of 55,000, 58,000, 100-105,000 and 118,000 daltons probably correspond to proteins gp55, gp58, gp95 and gp120, previously identified by Chen and Lancet. In addition, glycoproteins above the exclusion limit of the gel (>200,000 daltons) are prominent. The isolated olfactory cilia are sealed membrane vesicles with an internal volume of 2.3 ± 0.5 µl/mg protein as measured by equilibration with $^{86}Rb^{+}$. These structures bear some resemblance to acetylcholine receptor-rich membranes from Torpedo electric organ and hold promise as the starting material for functional reconstitution studies once a signal transduction mechanism has been unveiled.

13

Strain Differences In Expression Of The Dopamine Phenotype In Normal And Deafferented Olfactory Bulb.
H. BAKER (Cornell Univ. Med. Coll.) and F. L. MARGOLIS (Roche Inst. of Molecular Biology).

Peripheral deafferentation produces a large decrement in the expression of properties specific to the dopaminergic phenotype in periglomerular cells of the mouse main olfactory bulb (MOB). Dopamine levels, tyrosine hydroxylase (TH) activity and immunocytochemical staining are reduced profoundly. However, staining with antibodies to dopadecarboxylase, an enzyme not specific to catecholamine neurons, indicates that most periglomerular cells, although not expressing TH, are still present in the MOB. Periglomerular cells in the BALB/cJ mouse strain purportedly are not contacted by receptor cell axons as they are in other mouse strains, as well as other mammals. The response to deafferentation, therefore, may differ from that observed in the CD-1 mouse used for previous studies. To test this hypothesis BALB/cJ and CD-1 mice were deafferented by intranasal irrigation with $ZnSO_4$ (0.17M in saline) and three weeks later dopamine levels and TH staining analyzed in normal and lesioned mice. MOB DA levels were 2x greater in normal BALB/cJ than CD-1 mice ($\bar{x}$ pmols/g tiss. ± SD; 2207 ± 169 and 1180 ± 109, respectively). In lesioned mice from both strains DA levels were reduced to about one-third of control levels (BALB/cJ, 674 ± 110; CBA/J, 336 ± 60). The DA levels in MOB's from lesioned BALB/cJ mice were maintained at about two-thirds that observed in control CD-1 mice. TH staining followed the same pattern as dopamine levels with more staining in control BALB/cJ than CD-1 mice. In deafferented CD-1 mice TH staining was practically abolished, but was appreciable in BALB/cJ mice even through the glomeruli appeared reduced in size. These data suggest that strain differences in peripheral afferent input to periglomerular cells may result in both higher normal TH activity and a different response to peripheral deafferentation. Since BALB/cJ mice have higher TH activity associated with greater number of dopamine neurons in both hypothalamus and substantia nigra, than other strains examined, the data also suggest that the larger number of dopamine neurons found in the BALB/cJ strain may be a result of differences in afferent input to dopamine neurons in all parts of the central nervous system.

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14

Taste Stimulation of Localized Tongue Areas: The Q-tip Test.
L.M. BARTOSHUK (Pierce Foundation and Yale University), S. DESNOYERS (Albertus Magnus College), M. O'BRIEN (Vassar College), J.F. GENT, F.C. CATALANOTTO (University of Connecticut

Patients are often unaware of loss even when some areas of the tongue are completely devoid of taste (e.g., severed chorda tympani). In such cases, a conventional sip and spit test may fail to detect any abnormality. In early psychophysical and electrophysiological studies, taste stimuli were often applied to localized areas with paint brushes. We adapted this method for use in the Taste and Smell Center. We "paint" taste stimuli on specific areas with long-handled, sterile Q-tips. The present study compared psychophysical functions for NaCl, sucrose, citric acid, and quinine hydrochloride obtained from unilateral stimulation of the front (fungiform papillae) and rear edge (foliate papillae) of the tongue. Subjects also tasted NaCl by sip and spit. If spatial summation were complete in taste, then the perceived intensity of a localized stimulus would reflect the proportion of the sensory field stimulated. Spatial summation is known to occur in taste but is not complete (Smith, J. Exp. Psychol., 1971, 87, 163-171 and Gent, Sen. Proc., 1979, 3, 303-316). The present data confirm earlier conclusions (Gent, 1979) that an area of about 1/10 of the sensory field can produce taste intensities that are almost equal to those from the whole mouth (the effect appears to be greater for lower concentrations). The Q-tip stimulation produced good psychophysical functions that were approximately the same for the front and rear and were similar to the functions generated with the filter paper method (Gent, AChemS 1983). The observation that a small, localized area produces taste intensities close to those evoked from stimulation of the whole mouth is consistent with the effects of injected anesthesia; even after extensive areas are anesthetized, the remaining areas produce near normal taste intensities.

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15

Behavioral Effects of Removal of the Vomeronasal Organ in Neonatal Mice. N. JAY BEAN (Monell Chemical Senses Center and Vassar College), CHARLES J. WYSOCKI (Monell Chemical Senses Center).*

The main (MOS) and the accessory (AOS) olfactory systems appear to have interactive but functionally separate roles in mediating the behaviors of rodents. Many socially relevant, non-volatile chemosignals appear to be detected by the AOS (vomeronasal organ) while the MOS primarily detects odorants of greater volatility. Because the AOS appears to be anatomically intact at an earlier age than the MOS, one would expect the vomeronasal organ to play an important role in development. The present study was designed to assess the effects of removal of the vomeronasal organ of mice on the first full day post-parturition. Body weight measures indicated no differences between the vomeronasal removal group, the sham surgery group or the anesthesia control group animals. Tests of these animals for preference for their own nest odors or those of another litter showed no differences between the groups of animals' abilities to detect and prefer their own nest odors. Similarly, no differences were found in locomotor activity among the groups and no differences were noted in age at time of vaginal opening for the groups of females. Additional results will be reported concerning aggresion in males and reproductive behaviors in both males and females. All of the results are tentative pending histological verification of vomeronasal removal.

Supported in part by BNS83-16437

16

The Comparative Gustatory Response Profile of the Greater Superficial Petrosal and Chorda Tympani Nerves of the Hamster and the Rat to Some Chemical Stimuli. BEIDLER, L.M. and NEJAD, M.S. (The Florida State University)

In some species, the external facial taste system appears important for search and localization of food and oro-pharyngeal taste buds are assumed to be a significant factor in the final acceptance or rejection reflexes. The greater superficial petrosal (GSP) nerve trunks in the middle ear of the hamster and the rat were cut distal to the geniculate ganglion. In each animal the integrated neural activities of the GSP and/or chorda tympani (CT) nerves were studied simultaneously, individually or serially in response to some chemical stimuli. The response profiles of the GSP and CT nerves of the hamster to 0.02M NaCl, 0.5M Sucrose, 0.02M Na-Saccharin and 0.02 M Na-Cyclamate when normalized to the response magnitude to 0.02M NaCl, appeared to be: Sucrose > Na-Saccharin > Na-Cyclamate ≅ NaCl. The GSP and CT nerves responses profiles of the rat to the above compounds were: CT; Na-Saccharin>Sucrose >NaCl> Na-Cyclamate. GSP; Sucrose> Na-Saccharin > Na-Cyclamate > NaCl. The neural response profile of the GSP and CT nerves of the hamster to some chemical stimuli representing the four basic taste qualities were: GSP; 0.05M Citric Acid >0.5M Sucrose> 0.1M NaCl> 0.01M Quinine-HCl. CT; 0.1M NaCl > 0.05M Citric Acid > 0.5 M Sucrose >0.01M Quinine-HCL. It was noted that the GSP nerve of the hamster was very responsive to 0.05M Citric Acid, whereas, the GSP nerve of the rat was extremely responsive to 0.5M Sucrose. The response profile of the GSP and CT nerves of the hamster to 0.3M chloride salt solutions appeared the same: LiCl ≅ NaCl >$CaCl_2$ >NH_4Cl >KCl. The salt profiles of the GSP and CT of the hamster looked similar to that of the GSP nerve of the rat. It was inferred that not only differences exist among various species in the ability of their taste receptors to respond to a number of tastants, but also intra-differences in the gustatory receptor subpopulations of species exist, as well.

17

High Salt Diet: Lower NaCl Preference and Increased Neural Taste Responses to Salt, but Paradoxical Increase in NaCl Intake. RUDY A. BERNARD and TIMOTHY W. PRIEHS (Dept. of Physiology, Mich. State Univ., East Lansing, MI 48824).

The increased salt appetite of sodium deficient and adrenalectomized rats is accompanied by a specific decrease in neural responsiveness to salt stimulation (Contreras,1977; Kosten & Contreras,1983). We did the first set of experiments reported here to determine whether the decreased salt preference of rats on a high salt diet (Pfaffmann, 1957) was characterized by increased neural responses to salt. Neural recordings were made from the chorda tympani nerve of 8 experimental and 8 control rats following 14 days of preference tests, which were preceded by 10 days of adaptation to the test diet. The 24-hr 2-bottle choice method was used to measure preference and intakes were calculated by daily computerized weighing of the flavor and water bottles. NaCl solutions were presented in ascending order of concentrationin in 1/2 log steps from .001M to 1.0M. Each concentration was tested for 2 days, with the position of the flavor bottle changed on the 2nd day. Rats were tested in staggered groups of 2 experimentals and 2 controls, so that nerve recordings could be performed after the same relative time on diet and preference tests. Both groups received an artificial diet, which differed only in its content of NaCl-6% for the high salt and 1% for the normal group. As expected, the experimental group showed a lower preference at all concentrations, but paradoxically, absolute intake of NaCl solution was significantly greater than control at all concentrations below .3M. Summated nerve responses were calculated relative to .001M NaCl, which produced absolute responses (mean ± SD) in both groups which were not significantly different (570±148 vs 695±238 mV). The relative responses of the high salt group were significantly greater than control at all concentrations above .003M. This was also true for KCl, which was not tested behaviorally. In a second set of experiments the effect of diet was tested by keeping 5 experimental and 2 control rats on a single preferred concentration (.1M NaCl) and measuring the effects on water and saline intake produced by changing to the 6% NaCl diet. In this experiment standard lab chow (1% NaCl) was used for the control diet. Once again the high salt group showed a significant increase in saline (from 24±9 to 38±7ml; p<.01) and water (from 20±7 to 48±7 ml; p<.001) intake, whereas NaCl preference decreased from 55±17 to 42±10% (p<.02).

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18

Effect of Taste Experience during the Suckling Period on Adult Taste Preference of Rats. ILENE L. BERNSTEIN, DOUGLAS P. FENNER & JAIME DIAZ (Dept. Psych. Univ. of Washington, Seattle, WA 98195)*

Effects of taste deprivation and selective taste exposure during the suckling period on adult preference for sucrose and NaCl solutions was examined. Taste deprivation was achieved by rearing rat pups "artificially", in individual cups with intragastric feeding from Postnatal Days 4 through 18. In the first study Artificially Reared (AR) rats were examined in adulthood for their intake and preference for NaCl and sucrose solutions. Preference as a function of solution concentration of AR animals was compared to that of Normally Reared (NR) litter mates. No differences were observed between AR and NR rats in their preference curves or preference thresholds. These results suggest that suckling stimulation from Days 4 through 18 is not necessary for normal development of NaCl and sucrose preference. In the second study we examined whether artificially reared rats selectively exposed to sucrose solutions during the suckling and postweaning period would demonstrate altered adult taste preferences. Exposure to sucrose was accomplished by placing AR rats in an incubator on towels saturated with a 10% sucrose solution for 30 minutes each day during the period of artificial rearing. Infant rats ingest considerable amounts (5-10% of their body weight) of sucrose solution in this setting. From Days 19 through 35 they were group housed and received AIN diet (50% sucrose) to extend the period of exposure to sucrose. Animals were again tested in adulthood for their preference for NaCl and sucrose solutions. Results were essentially the same as in the first study; AR-Sucrose animals failed to differ from NR controls in their preference for NaCl or sucrose solutions. These findings suggest that adult taste preferences of rats are not easily altered by taste deprivation or selective taste exposure during the suckling period. Other interpretation of these results will also be discussed.

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19

Rats Display Varying Salt Preferences in Foods

Mary Bertino & Gary K. Beauchamp (Monell Chemical Senses Center)*

When given a choice between isotonic saline and water, rats consume more saline. However, unlike their responses to salt water, rats do not appear to prefer a number of salted solid foods (Beauchamp & Bertino, 1984). In the present study, rats' salt (NaCl) preferences were investigated in a variety of liquid milk products.

Rats were given one hour choices between salted and unsalted heavy cream, half & half, and skimmed milk. The following concentrations were tested; .075 M, .150 M, .300 M and each concentration was tested for four consecutive days. Rats were also given four day choices between .150 M NaCl in whole milk vs. plain whole milk and .150 M NaCl in low fat (1%) milk vs. plain low fat milk.

Skimmed milk containing .150 M NaCl was preferred to its unsalted counterpart. In all other tested milk products and at all other concentrations, the salted food was either consumed in amounts equal to the unsalted food or avoided. Viscosity, fat content and water content are possible factors influencing whether or not rats express salt preferences.

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20

Effects of Temperature on the Sweetness of Polyols.

GORDON G BIRCH (University of Reading)

The sweetness intensities and persistences of glycerol, xylitol and sorbitol have been determined on the "SMURF" by ten panellists at temperatures ranging from 15-55°C. The differences in sweetness intensity between any pair of polyols at 15°C were always greater than at 55°C. The same was true for sweetness persistence. However, not all of these temperature effects are significant. The diminution of sweetness differences between polyols as the temperature is raised is consistent with the intermediation of a hydrogen-bonding. Possibly pseudo-cyclic structures of polyols exist at 15°C, which resemble those of sugar molecules. These are then disrupted at 55°C. It is notable that the persistences of the three polyols bear an inverse relationship to their molar volumes whereas the intensities do not. These and related thermodynamical considerations may give clues to the access of stimulus molecules to receptors.

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21

Dynamic Properties and Self-Adaptation of NH_4 cells in lobster taste organs.

PAOLA F. BORRONI and JELLE ATEMA (Boston University Marine Program, Marine Biological Laboratory, Woods Hole).

NH_4-specialized cells compose the second most common population of narrowly tuned taste receptors found in the walking legs of H. americanus (JOHNSON et al. 1984, J. Comp. Physiol. A 155:593-604). In contrast to other amino acids and amines tested, NH_4 by itself can elicit lobster feeding motions. Coastal seawater has NH_4 background concentrations of 10^{-6}M, and common lobster prey tissue $2x10^{-2}$M. Thus the receptor cells must function over a large dynamic stimulus range and maintain acceptable signal to noise ratios. We describe dose-response functions of NH_4 cells, and the effects of self-adaptation in elevated NH_4 backgrounds.
Single cells were identified by stimulation with $3x10^{-6}$M NH_4Cl in artificial seawater (ASW). Dose-response functions were obtained from a log step ascending ($3x10^{-8}$ to $3x10^{-3}$M) NH_4 concentration series either in ASW, or in a $3x10^{-6}$ or $3x10^{-5}$M NH_4 background. Single cell dose-response functions ranged over the entire 4-5 log steps tested without saturating at the highest concentration. They can be divided into two classes with dose-response slopes of $\sim$0.4 and $\sim$0.2 respectively. Elevating the NH_4 concentration in the background had unexpected effects on the dose-response functions. In either background the responses to the highest stimulus concentration were decreased by 40-50%, while those closest to the background were least affected. Responses to $3x10^{-6}$ in $3x10^{-6}$M and to $3x10^{-5}$ in $3x10^{-5}$M backgrounds (i.e. stimulus = 2 x background) were hardly affected. However, the response to $3x10^{-6}$M was eliminated in the $3x10^{-5}$M background.
These results are unexpected and different from other published data. They cannot be explained by (linear) competitive inhibition. We hypothesize the presence of two interacting receptor sites with different affinity for NH_4.

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22

Single Unit Recordings From the Petrosal Ganglion of the Rat Glossopharyngeal Nerve.

JAMES C. BOUDREAU, LY THI DO, LATHA SIVAKUMAR, JOSEPH ORAVEC (Sensory Sciences Center, University of Texas at Houston)

Spontaneous and evoked spike discharges were recorded from the petrosal ganglion of anesthetized rats. Taste units seemed to constitute a fractional portion of the units recordable in this sensory diverse ganglion. Taste units could in part be detected by their complex spontaneous discharges, much like those of the geniculate ganglion. Interspike interval histograms of most taste units were multimodal, although a few were unimodal. Almost all units exhibited marked grouping of spikes during evoked discharges similar to that shown by geniculate ganglion X units. Many units exhibited marked nonstationarity of evoked discharge. A wide range of chemical compounds were tested to determine effective stimuli. In general, ionic stimuli were less often effective than in the geniculate ganglion, but nitrogen compounds (e.g., amino acids and alkaloids) and sugars more so. Four different unit clusters were tentatively identified on the basis of chemical stimuli active and certain neurophysiological properties: acid units, salt-nucleotide units, alkaloid units, and sugar-amino acid units. These classes must be considered only partially resolved, especially the latter two, since they show much overlap in stimulus chemistry. The salt-nucleotide units can be differentiated from salt units in the rat geniculate ganglion on the basis of stimulus chemistry and elicited discharge patterns. Similarly, the acid units could be differentiated from acid units in rat geniculate ganglion by stimulus chemistry (partly) and by their evoked discharge patterns. The sugar-amino acid units and the alkaloid units, on the other hand, were similar to the rat geniculate ganglion amino acid units and X units respectively. A Test Series of chemical solutions has been developed to partially differentiate petrosal ganglion unit groups.

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23

Neural Control of Von Ebner's Glands in the Rat.
ROBERT M. BRADLEY (Univ. Michigan, Ann Arbor, MI 48109).

In mammals the fluid environment of most lingual taste buds is provided by the secretions of the lingual serous salivary glands of von Ebner. The glands are extensive and in the rat occcupy a triangular mass in the postertior tongue. The circumvallate papilla is situated at the apex and the foliate papillae are at the ends of the base of the triangle. The glands extend a distance of 6mm in an anterior to posterior direction, 7mm laterally from one side of the tongue to the other and 3mm into the depth of the tongue. Since the rat tongue is about 25mm in length, von Ebner's glands occupy approximately one quarter of the tongue.
To understand the possible role of these glands in taste function, experiments are in progress to determine the neural control of von Ebner's glands. HRP injected into the circumvallate papilla in 18 rats was transported centrally along afferent sensory pathways as well as efferent motor pathways. The efferent parasympathetic fibers originated as a discrete set of cells in the inferior salivatory nucleus. The location of this nucleus, closely apposed to the solitary nucleus, suggests interactions between afferent gustatory information and efferent parasympathetic activity to the von Ebner glands. These efferent fibers travel in the glossopharyngeal nerve. Electrical stimulation of the distal portion of the cut glossopharyngeal nerve resulted in a copious secretion of fluid from the clefts of the circumvallate and foliate papillae. There is thus evidence that the von Ebner glands are controlled by the parasympathetic nervous system.
It is often stated that the secretion of these glands merely serves to rinse out the clefts of the circumvallate and foliate papillae. Since these salivary secretions provide the microenvironment in which initial taste stimulus-receptor contact and subsequent transduction occur, they probably play a more dynamic role in taste function than simply removing stimuli.

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24

Amount and Type of Fatty Acids in Lipids from Taste and Non-Taste Epithelium of Steer Tongues.
J.G. BRAND*+, J.L. RABINOWITZ+, T. HUQUE* AND D. BAKER+ (Monell Chemical Senses Center*, 3500 Market Street and Philadelphia V.A. Medical Center+, University of Pennsylvania, Philadelphia, PA)

Epithelial tissues from 5 regions of the steer tongue were isolated and fatty acids of each lipid class in the polar and neutral fractions were assayed by gas liquid chromatography. Regions of the tongue sampled were circumvallate papilla (CVP) epidermis (taste-related), dorsal epidermal surface of fungiform (taste-related), supporting dermis of CVP (non-taste), posterior epidermis (non-taste) and ventral epidermis (non-taste). In all tissues, the primary saturated fatty acids were palmitic (16:0) and stearic (18:0) acids. Arachidonic acid (20:4) and other fatty acids of higher molecular weight were found in lipids of all regions sampled, particularly in phosphatidyl insoitols, ethanolamines and cholines and in cholesterylesters. Production of prostaglandin E_2 was detected through cyclo-oxygenase activity in tissues of all regions, with posterior epidermis and fungiform dorsal epidermis producing the most, CVP epidermis the least. Plasmalogens were detected primarily in the fraction of phosphatidylethanolamines in all regions sampled. Plasmalogens were measured in aliquots of extracts by an iodine-addition method (which is specific for the unsaturated ether linkage) and by an acid hydrolysis-two dimensional -TLC method. Results from both methods agree. Using the iodine-addition method, the lowest amounts of plasmalogens were found in ventral epidermis (5-6% of total phospholipids), with all other regions of the tongue containing higher amounts (13-15%). The heterogeneity of patterns of lipids and fatty acids found in the epithelium of the tongue suggests possible zonal specialization to satisfy regional physiological needs.

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25

A Computer-Controlled Automated System For Gustatory Psychophysics.
GARY BROSVIC, BURTON SLOTNICK, AND SANDRA TANDECIARZ (The American University)*

We describe an improved version of the operant taste discrimination test procedure reported previously at AChemS (Slotnick, 1981). In this procedure rats are trained to lick at a 10-barrel stimulus delivery tube for a .005-ml sample and switch to an adjacent single tube (reinforcement) upon delivery of S+ (tastant) but not switch upon delivery of S- (water). Appropriate switching behavior is reinforced with .02-ml of water at the single tube. Switching in response to S- constitutes a false alarm and is punished by a 3-sec signaled time out (house light on). Not switching in response to S+ constitutes a miss and delivery of the next stimulus is contingent upon switching (which produces a .005 reinforcement). Stimulus delivery is dependent upon completion of a VR-20 on the 10-barrel tube. On an S+ trial a correct response requires switching to the reinforcement tube before an additional 10 sampling responses occur. Each barrel of the sampling tube is connected by tygon tubing to a separate normally closed solenoid valve and 10-ml fluid reservoir. Animal responses and stimulus delivery are controlled with a PDP-8 computer, SKED interface and software. Because the procedure is completely automated and selection of stimuli are under software control, an entire psychophysical test can be completed in a single session (800 trials per session). In contrast to the performance obtained using the DRH procedure described previously, discrimination learning is rapid, performance is stable, and no failures in training have occurred. Rats learn within 1-2 sessions (300 trials per session) to switch responding to the reinforcement tube upon presentation of S+ and to continue licking at the stimulus tube upon presentation of S-. The mean absolute threshold for NaCl obtained in 10 rats was .0045% (descending method of limits) and the mean intensity difference threshold (ascending method of limits) in 2 rats was .2% (using 1% NaCl as the standard stimulus). Because the procedure is computer-controlled and many stimuli are available within a single session, it is well suited for threshold determinations and tests of multiple taste discrimination and stimulus generalization.

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26

Unilateral Odor Deprivation: Time Course of Changes in Laminar Volume.
PETER C. BRUNJES (Dept. of Psychology, University of Virginia, Charlottesville, VA 22901)

Surgical occlusion of single nares in rat or mouse pups shortly after birth results in a 25% reduction in the size of the ipsilateral olfactory bulb in pups examined on Day 30. Recently, we have been tracing the sequence of development in normal and deprived bulbs in order to clarify the processes by which size reductions occur. Examinations of patterns of bulb growth are reported here. In the first study, rats underwent either naris occlusion or sham surgery on the day after the day of birth (Day 1) and 4 pups from each group were sacrificed on postnatal days 4, 8 or 12. Horizontal sections through both bulbs were Nissl-stained and laminar volumes were determined by serial section planimetry. Control subjects exhibited very similar left vs. right bulb size at all ages, indicating no laterality in normal development. Deprived bulbs grew substantially during the period of study but were 10% smaller than controls by Day 12. These findings indicate that 1) deprived bulbs do indeed grow, suggesting the existence of both experience-dependent and -independent maturational processes, and 2) that deprivation-induced changes must begin shortly after surgical treatment. In a second study, pups were occluded at either Day 10 or 20 and reared for 30 days to determine the length of the period of susceptibility to the effects of deprivation. Analyses of laminar volumes indicated that occlusion at Day 10 resulted in almost identical changes as those seen after earlier occlusion: a 25% reduction in bulb size. Occlusion at Day 20 also resulted in reduced bulb size, but the reduction was much smaller--about 10 %. The findings indicate that experiential modification of bulb growth may occur throughout the preweanling period and that the period of susceptibility does not end abruptly, but progressively diminishes during the third postnatal week.

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27

Reaction Times for Discrimination of Salty and Sweet in PTC Tasters and Non-Tasters. D. Burke, R. Frank (University of Cincinnati), J. Kuznicki (Procter & Gamble Co.)

Recent findings from several laboratories have been used to argue that sweetness perception differs in tasters and non-tasters of phenylthiocarbamide (PTC). Sweetness perception in these two groups was further explored by recording reaction times for sweet and salty discrimination judgments. Twenty tasters and non-tasters of PTC (as defined by a staircase modification of the method of limits procedure) made judgments of sweet/not sweet and salty/not salty for pure and binary mixtures of sucrose, aspartame, sodium chloride, quinine, PTC and hydrochloric acid. Two distilled water trials were also included. These stimuli were judged once for their sweetness and once for their saltiness in two counterbalanced blocks of trials. The subjects rinsed with tap water following each trial and the intertrial interval was maintained at 30 sec. Reaction times and stimulus ratings were recorded on each trial. Contrary to expectations, non-tasters were 205 msec faster than tasters for sweet judgments and 218 msec faster for the salty judgments (both $p < .01$). Judgments of saltiness were made more quickly by non-tasters for all 20 stimuli and for 17 of 20 stimuli when judging sweetness. The pattern of errors produced by tasters and non-tasters was essentially identical. This somewhat paradoxical set of results may be explained by noting the subjective intensity of the mixture components were standardized for tasters. If non-tasters perceived sweet solutions as less intense, the mismatch of intensities within a mixture may have provided another discrimination cue for non-tasters (in addition to quality). This hypothesis is presently being investigated in our laboratory.

28

Bilaterality of Olfactory Deficits. W.S. Cain (Pierce Foundation), J.F. Gent (UConn Health Center)

The great majority of patients with olfactory loss seen at the CCCRC exhibit approximately equal deficits in the two nostrils. For example, 70% of patients with the two most frequent specific etiologies (post-upper respiratory infection and nasal-sinus disease) have olfactory function scores that differ by no more than 10 points (out of 100) between the nostrils and 95% have scores that differ by no more than 40 points. This situation suggests that those indices of pathology (ENT exam, sinus x-rays) that allow a decision about laterality should generally reveal bilateral pathology. When taken together, they do. In only 15 of 111 patients with any positive outcome on the ENT exam or x-rays did the indices imply one pathological and one normal nostril. The olfactory function scores of the seemingly pathology-free nostrils are of interest. They can indicate whether strictly unilateral nasal disease can occur or whether an appearance of normality results simply from insensitivity in the ENT exam and x-rays. The latter seems to be true. The average function score of the seemingly pathology-free nostrils equalled the low value of 27 points. This virtually equals the average score of nostrils with one positive index (24 points) and is twice that of nostrils with two positive indices (11 points). In no instance did the olfactory function scores imply a normal nostril paired with a deficient nostril. The results support the two conclusions that unilateral olfactory deficits are extremely rare and that any positive sign of nasal disease on either side can be taken as evidence of bilateral pathology.

29

Influence of Instruction on Suprathreshold Judgements of Sweetness and Bitterness, Alone and Mixed. CALVIÑO, A. M.; RODRIGUEZ, M.B.; COMETTO-MUÑIZ, J.E. and GARCIA-MEDINA, M.R. (Laboratorio de Investigaciones Sensoriales, CONICET-Esc.Sal.Públ.,Fac.Medicina, UBA, C.C.53-1453 Buenos Aires, Argentina).

Two instructions were used to evaluate the sweetness, bitterness, or sweetness and bitterness of sweet and bitter samples (5, 10, 20 and 40 %W/V sucrose; 0.125, 0.250, 0.5 and 1.0 %W/V caffeine) as well as of nine binary mixtures.

One instruction required a group of subjects (n=10) to rate sweetness and another group (n=10) to rate bitterness of the aforementioned stimuli by magnitude estimation. The other instruction required a third group (n=10) to rate sweetness and bitterness (giving two numbers) of the same stimuli than before, also by magnitude estimation.

Results confirmed previous findings showing mutual suppression between sweetnes and bitterness in binary mixtures (Lawless, 1979) independently of the instruction. With the stimuli employed,we found that sweetness diminishes bitterness more than viceversa.

In terms of effects of instruction, we found that the bitterness response is sharply reduced ($p<0.01$, t test) when both qualities are rated simultaneously, whereas the sweetness response is scarcely affected by the change in instruction. No significant differences across the two instructions were found for the slopes of either the bitterness or sweetness psychophysical functions. Another t test showed that the suppression effect of each quality on the perceived intensity of the other is similar for both instructions, with the exception of bitterness at the highest level of sucrose, which shows a significant increase in suppression for the second instruction (both qualities rated simultaneously).

The observed asymmetry of the effects of instruction on the two gustatory qualities, implies that judgements of caffeine bitterness are more suceptible of being affected by simultaneous evaluation of sucrose sweetnessthan viceversa.

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Behavioral Responses of Shrimp to Components of Food Odors Indicate Synergistic Mixture Interactions. WILLIAM E. S. CARR and CHARLES D. DERBY[1] (C. V. Whitney Laboratory, University of Florida, Rt. 1, Box 121, St. Augustine, FL 32086)*

Chemoattractants for a shrimp, Palaemonetes pugio, were studied to identify the active components of stimulatory food odors, and to determine whether mixtures of components present in natural odors express themselves in an additive or an interactive manner. Analyses of the amino acids, quaternary ammonium compounds, organic acids, nucleotides, and related substances in extracts of four organisms were used to produce artificial odor mixtures comprised on the basis of each extract. Artificial mixtures of the above substances accounted for most of the stimulatory capacity of extracts of crab and shrimp, but not for that of extracts of oyster and mullet. Hence, even when only a single species of test animal is employed, different substances may make important contributions to the effectiveness of odors from different sources. To determine whether the individual components in the four artificial mixtures expressed themselves in an additive or an interactive manner, the methods of stimulus substitution and response summation were employed. These additive models were used in conjunction with dose-response functions for the individual components of each mixture to compare the responses a mixture was predicted to elicit vs. the responses a mixture was observed to elicit during the bioassays. Synergistic interactions were evident since each mixture was markedly more effective than predicted by the additive models. The magnitude of the synergism varied with both the composition and the concentration of the mixtures.

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Relationship between etiology and zinc in patients with chemosensory dysfunction. F.A. CATALANOTTO, K.M. OSTROM, J.F. GENT, R.B. GOODSPEED, M. PETERSON, M. TESTA (University of Connecticut Health Center), L. BARTOSHUK AND W. CAIN (John B. Pierce Foundation).

The relationship between zinc and etiology of chemosensory dysfunction was studied in 271 patients of the Taste and Smell Center and 110 control subjects. Zinc parameters included plasma, serum, red blood cell, white blood cell, and whole blood zinc levels as well as zinc bound to protein, albumin, and alpha-2 macroglobulin. All subjects received the chemosensory tests administered at the Taste and Smell Center. Subjects were classified by all zinc parameters, AGE, SEX, and ETIOLOGY of their chemosensory disorder (NASAL DISEASE, POST-UPPER RESPIRATORY INFECTION, IDIOPATHIC etc.); these factors were used as predictor variables. Chemosensory outcome variables for each subject included SMELL DIAGNOSIS, COMPOSITE SMELL SCORE, TASTE DIAGNOSIS, and HYPOGEUSIA SCORE.

There were a number of AGE and SEX correlations among the zinc profile. There were no significant differences in mean zinc levels among any of the etiological categories or chemosensory outcomes. Data were then subjected to Discriminant Function and stepwise Logistic Regression analyses. AGE and red blood cell zinc correctly predicted the HYPOGEUSIA SCORE outcome in 77% of the cases but the other zinc measures when not combined with etiology predicted outcome only a little better than chance. However, ETIOLOGY and red blood cell zinc predicted HYPOGEUSIA SCORE outcome in 85% of the cases. ETIOLOGY and white blood cell zinc predicted the COMPOSITE SMELL SCORE outcome in 95% of the cases.

Results suggest that ETIOLOGY is the most consistent predictor of chemosensory outcome. This supports the notion that these etiological categories represent distinct disease groups. While there is a trend for the zinc profile to predict chemosensory outcome, only red blood cell and white blood cell zinc levels demonstrated significant predictive ability.

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Human Ability to Perceive Sour is Related To Salivary Flow Rate. CAROL M. CHRISTENSEN (Monell Chemical Senses Center, Philadelphia, Pa.) and DANIEL MALAMUD (School of Dental Medicine, Univ. of Pennsylvania).

In previous experiments, we demonstrated that exposure to saliva in the oral cavity increases the pH of acid taste solutions, and these pH changes are of sufficient magnitude to affect taste thresholds for acids. In the present study, we tested the hypothesis that the ability to perceive sour should be inversely related to salivary flow rate. This prediction is based on two findings from earlier experiments: (1) individuals receiving drugs that reduce salivary flow rate have lower recognition thresholds for citric acid, and (2) a significant positive correlation exists between an individual's salivary flow rate and the pH increases observed in acid taste solutions after expectoration.

We measured detection and recognition thresholds and obtained magnitude estimates of the perceived intensity of 4 and 20 ml quantities of HCl and sucrose prepared in deionized, distilled water. Using whole mouth resting salivary flow rates, we selected subjects with either low ($\leq$0.2 g/min) or high ($\geq$0.6 g/min) flow rates, representing the lowest and highest 20% of the flow rate range. The psychophysical results conformed to our hypothesis. The group with low salivary flow rates had significantly lower thresholds for HCl in both detection and recognition tasks, and recognition thresholds were significantly lower for 20 ml quantities of HCl in the group with high salivary flow rates. High and low salivary flow rate groups had similar detection and recognition thresholds for sucrose and no volume-related differences in threshold were found. Magnitude estimates of solution sourness also conformed to expectations based on expectorated pH values. The high salivary flow rate group perceived large differences in sourness between 4 and 20 ml volumes of HCl at lower concentrations where salivary buffers dramatically increase solution pH, particularly of the smaller volume. At high acid concentrations, salivary changes in acid pH are small, and subjects perceived little difference in the sourness of the two volumes. Individuals with low flow rate produce small changes in acid tastant pH, and correspondingly showed only small concentration- and volume-dependent effects in sour judgments.

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Topographic organization of peripheral input to the hamster main olfactory bulb. Andrew N. Clancy, Thomas A. Schoenfeld and Foteos Macrides (Worcester Foundation for Experimental Biology, Shrewsbury, MA 01545)

Our recent neuroanatomical studies in the hamster provided evidence for two topographically organized central olfactory pathways. An interbulbar commissural system via pars externa of the anterior olfactory nucleus interconnects homotopic, longitudinally oriented sectors of the left and right main olfactory bulb (MOB), i.e., this projection system is topographically organized with respect to the medial-lateral and dorsal-ventral axes but not the rostral-caudal axis of the MOB. An intrabulbar associational system exhibits a true point-to-point topographic organization that interconnects opposing medial and lateral patches within each MOB. We therefore developed retrograde tracing procedures, using fluorescent stilbene isothiocyanates (SITS and DIDS), to examine the topographic organization of peripheral projections to the olfactory bulbs and to compare this organization with those of the interbulbar and intrabulbar projection systems. Our results to date show an absolute topographic organization of peripheral input to the MOB with respect to the medial-lateral axis, such that injections into the medial side of the MOB label receptor neurons exclusively in medial regions of the olfactory epithelium and injections into the lateral side label neurons in lateral regions. A comparably precise topographic organization of peripheral inputs is indicated with respect to the dorsal-ventral axis. Injections placed rostrally or caudally in the MOB preferentially label receptor neurons in rostral or caudal regions of the olfactory epithelium, respectively, but retrograde labeling typically extends throughout the rostral-caudal axis of the epithelium. Neurons in the septal organ are labeled by injections into the ventral-medial part of the MOB, regardless of their rostral-caudal placement. The topographic precision of the peripheral input with respect to the rostral-caudal axis thus appears to be intermediate between the precisions of the interbulbar and intrabulbar projection systems.

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Amiloride Alters Behavioral and Neural Gustatory Responses to Salt Solutions. ROBERT J. CONTRERAS, ELISABETH K. FARNUM, & EDYTHE BIRD (Yale University).*

We have proposed previously (Contreras, et al., Chemical Senses, 8:275-288, 1984) that changes in neural activity of chorda tympani fibers may be a peripheral mechanism for mediating changes in salt intake in the rat. One of our major goals is to establish a relationship between neural responses of the chorda tympani and behavioral intake responses to NaCl. In the present set of experiments, we have studied the effect of the specific sodium transport blocker, amiloride hydrochloride dihydrate, on: (1) the integrated responses of the chorda tympani nerve to NaCl, LiCl, and KCl, and (2) the NaCl intakes of 21 and 90 day old rats.

In the neurophysiological experiments, the chorda tympani nerve was isolated in urethane-anesthetized animals, and the tongue bathed continuously in either deionized water or in 100 µM amiloride for 2-min. Taste stimuli were presented for 10-s after each 2-min rinse. Our results are consistent with previously reported findings: we found that the chorda tympani responses to NaCl and LiCl (but not KCl) after amiloride rinse were reduced by 50% in adult rats (Heck, et al., Science, 223:403-405, 1984; Brand, et al., AChemS Abstr., 6:27, 1984), but not in 21 day old rat pups (Hill & Bour, ECRO Abst., 5:63, 1984).

In the behavioral experiments, the 10-min intakes of NaCl solution (.1, .3, & .5 M) in moderately water deprived rats were measured under two conditions. In our preliminary studies, when 100 µM amiloride was added to the saline solutions, NaCl intake was not altered in tests with 21 and 90 day old rats. When animals drank 100 µM amiloride for 2-min prior to receiving the test solutions, however, intakes of 0.3 and 0.5 M NaCl were increased above those of rats given water for 2-min, but only in the 90 day old subjects. Thus, amiloride's effect on taste receptors can be studied indirectly by both electrophysiological and behavioral methodologies.

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Acceptance of Salty Tastes by Human Infants and Children. BEVERLY J. COWART and GARY K. BEAUCHAMP (Monell Chemical Senses Center, Philadelphia, Pa.).

Although human newborns exhibit a strong ingestive preference for sugar water over plain water, they do not differentially consume sodium chloride (NaCl) solutions and plain water. This observation suggests that human preferences for salty tastes may, unlike sweet preferences, be gradually acquired. There have, however, been few attempts to assess ingestive responses to NaCl in older infants and very young children.

We report here that human infants 2-4 months of age, like newborns, appear to be indifferent to moderate saline concentrations (0.1 and 0.2 M) relative to water. In marked contrast, infants and children 4-23 months of age exhibit a heightened acceptance of salt water, ingesting considerably more of it than of plain water. Still older children (>30 months of age) reject salted water but express a preference for a quite high concentration of salt (0.34 M) in soup.

These data demonstrate not only a much earlier manifestation of NaCl acceptance in humans than has been previously reported but also that this acceptance is initially independent of interactions between the taste of salt and that of food. Given the typically low levels of dietary exposure to NaCl prior to 6 months of age, and in conjunction with recently reported neurophysiological and behavioral data on other mammals, our findings seem most consistent with a hypothesis of a postnatal maturation of salty taste preference in humans which is largely unlearned. Subsequent dietary experience may then channel the expression of this preference to specific food/beverage contexts.

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Chemical Nature and Release Characteristics of Lobster (Homarus americanus) Feeding Attractants in Natural Baits. DANIEL, P. C. and R. C. BAYER (University of Maine at Orono).*

Development of successful artificial baits for American lobsters (Homarus americanus) requires identification of both types of feeding attractants and their release pattern into the environment. A behavioral bioassay, capable of testing 100 juvenile lobsters (< 15mg) within two hours, was developed to test chemical fractions of herring leachates collected from various commercial bait preparations. Complete removal of protein and other large low polarity molecules was achieved by a two step process involving cold methanol precipitation and preparative adsorption chromatography using Sm7 Biobeads (to remove any remaining peptides). Complete removal of protein with retention of primary amines and amino acids from herring leachate had no effect on concentration necessary to elicit response in 50% of lobsters (EC50 = 5ug/ml). This further supports the hypothesis that amines and amino acids are the primary feeding stimulants in bait and prey extracts. Protein and amino acid leaching rates of various herring preparations (frozen, fresh and 10% brine) were determined over a 45 hour period in order to evaluate characteristic profiles for lobster baits. Over the first 24 hours, salted and frozen herring had high but declining amino acid leaching rates with salted herring being somewhat higher. Fresh herring amino acid leaching rates were much lower but increasing . After 24 hours the leaching rates of all preparations were equivalent and declining gradually. Behavioral bioassay of the leachates collected over the 45 hour period revealed no qualitative differences between bait types. Additionally there was no change in response to leachates for the first 24 hours but an overall decrease in response after 45 hours for the same amino acid concentrations suggesting a degradation in attractant quality.

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Gustatory Recipient Zone of the Nucleus of the Solitary Tract in the Hamster: Electron Microscopic Observations. BARRY J. DAVIS and TAICHANG JANG (Univ. of Alabama at Birmingham)

At the ultrastructural level, the gustatory zone of the nucleus of the solitary tract (NST) is characterized by neuropil with very few myelinated fibers. Neurons are loosely packed but groupings of 2-3 neurons are common. The neuropil is penetrated by isolated fascicles of about 50 myelinated and unmyelinated fibers that appear to arise from the solitary tract. Terminals within the NST possess enlarged synaptic complexes densely packed with spherical vesicles and in asymmetrical synaptic contact with small dendrites in a calyx and glomerular-like fashion, and with the shafts of larger dendrites. The glomerular complex is isolated by a glial envelop. Both our Golgi and EM material find few dendritic spines on NST neurons. Contacts possessing symmetrical synaptic thickenings and flattened vesicles are also seen on the shafts of larger dendrites. Injections of HRP into the pontine taste area retrogradely label NST output neurons. These neurons are most often characterized by elaborated nuclear invaginations and usually belong to the larger of the two morphologically distinct classes of neurons in the NST. Invaginated neurons represent about 80% of the neurons studied and these neurons account for 79% of the HRP positive output neurons; a second class of HRP positive neurons does not possess nuclear invaginations and accounts for 21% of the neurons labelled after pons injections. Only an average of 26% of all neurons studied are retrogradely labelled after large HRP injections. Both about 26% of all invaginated and all non-invaginated neurons were HRP positive, suggesting that subgroups of each class are output neurons and project rostrally.

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Odor Pleasantness Judgments Compared Among Samples From 20 Nations Using Microfragrances. R.G. Davis (VA Medical Center, Lexington, KY), R.M. Pangborn (University of California at Davis).

Pleasantness of odors can vary for individuals due to social, historical and situational influence. Among these factors, the impact of cultural and ethnic influence is poorly understood. The Microfragrance (3M reg. TM) method, a compact olfactory testing device, was used to assess odor pleasantness perception.

The test consisted of 22 odorants presented four times, once in each of four unsystematic sequences. The odorants were carried in microcapsules on pages in a book. Subjects indicated judgments by choosing one of nine positions on a vertical, nine segment scale. There were 24 samples obtained from 20 countries, with 30 persons in most samples. Group scales were correlated, and these correlations were treated as intergroup distances. The correlation matrix was described by an INDSCAL stimulus space.

The odorant determined the largest proportion of variance, that is, a given judgment depended mostly on the particular odor being judged. The country of origin did influence the judgments to a small, but significant degree, both as a simple main effect, as well as an interaction with odor and presentation sequence. The high degree of agreement among countries was the most impressive finding. All intergroup correlations were greater than .645, with a mean of .864, standard deviation of .065, and a median value of .876. In terms of similarity, California, Kansas, Japan, West Germany, Taiwan, Canada, Brazilian Italians, Phillipines, and California Taiwanese formed one cluster of samples with more similar results. The cluster most dissimilar to this one consisted of Switzerland, Poland, England, and South African Blacks. A third cluster intermediate between these two clusters consisted of South African Whites, Austria, Sweden, France, Norway, East Germany, Finland, Mexico, and Japanese and African residents in Brazil.

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Cell Lineage in the Mouse Vallate Taste Bud. DELAY, R., KINNAMON, J.C. and ROPER, S. (Rocky Mountain Taste & Smell Center, University of Colorado Health Sciences Center, Denver, CO 80262).

There is considerable controversy regarding the existence and origin of different classes of cells in the vertebrate taste bud. Several different cell types have been defined by many workers. Whether these represent different cell lines within a taste bud is an unsolved problem. We injected tritiated thymidine (H^3-T) and tracked the taste cells which incorporated the radioactive label. Animals were killed at 1, 6 and 12 hour and 1 to 10 day intervals. Lingual tissues were prepared for high voltage electron microscopic autoradiography so that we could view the ultrastructure of labelled cells. Four categories of cells could be identified: basal cells, dark cells, intermediate cells and light cells. Basal cells were polygonal cells located near the basolateral sides of taste buds and were characterized primarily by the presence of filaments tangential to the nuclear envelope. Dark and light cells had the typical features described by others (e.g. Farbman, 1965; Murray, 1973). Intermediate cells had features in between those of dark and light cells, for example, a slightly dense cytoplasm but a large round nucleus. At intervals up to 2 days after injecting H^3-T, over 90% of the labelled cells were basal cells. Labelled dark cells appeared at one day, and from 5 to 10 days remained a fairly constant proportion of the whole labelled cell population (ca. 25-30%). Labelled intermediate cells appeared at day 2, and labelled light cells at four days after injecting H^3-T. These data indicate that basal cells are the initial cells formed during cell turnover in the taste buds. Dark cells are formed early and light cells late in the taste cell cycle. The data do not conclusively show that dark cells transform into light cells, but this remains a possibility.

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Mixture Suppression in Olfaction: Identification of Suppressants and Analysis of Peripheral and Central Components of Suppression. CHARLES D. DERBY*, RICHARD A. GLEESON and BARRY W. ACHE. (C. V. Whitney Lab, Univ. of Florida) (*present address: Dept. Biology, Georgia State Univ.)

Marked suppression among the components of stimulus mixtures is common in both olfaction and taste. The role of peripheral and central events in this phenomenon is a paramount issue in understanding the neural mechanisms responsible for the perception of complex odors and tastes. We are studying mixture suppression in the olfactory system of the spiny lobster. Using a stimulus-substitution analytical model to quantify the responses of brain-output interneurons, we identified the components of a 31-component food odor that are stimulatory and/or interact with other components in the mixture. 12 components were found to be stimulatory, of which 2 were also synergistic and 1 was suppressive; 3 other components were non-stimulatory, but suppressive; and 16 components did not contribute to the mixture. Confirmatory experiments, in which components of the mixture were tested by class (the stimulatory, the suppressive, the synergistic, and the non-contributory components), were performed on both receptor cells and brain-output interneurons. These experiments failed to support any overall synergism, in contrast to supporting a strong overall suppression. Both peripheral and central events contribute to mixture suppression. In addition to the confirmatory experiment which identified receptor cells as sites of mixture suppression, a class of taurine-excited receptor cells has been identified for which the response to taurine is suppressed by several other amino acids, probably by competitive inhibition. Mixture suppression is also generated in the CNS. 50% of the recorded brain-output interneurons still show mixture suppression when the stimulants are presented simultaneously but to spatially-separated regions of the receptive field. The nature of the suppression generated within the CNS is presently unknown.

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The Voltage-Clamped Frog Olfactory Mucosa: Odor-Stimulated Current Transients. J. A. DeSIMONE, G. L. HECK, S. MIERSON, (Dept. Physiol & Biophys., Med. Coll. Va., Richmond, VA 23298) M. L. GETCHELL, and T.V. GETCHELL (Dept. Anatomy and Cell Biol., Wayne State Univer. School of Medicine, Detroit, MI. 48201).

We have recorded standing transmucosal current and current transients associated with odorant stimulation of the frog olfactory mucosa *in vitro*. The tissue was mounted in Ussing-type chambers and bathed symmetrically in amphibian Ringer's. In the steady state the system developed a transmucosal potential (blood side electropositive) indicating continuous active ion transport. The direction of positive current is from the ciliated toward the non-ciliated side. Seven preparations gave the following mean (±SEM) values for the potential (Voc), short-circuit current (Isc), and resistance (R): Voc = 3.8 ± 0.6 mV, Isc = 56.0 ± 16.8 $\mu A/cm^2$, R=73±15 $\Omega\ cm^2$. The standing short-circuit current served as a baseline for observing the odorant-stimulated current transients. A dose-dependent increase in inward positive current was observed when the cilitated surface was stimulated with 2-methoxy-3-isobutylpyrazine in Ringer's. The magnitude of the current excursion from baseline ranged from a mean of 0.2 $\mu A/cm^2$ at the lowest concentration to 3.7 $\mu A/cm^2$ at the highest. Odorant-induced current transients of less than 5 $\mu A/cm^2$ are in accord with the magnitude of the voltage and resistance changes. The diuretic furosemide, a potent blocker of sodium chloride cotransport systems eliminates both the standing and the stimulated short-circuit current. This suggests that the odor-stimulated voltage transient and current are dependent on a specific transcellular chloride flux. It is not yet possible to assign a precise locus to the ion pathways involved. It is likely, however, that both receptor and sustentacular cells comprise part of the local circuit. Whatever the topographical arrangement of the ion pathways, the voltage clamp method should permit the identification of the transmucosal current carriers mobilized by various classes of odorants. In addition the method is well-suited to the investigation of secretagogues promoting ion translocation. Supported by NIH-NS13767 and NS16340.

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Response Properties of Fibers in the Hamster Superior Laryngeal Nerve. J. DAVID DICKMAN and DAVID V. SMITH (Department of Psychology, University of Wyoming, Laramie, WY 82071).

The superior laryngeal nerve (SLN) is a branch of the vagus which carries afferent information from taste receptors on the epiglottis, from somatosensory receptors in the laryngeal musculature, and from cardiac baroreceptors via a communicating branch from the recurrent laryngeal nerve. Electrophysiological responses of fibers in the SLN have been obtained from several mammalian species, with emphasis on the chemosensory properties of the nerve in studies on the cat and sheep (Stedman, Bradley, Mistretta, and Bradley, 1980). Responses of single fibers in the SLN of the hamster were recorded as the epiglottis was stimulated with an array of 20 chemical stimuli at concentrations that are midrange for the anterior tongue. Stimuli were delivered to the epiglottis via a push-pull cannula driven by a syringe pump at a rate of 0.1 ml/sec. Responses were the number of impulses elicited over a 15-sec period following stimulus onset, above or below the background activity elicited by a previous rinse with physiological saline. Unlike fibers in the hamster chorda tympani nerve, these cells were not easily classifiable into response types. The best stimulus for about 2/3 of the fibers was 1.0 M urea, which is not a particularly effective stimulus on the anterior tongue. Excitatory stimuli were primarily bitter stimuli and acids. The order of their effectiveness was urea >> tartaric acid > citric acid > caffeine > KCl. The sweet stimuli and most salts other than KCl were primarily inhibitory, with the order of inhibitory effectiveness being $CaCl_2$ > sucrose >NH_4Cl > LiCl > fructose. Across the 20 stimuli, most cells were broadly excited or inhibited, with little specificity.

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Responses to NaCl of parabrachial units that were conditioned with intravenous LiCl. PATRICIA M. DI LORENZO (Department of Psychology, Smith College, Northampton, MA 01063)

The effects of "taste aversion" conditioning on unit responses to NaCl were recorded in the parabrachial nucleus of rats under flaxedil. Initially, responses to NaCl (.1 M), HCl (.01 M), Sucrose (.5 M), NaSaccharin (.1%), and QuinineHCl (.01 M) were recorded. Each solution was followed by a 20 sec. rinse of distilled water. Units were then conditioned by pairing a presentation of NaCl with an intravenous injection of LiCl (1 cc). After at least 5 min., the responses to all solutions were recorded again with NaCl presented last. At least 6 postconditioning trials were presented and were followed by a third presentation of each of the other solutions. Analysis of both single and multiunit records suggests that this conditioning procedure resulted in an overall increase in the magnitude of the response to NaCl in a subset of neural elements. This increase was sustained over all postconditioning trials and was specific to NaCl. Control procedures showed that pairing LiCl injection with other tastants did not affect the response to NaCl. Analysis of the response profiles across stimuli suggests that the conditioned units are more narrowly tuned than units that were not conditioned, but did not necessarily respond best to NaCl. Furthermore, the absolute magnitude of response to NaCl did not predict whether the unit would be affected by the conditioning procedure. No alterations in the temporal pattern of response to NaCl were found after conditioning, i.e. both phasic and tonic portions of the NaCl response increased in magnitude. This contrasts with previous data that showed changes in the temporal pattern of response to NaSaccharin after conditioning. It is possible that these two tastants are encoded differently by the nervous system and that this differnce is a direct reflection of the thier unique functions as dietary requirements for survival.

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Influence of Intertrial Interval and Sniff Bottle Volume on Phenyl Ethyl Alcohol Odor Detection Thresholds. RICHARD L. DOTY, STEVEN A. APPLEBAUM, R. GREGG SETTLE & TERESA VOLLMECKE (Smell and Taste Center & Department of Psychology, University of Pennsylvania).*

The relative influences of intertrial interval and sniff bottle volume on phenyl ethyl alcohol odor detection thresholds were determined in two experiments. In the first, thresholds were measured for 20 men and 20 women using 8, 16, 32, and 64 sec intertrial intervals within a Latin Square design. No significant influence of intertrial interval was apparent. In the second, such measures were established for 24 men and 24 women in a similar design using sniff bottles of 65, 120, and 285 ml volumes. Sniff bottle volume was significantly and markedly related to the magnitude of the detection threshold measures. These findings suggest that (a) rigid control of intertrial interval is not necessary for the meaningful determination of phenyl ethyl alchol thresholds and (b) standardization of sniff bottle volume is critical before thresholds from different clinics or laboratories can be validly compared.

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Sex Differences in Odor Identification Ability: A Cross-Cultural Analysis. RICHARD L. DOTY, STEVEN APPLEBAUM, HIROYUKI ZUSHO & R. GREGG SETTLE (Smell and Taste Center, University of Pennsylvania, and Kanto Rosai Hospital, Nakahara-ku Kawasaki-shi, Kanagawa, Japan).

To ascertain the generality of a sex difference noted in odor identification ability, the University of Pennsylvania Smell Identification Test (UPSIT) was administered to four groups of subjects: Black Americans (n = 438), White Americans (n = 1559), Korean Americans (n = 106), and Native Japanese (n = 308). The women of all four groups outperformed the men to the same general degree. Although the Korean American group outperformed both the Black and White American groups (which, in turn, outperformed the Native Japanese), the absolute differences in scores between the groups were not large. The proportions of subjects correctly answering each of the test items were remarkably similar among groups, as well as between the sexes within groups. Taken together, these data suggest that sex differences in odor identification ability are probably not due to ethnic or cultural factors, per se.

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Relationship between olfactory sensitivity and nasal airway resistance during alternate phases of the nasal cycle. RICHARD L. DOTY, RICHARD FRYE, RONALD HARTIKKA & BRUCE LONDA (Smell & Taste Center, University of Pennsylvania)*

Although several lines of evidence suggest that olfactory sensitivity is related to nasal airway resistance in humans (see Ghorbanian et al., Pediatrics, 1983, 72, 510; Schneider & Wolf, J. Appl. Physiol., 1960, 15, 914), no quantitative assessment of this relation has been made using sophisticated rhinometric equipment. We measured the airway resistance of each nostril in 20 subjects using computerized rhinometry before and after air-dilution threshold and suprathreshold testing at the opposite phases (180°) of the nasal engorgement cycle. A strong relationship was found between nasal resistance and both threshold and suprathreshold measures of olfactory sensitivity at all segments of the pressure/flow continuum. Under the condition where an odorant is presented unilaterally, but sniffing is allowed using both nostrils, olfactory sensitivity was found to be greatest in the more patent nostril. However, under the condition where an odorant is presented unilaterally, but the contralateral nostril is manually occluded, olfactory sensitivity is greatest in the less patent nostril. Thus, under normal sniffing conditions, greatest sensitivity is observed in the more patent nostril. These results suggest that unilateral measures of olfactory function are not valid unless the presentation procedures are specified and the relative degree of nasal engorgement is taken into account.

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Smell Dysfunction in Parkinson's Disease. RICHARD L. DOTY, STANLEY STELLAR, THOMAS GREGOR, RONALD HARTIKKA & STEPHANIE ROSEN (Smell & Taste Center, University of Pennsylvania, and Department of Neurology, St. Barnabas Medical Center, Livingston, New Jersey)*

The University of Pennsylvania Smell Identification Test (UPSIT) was administered to 50 persons with Parkinson's disease. Less than 10% scored above the 50th percentile of age- and gender-matched controls, with more than half scoring below the 10th percentile. Despite their low scores, a number of patients reported having experienced smell sensations which did not correspond to the test's response alternatives, suggesting that their olfactory problem was characterized by dysosmia, rather than by anosmia or hyposmia, per se. In some cases, patients reported having experienced a disturbance of smell function before the onset of the motor symptoms. The data suggest that olfactory dysfunction is a marker for Parkinson's disease, and that such dysfunction is present even in patients receiving L-dopa treatment. The relationship between UPSIT scores and neurological symptoms will be discussed, along with possible explanations of this phenomenon.

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Taste and Eating Disorders: Hedonic Responsiveness in Anorexia Nervosa and Bulimia. ADAM DREWNOWSKI (University of Michigan), PAUL DUBERSTEIN, JAMES GIBBS, KATHERINE A. HALMI, BEVERLY PIERCE, GERARD P. SMITH (New York Hospital - Cornell Medical Center)*

Taste responses of young women under hospital treatment for anorexia nervosa (n=5), anorexia with bulimia (n=13), or bulimia (n=4) were examined using a range of sucrose and lipid-containing stimuli and a mathematical modelling technique known as the Response Surface Method. The women (age range 14-30) were tested on admission to the Eating Disorders Program (mean weight: 43.4±1.4kg) and on discharge 6 to 8 weeks later (weight: 50.5±1.0kg). The taste stimuli were 20 different mixtures of skim milk, milk, cream, and safflower oil containing five levels of lipid (range 0.1 to 52.7% fat w/w), sweetened with 0, 5, 10, or 20% sucrose and chilled to 5°C. The subjects used 9-point category scales to rate the perceived sweetness, fatness, and creaminess of the stimuli and assigned a hedonic preference rating to each sample. Estimates of stimulus sweetness or fatness rose as logarithmic functions of ingredient concentration. Some mixture effects but no significant inter-group differences were observed. No differences in intensity ratings were observed following weight regain. In contrast, hedonic responsiveness depended on the relative sucrose and lipid content of the stimuli and was found to vary across subject groups. Bulimic patients gave the highest hedonic preference scores and showed an enhanced liking for intensely sweet stimuli (20% sucrose w/w). Anorectic patients (exclusive dieters) showed suppressed hedonic responsiveness and a dislike for high-fat stimuli, while anorectics with bulimia showed a mixed pattern of response. Hedonic responses of dieting anorectics were modified following weight regain. Hedonic taste responsiveness to dietary sugars and fats appears linked to the pattern of dieting in individuals with eating disorders.

* Supported by funds from the Obesity Core Center, St. Luke's Hospital (NIH Grant AM26687) and from the Westchester Division, New York Hospital - Cornell Medical Center.

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"Additional" Evidence for Acidic, Basic and Neutral Amino Acid Olfactory Receptor Sites in the Catfish. J. DUDEK and J. CAPRIO (Dept. of Zoology & Physiology, LSU).

Recent electrophysiological cross-adaptation experiments indicated the presence of relatively independent olfactory receptor sites for amino acids in the channel catfish, *Ictalurus punctatus* (Caprio & Byrd, 1984). The present experiments were designed to extend the findings of the previous study by clarifying further the degree of independence of these sites. This was accomplished by determining the effects of binary amino acid olfactory stimuli on EOG activity in the catfish. A similar technique was used to determine the effects of mixtures in both the hamster taste system (Hyman & Frank, 1980) and spiny lobster olfactory system (Derby & Ache, 1984). The individual components of each mixture in the present experiments were adjusted both in concentration (to provide approximately similar response magnitude) and in pH (7.8 to 8.0). Binary mixtures of amino acids (A=acidic; B=basic; N=neutral) that were indicated by cross-adaptation experiments to interact with (I) different transduction processes (i.e. different receptor sites) and (II) the same transduction process were tested. Binary mixtures that showed the greatest additivity were composed of those amino acids (A+B; A+N; B+N) indicated from cross adaptation experiments to interact with different receptor sites. These responses approached the sum of the responses to the individual components, although the power function exponent characterizing the EOG dose response function for amino acid stimuli is approximately 0.2. The responses, however, to binary mixtures of amino acids (A+A; B+B; N+N) thought to share the same transduction process were similar to either component at twice its individual concentration in the mixture (i.e. response approximately equivalent to the "mixture" of equal concentrations of the same stimulus) and therefore perceived as the same stimulus by the olfactory system. The present results concerning the relative independence of olfactory receptor sites for amino acids in the channel catfish agree with those from cross-adaptation experiments using the same stimulus set in the same species. Supported by NIH grant NS-14819.

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Comparison of Visual and Olfactory Stimuli in Reversal Learning with Pigeons. HEATHER J. DUNCAN (Monell Chemical Senses Center, Philadelphia, PA 19104) and BURTON M. SLOTNICK (The American University, Washington, D.C. 20016)

Pigeons trained to discriminate either two odors or two lights, using a go, no-go procedure acquired their discriminations at similar rates. When the S+ and S- stimuli were reversed within a modality, the birds using visual cues acquired the new discrimination more rapidly than in original learning (positive transfer), whereas the birds using olfactory cues acquired their discrimination reversal less rapidly (negative transfer). On subsequent reversals, pigeons in the visual task condition developed a successive discrimination reversal set while those in the olfactory condition did not. In a second experiment, with visual and olfactory cues combined as discriminative stimuli, birds previously trained with odor cues used visual cues to make discriminations, whereas birds originally trained to discriminate lights did not use odor cues. These findings are compared to similar studies using rats as subjects.

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The "Rod Cell" in Trout Olfactory Epithelium: Fact or Artefact?" PAMELA A. Eller, J. CARTER ROWLEY III, and DAVID T. MORAN (Rocky Mountain Taste & Smell Center, University of Colorado Health Sciences Center, Denver).

In the course of investigating the olfactory epithelia of teleost fishes, a number of workers have observed unusual-looking cells variously called "rod cells", Type I cells, Type IV cells, cells bearing macrociliary structures, and the like. In most cases, these cells--often believed to be receptors--possess prominent dilatations of the cell surface that contain many coiled ciliary axonemes. In our initial investigations of trout olfactory epithelia, conventional tissue preparation--i.e., removal of olfactory rosettes from the nasal sacs and subsequent immersion in aldehyde fixatives--yielded epithelia with an abundance of "rod cells" similar to those reported elsewhere. Close examination of these cells by transmission electron microscopy indicated they were, save the distorted cell surface, identical in fine structure to ciliated olfactory receptors and/or ciliated epithelial cells. These observations suggested that "rod cells" might be artefacts of fixation produced by distortion of the apical cell surface during tissue preparation. In a series of experiments, we discovered that the "rod cells" could be eliminated from trout olfactory epithelia by: 1) fixation of olfactory rosettes in situ in the living fish by 2% buffered OsO_4; 2) fixation of olfactory rosettes in situ, in vivo, by aldehydes; and 3) fixation by intravascular perfusion with aldehydes. These data are consistent with the hypothesis that "rod cells" are not a distinct cell type, but rather represent artefactual distortions of other cells present in the olfactory epithelium incurred during the course of tissue preparation for light and electron microscopy.

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Nerve Root Responses to Chemical Stimulation of Dorsal Lip Sensilla in the Leech. ELLEN J. ELLIOTT (Department of Zoology, University of Maryland, College Park, MD 20742)*

Leeches have been shown to feed differentially on, and thus to discriminate, a number of salts, sugars and amino acids. In addition, chemical cues may contribute to the high degree of host specificity shown by some leeches. However, little is known about the chemosensory systems of leeches or other annelids. A band of about 150 sensilla (sensory structures containing several hundred ciliated cells each) lines the dorsal edge of the mouth of the leech Hirudo medicinalis. Four pairs of nerve roots from the 'brain' (the supraesophageal-subesophageal ganglionic complex) innervate these sensilla. Extracellular recording from these nerve roots has revealed two types of responses to stimulation of the lip with a natural stimulus such as blood: low amplitude compound action potentials whose time course follows that of the stimulus, and large amplitude unit spikes whose onset often lags behind that of the stimulus by several seconds. The low amplitude response is believed to result from the activation of thousands of primary chemoreceptors whose axons are of sub-micron size. The large unit spikes are believed to be the action potentials of mechanosensory axons, sometimes 10-15 μm in diameter, that are activated by muscle contraction which sometimes follows chemical stimulation. Whole blood, plasma, and red blood cells all elicited similar responses. No single chemical tested was as effective as blood or blood fractions. Of the amino acids and salts tested, arginine (10 mM) and NaCl (150 mM) were the most effective stimuli. Sugars alone, including glucose and sucrose (up to 300 mM) were ineffective as stimuli. Quinine (5 mM) and HCl (1mM) elicited strong mechanosensory but not chemosensory responses. This information on effective stimuli will be used in searching, by intracellular recording methods, for ganglionic neurons involved in chemosensory processing.

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Discrimination Between Stimulus Sets: The Effect of a Multidimensional Context. DANIEL M. ENNIS (Philip Morris, U.S.A.), KENNETH MULLEN (University of Guelph)

Methods to measure differences between complex stimulus sets (such as foods and beverages) are numerous. One of the most commonly used procedures in food and beverage sensory research is the triangular method. A comparison of unidimensional and multidimensional normal models for the triangular method using Monte Carlo simulation showed that the expected subject response distribution depends not only on the size of the unidimensional discriminal distance between stimulus sets, but also on the number of dimensions for which the discriminal distance is zero in each case. Since the number of dimensions for which these conditions apply are usually unknown in complex systems, the power of the triangular method will be unknown. These findings may have important implications for the interpretation of results from many methods which involve a comparison of distance estimates in a multidimensional space.

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Comparisons of the Estimates of Smell, Taste, and Overall Intensity in Young and Elderly People. Melvin P. Enns, David E. Hornung, Donna J. Hagberg, and Colleen A. Russell. St. Lawrence University, Canton, N.Y. 13617.

Using the Two-Module Delivery System for stimulus presentation (Chemical Senses, 9: 97-106, 1984), absolute magnitude estimates of smell, taste, and overall intensity were examined in young (18-21 years) and elderly (61-93 years) people. On the average, when compared with young adults, elderly subjects gave significantly lower estimates to the smell, taste, and overall intensity of almond extract solutions. For individual elderly subjects, low estimates for odorants, did not necessarily mean low estimates for tastants, and vice versa. When the odorant was lime and the tastant sucrose, there were no significant differences between the elderly and young subjects in the magnitude estimates of smell, taste, and overall intensity. An analysis of the estimation of line lengths suggested that the young and elderly people were not using different numbering systems. These data suggest that differences in olfactory and gustatory responses may be stimulus specific. Further, an analysis of the responses given by individual subjects suggests that the lower magnitude estimates given by the elderly were not universal, with some elderly subjects scaling almond taste and/or smell with the same numbers that the young adults used. Although the percentage suppression (1 - Overall Intensity/(Smell + Taste)) was different for each stimulus pair, (almond/almond: 41%; lime/sucrose: 22%), these ratios were not affected by the age of the subjects. Thus, the data suggest that aging does not affect the process by which overall intensity is determined in the same manner that it may affect the estimation of the strength of an olfactory or gustatory stimulus.

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Odor Perception and Odor Memory in Temporal Lobe Epilepsy Patients with and without Temporal Lobectomy.

BRENDA ESKENAZI (University of California, Berkeley), WILLIAM S. CAIN (John B. Pierce Foundation and Yale University), ROBERT A. NOVELLY, and RICHARD MATTSON (West Haven VA Hospital and Yale School of Medicine)

Sixteen temporal-lobe epileptic patients who had undergone unilateral lobectomy and 18 who had not were compared to normal controls in three olfactory tasks (detection, recognition memory, and identification) and in recognition memory for amorphous shapes. The detection task entailed the measurement of threshold to 1-butanol via a standard clinical test. Odor recognition memory (tested at 10 and 40 min after stimulus inspection) and odor identification entailed the use of everyday odors presented at normal strength. The two groups of patients differed from the controls in different ways. The nonsurgery patients had equal sensitivity to the controls and approximately equal odor recognition memory, but poorer shape memory and odor identification. The surgery patients had poorer sensitivity than controls, poorer odor memory, poorer shape memory, and very poor odor identification. The difference between the surgery and nonsurgery groups in absolute sensitivity was a bilateral phenomenon, but some other differences were unilateral. In odor memory (10 min retention) and odor identification, the surgery and nonsurgery patients differed only in the nostril ipsilateral to the resection (surgery group) or epileptogenic focus (nonsurgery group). The surgery group performed worse via the ipsilateral nostril. Conceivably, the bilateral primary olfactory loss (poorer absolute sensitivity) may have allowed the ipsilateral-contralateral imbalance in odor memory function and identification to emerge. This imbalance may offer certain diagnostic advantages.

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The effect of odor deprivation on olfactory epithelium in developing rats.

A.I. FARBMAN, S.M. RITZ (Dept. of Neurobiology & Physiology, Northwestern Univ., Evanston, IL 60201) and P. BRUNJES (Dept. of Psychology, Univ. of Virginia, Charlottesville, VA 22901).

Several groups have reported that unilateral odor deprivation of neonatal rats and mice results in a reduced volume of the ipsilateral olfactory bulb, presumably as a result of retarded development. None of these studies suggested there was an accompanying retardation of olfactory epithelial development. In our study, we cauterized the right naris of neonatal rats. After 30 days, we made coronal histological sections of the heads and counted the numbers of epithelial cell nuclei along a 0.2 mm length of septum. 5 sections, at approximately 0.6 - 0.7 mm intervals, were counted in each animal. The few animals that had rhinitis were discarded. In every section of each animal the total number of olfactory receptor cells on the deprived side was less than that on the control side. The average of 30 counts on 6 animals, expressed as a ratio of cells on deprived:non-deprived sides, was 0.82 (S.D.= .09). In 6 control, unoperated littermates, the ratio was 1.01 (S.D.= .08). There was no significant difference in number of supporting cells between deprived and non-deprived sides. We stained several sections with the immunocytochemical technique for olfactory marker protein (OMP) and found that the number of olfactory dendritic knobs on the two sides was not significantly different.
The results suggest that the olfactory epithelium on the deprived side has fewer immature cells, possibly because of a lower mitotic rate and/or longer survival time of mature neurons. Immature olfactory epithelial cells grow axons which reach the bulb before their dendrites mature. The reduced number of immature receptors could account for the results of others showing a reduced volume of the bulb.

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Preference for Calcium Salts and Hypertension in Dahl Salt-sensitive Rats Fed Two Levels of NaCl.

FAY FERRELL (Dept. of Nutrition, Univ. of California, Davis, CA) and NICHOLAS L. BRAITO* (El Molino High Schl, Forestville, CA).

Enhanced Ca appetite with Ca deficiency occurs in several species. Dietary Ca deprivation and parathyroidectomy produce increases in Ca intake. Recent epidemiological and animal studies implicate dietary Ca as playing a role in blood pressure maintenance. Patients with low renin, a subset of human hypertensives who respond to high dietary NaCl with increased BP, have been reported as having low blood Ca levels, with BP reduced by Ca supplementation. The Dahl salt-sensitive (S) rat has low renin levels and develops hypertension when fed a high NaCl diet. This study investigated whether Ca preference or intake increase in Dahl S fed high NaCl diet, and, if so, whether increased Ca ingestion can prevent or delay the onset of NaCl-induced hypertension in that strain.
Rats were fed either 0.4% or 8.0% NaCl and ad lib distilled deionized water. Two groups of Hi NaCl rats additionally received early exposure to either $CaCl_2$ or Ca Lactate solutions (0.002M-0.05M) for 20 days. Control and Hi NaCl rats were then tested (and early Ca exposure groups retested) on preference for $CaCl_2$ or Ca Lactate. BP was measured every 4-6 days. Rats fed 0.4% NaCl had higher preferences for Ca solutions than either rats fed 8.0% NaCl alone, or with $CaCl_2$ or Ca Lactate. Neither Ca salt lowered the high blood pressure caused by high NaCl feeding. $CaCl_2$ actually worsened its effects. In 0.4% Controls, Ca ingested as $CaCl_2$ (but not as Ca Lactate) was negatively correlated with both absolute BP ($p<0.05$) and in increase over baseline in BP ($p<0.01$). These data suggest that NaCl stress in the Dahl S rat does not result in enhanced Ca preference, and that Ca supplementation in that strain can exert either a beneficial or harmful effect on BP, depending on level of NaCl consumed and on the anionic component of the Ca salt ingested.

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Food And Eating Problems In Patients With Chemosensory Deficits.

A.M. Ferris, J. Schlitzer, F.A. Catalanotto, (UConn, Storrs and UConn School of Dental Medicine, Connecticut Chemosensory Clinical Research Center)

Over one-half of the patients (n=227) evaluated for this study at the Connecticut Chemosensory Clinical Research Center (CCCRC) reported that their chemosensory disorder negatively affected the way they eat. Although patients who primarily had a taste problem were more likely to have a food complaint, the severity of the deficit did not seem to directly correlate with the degree of dissatisfaction within each diagnostic group. For example, while over 75 percent of the hypogeusic/normal smell population had a food complaint, only 51 percent of the hypogeusic/anosmic sample registered a similar problem. Food problems were almost twice as prevalent in the dysgeusic or parosmic group that had normal taste or smell function than in the dysgeusic or parosmic patients who had an associated chemosensory loss. The frequency of food complaints also seemed to be inversely related to the duration of the chemosensory disorder. Problems ranged from avoiding certain foods to severe appetite depression, but in many cases the presence of a food complaint did not insure an inadequate diet.

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Tyrosine hydroxylase-like immunoreactivity in the Olfactory Bulb and Tracts of the goldfish. THOMAS E. FINGER and JOAN C. YONCHEK (Rocky Mountain Taste and Smell Center, Univ. of Colorado Health Science Center, Denver, CO 80262)

At least two classes of tyrosine hydroxylase-like immunoreactive (THLI) neurons are associated with the central olfactory pathways in goldfish. One class of THLI neuron resides in the olfactory bulb and has an apical dendritic process which branches locally within the glomerular layer. These neurons may be equivalent to the THLI periglomerular cells reported in mammals. A few other, THLI neurons of the olfactory bulb have occassionally been observed in deeper bulbar layers. The second class of THLI reactive neuron in the goldfish olfactory system lies along the length of the olfactory tract which, in the adult of this species is approximately 3 mm long and connects a displaced olfactory bulb to the telencephalic mass. The THLI neurons of the tract are bipolar cells, approximately 15 x 8 um in size. Each neuron possesses two fine processes, one extending anteriorly in the tract, and the other posteriorly in the tract. The olfactory tract on each side of a typical 15 cm fish contains between 100 and 225 of these THLI neurons randomly distributed along the length of the tract. The fine THLI processes that emerge from the tract neurons do not appear to branch and may extend the full length of the olfactory tracts. A few (3-5), thicker THLI axons are also observed in the olfactory tracts. These thicker axons arise from the locus coeruleus and terminate around the cell bodies of the n. terminalis ganglion cells which, in goldfish, lie at the anterior end of the olfactory bulbs (Fernald & Finger, Soc. Neurosci. Abs. '84). Neurons which exhibit THLI have also been reported to lie within the olfactory tracts of some mammals. Whether the THLI tract neurons of mammals are homologous to those of goldfish can not be ascertained without further study.

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Behavioral Correlates of Gustatory Neurophysiology in the Developing Rat. BRADLEY K. FORMAKER & DAVID L. HILL (Dept. Psychol., Univ. of Toledo, Toledo, OH 43606)

Neurophysiological taste response frequencies to NaCl and LiCl increase in the rat peripheral and central gustatory systems during development. To investigate whether neurophysiological changes are reflected in behavioral taste responses, a conditioned taste aversion paradigm was used.

All animals were maintained on a 23.5h water deprivation schedule with food available ad lib. The number of licks/10 sec. were measured for rats aged 25-30 days and for adults to the following randomly presented stimuli: 0.1M and 0.5M NaCl, NH_4Cl and KCl; 0.1M Na-saccharin, 0.1M citric acid, 1.0M sucrose and 0.01N HCl. This measurement was taken one day before and two days after aversion conditioning. Avoidance training was conducted by alterating 10 sec. exposures of either NaCl, NH_4Cl or sucrose with distilled water. Immediately following 30 such presentations, the rat was injected with either 0.3M LiCl (1% body weight; i. p.) or 0.3M NaCl (1% body weight; i.p.).

Major differences in taste-related behaviors occurred when the conditioning stimulus (CS) was NaCl. Although both age groups drank significantly less of the CS compared to matched controls, pups drank 66% more NaCl after conditioning than adults. No age-related differences were evident when the CS was NH_4Cl or sucrose. These results are in agreement with developmental neurophysiological data from the rat's peripheral and central gustatory systems and indicate that such data may be used to predict behavioral taste responses.

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Quantitative Covariance of Taste Responses: Empirical Critera for "Natural" Types of Mammalian Peripheral Gustatory Neurons. MARION E. FRANK (University of Connecticut Health Center, Farmington, CT 06032).

Peripheral nerve fibers of the chorda tympani in mammals differ in response profile across stimulus compounds, concentration-response dependence, and maximal response level. Classes of peripheral taste neurons with roles in taste discrimination have been identified but lack definitive empirical substantiation as "natural" types (Rodieck & Brening, 1984). All cases of a type should display common traits; the diverse response levels of taste fibers, presumably irrelevant to classification, were used to investigate quantitative covariance of traits. Bivariate orthogonal regressions were examined for pairs of responses of 88 hamster chorda tympani nerve fibers to 25 chemical stimuli. Responses to pairs of stimuli that significantly affect just one fiber class are highly correlated and their characteristic relative effects are described by a single regression line; this is consistent with the fibers comprising a type. Responses to stimulus pairs that affect several fiber classes may be highly correlated across all fibers and inconsequential to a distinction among fiber types, or they may be highly correlated across fibers of one class but uncorrelated across all fibers; in this latter case, regressions characteristic for each fiber class describe the data and distinguish among fiber types. If systematic relationships are not obscured by the hysteretic responses of taste fibers to stimuli, quantitative covariance of responses for fibers in classes identified by prototypal "best stimulus" (Frank, 1973) suggest the classes are not arbitrarily imposed on the data but are "natural" types.

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Information Integration in Sucrose/Sodium Chloride Mixtures: Global Differences for Intensity and Hedonic Judgments. R. A. Frank, D. Burke & J. Estep (University of Cincinnati).

Anderson's (1981) information integration approach was used to examine taste mixture integration for intensity and hedonic judgments. In Experiment 1, total intensity and hedonic ratings were made on a 20 point category scale. The stimuli included four concentrations of sucrose (0.16, 0.6, 0.9 and 1.2M), four of sodium chloride (0.9, 0.21, 0.34 and 1.0M) and their factorial combinations. Twenty five subjects made one rating/stimulus with the order of intensity/hedonic judgment testing counterbalanced across two sessions separated by at least one day. Subjects rinsed with tap water following each trial and a 30 sec intertrial interval was used. It was found that intensity judgments produced an interactive pattern characterized by extreme subadditivity at high sucrose/sodium. chloride mixtures. This pattern was not observed for the hedonic judgments, which demonstrated the parallelism indicative of mixture additivity. In Experiment 2, 18 subjects made sweetness or saltiness ratings for the mixtures instead of total intensity and hedonic judgments. These ratings were examined to determine whether mixture sweetness or saltiness predicted the total intensity and hedonic data. Neither sweetness nor saltiness judgments alone predicted the total ratings. However, if the sweetness and saltiness ratings were used to correct the mixture components for intensity suppression, an additive mixture model provided accurate predictions of total mixture intensity. This was not the case for the hedonic ratings. These experiments suggest that subjects use different aspects of the taste stimuli when making intensity and affective judgments. In addition, they are inconsistent with the view that affective processing is based on information subjected to prior sensory (e.g., intensity) analysis.

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Bulbar activity pattern generators in EEG during odor discrimination by rabbits. W.J. Freeman, Physiology-Anatomy, University of California, Berkeley, CA 94720.

Abstract

The mitral cells (excitatory) and granule cells (inhibitory) form an interactive neural mass that can be described as a distributed set of coupled oscillators. This dynamic system has three types of stable state. An equilibrium state occurs under deep anesthesia and is characterized by the tendency of activity to go to steady state and stay there. A limit cycle state occurs with each inhalation and is seen in waking motivated animals as a brief burst of sinusoidal activity at a frequency > 55 Hz in the bulbar EEG. A chaotic state is seen between bursts during exhalation and also in occasional bursts with frequencies < 55 Hz. It is characterized by a periodic activity. Each of these types of state manifests an attractor, which is a dynamic property of the neural mechanism that determines its activity pattern. There are mutiple attractors of each type in the bulb.

Each rabbit has a characteristic spatial pattern of bulbar EEG that like a signature is recognizable over successive bursts but is never twice the same. During acquisition of a conditioned response (CR) to an odor delivered as a conditioned stimulus under reinforcement (CS+) the subject's spatial pattern changes to a new pattern. We propose that this change manifests the formation of a learned limit cycle attractor that represents the conditioning odor. Rabbits that have been trained to discriminate 2 odors (CS+ and CS-) have 3 stable burst patterns in their EEGs, one in the control state and one that appears with each type of odor presentation. We suggest that the chaotic background state provides for quick and ready access to these stored neural patterns whenever the appropriate odor is present, and that there are as many limit cycle attractors in the bulb as the number of odors that a rabbit can discriminate.

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Central Afferent and Motor Connections from the Region of the Geniculate Ganglion in the Chicken. GANCHROW, D., GANCHROW, J.R. (The Hebrew University), GENTLE, M.J. (Agricultural Research Council's Poultry Research Centre)*

Taste buds in the chicken are distributed across oral epithelium in the upper beak, lower beak and posteroventrolateral anterior tongue. The chorda tympani branch of the VIIth nerve responds to buds stimulated in the anterior mandibular glands region (Gentle, M.J. Experientia, 39: 1002-3, 1983) while another branch innervates palatal buds. The central distribution from the geniculate ganglion region was studied in adult chickens by the horseradish peroxidase-TMB procedure. Animals survived for 24-48 hr after crystalline HRP (Sigma, Type VI) was unilaterally applied to the exposed ganglion located at the junction of the facial nerve trunk, superficial petrosal, chorda tympani and hyomandibular nerves. Labelled facial rootlets enter the brain dorsal to and/or intermingled with unlabelled rootlets of the VIIIth nerve, caudal to trigeminal principal sensory n. Most sensory fibers form a solitary tract (ST) dorsomedial to the trigeminal n. and turn caudally. At the level of n. angularis, the coarser ST fibers give rise to terminal clouds in the sensory nucleus of VII (sVIId). At the level of the IXth nerve root, terminal fields are seen in the ventrolateral- and presulcal- anterior solitary nuclei. Motor VII rootlets are followed medially, through their genu, to retrogradely labelled somata of dorsal, intermediate, and ventral divisions of motor VII n. (MVII). Smaller, spindle-shaped cells of the salivatory n. wedged between MVII and superior olivary nn. also show reaction product. No contralateral projections are evident. Homologous projections are reported in mallard and pigeon by Dubbeldam and colleagues (J. comp. Neurol., 170: 415-420, 1976; Brain, Behav. Evol., 24: 47-57, 1984), who suggest that ventrolateral anterior solitary and sVIId nuclei primarily mediate taste.

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Screening Questionnaire for Patients with Chemosensory Dysfunction. J.F. GENT, (UCONN Health Center), R.T. ZAGRANISKI (N.J. State Dept. of Health), R.B. GOODSPEED (UCONN Health Center), and F.A. Catalanotto (UCONN Health Center).

"I can't taste" is not necessarily an accurate symptom description from a patient whose primary complaint is chemosensory dysfunction. Patient reports tend to reflect the common confusion between taste sensitivity, (i.e. to salt, sour, sweet, bitter) and flavor perception (i.e. sensations including taste, smell, temperature, texture). A self-administered questionnaire has proven to be a clinically valid device for classifying symptoms according to what the dysfunction is (taste, smell or both); whether the problem is quantitative (reduced or absent sensation) or qualitative (distorted sensations); and what might have caused the dysfunction. The questionnaire's value as a source of information was assessed by comparing the self-reports of taste and smell symptoms to the clinical evaluation of chemosensory function for 101 new patients seen in the Taste and Smell Center in 1983. Close associations were found between reported and diagnosed quantitative problems for both smell and taste (χ^2=13.4, df=4, p<0.01; χ^2=6.8, df=1, p<0.01). Patients seem to over-report quality distortion problems: twice as many reported qualitative dysfunctions as were diagnosed. Self-reported events associated with the onset of chemosensory dysfunction appear to be valid indicators of clinically assigned etiologies of nasal disease (χ^2=24.2, df=1, p<0.001), post-upper respiratory infections (χ^2=15.3, df=1, p<0.0001), chemical exposure (χ^2=19.4, df=1, p<0.05), head trauma (χ^2=67.3, df=1, p<0.0001) and idiopathic (χ^2=8.0, df=1, p<0.005). In addition, nasal disease was related to reports of temporal fluctuations in inability to smell (χ^2=7.0, df=1, p<0.01). Upper respiratory infections were associated with quantitative taste problems (χ^2=11.6, df=1, p<0.001). The questionnaire is a valuable triage device for the Taste and Smell Center and has potential as a screening device for use by clinicians in general.

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Two Clinically Relevant Compounds Mediate Secretion From Olfactory Glands In The Salamander. M.L. Getchell, B. Zielinski & T.V. Getchell (Department of Anatomy & Cell Biology, Wayne State Univ. School of Medicine, Detroit, MI 48201).

The decongestant ephedrine and the expectorant guaiacol are components of many cold and cough medications. We have examined their effects on the cytological signs of secretion from the superficial Bowman's glands (sBG) and the deep olfactory glands (dG). One ml of 0.15M NaCl containing either 3% l-ephedrine hemi-sulfate or 1 mM guaiacol was slowly introduced into the intact nasal sacs. After 15 min, the animals were perfused with fixative and the tissue was plastic-embedded, sectioned and stained. Measurements of characteristics indicative of secretion from 171 cells in 30 acini of comparable areas from drug-treated and carrier-treated tissue were analyzed using computer assisted morphometric techniques. In sBG, the ratio of the secretory granule area to acinar cell area was reduced by 45% (p<0.001) with ephedrine and guaiacol; the ratio of secretory granule height to acinar cell height was reduced by 26% (p<0.001) with ephedrine and by 30% (p<0.001) with guaiacol. In dG, neither drug significantly reduced the proportion of the cell area or height occupied by secretory granules. However, large vacuolations within the area occupied by the secretory granules were prominent in dG after treatment with both compounds. The vacuoles are signs of water and electrolyte transport in other secretory tissue. In addition, the lumens of the dG treated with ephedrine were 52% larger (p<0.05) than those of the control, also indicative of secretion. Our results demonstrate that ephedrine and guaiacol, at the concentrations used, have differential effects on sBG and dG, eliciting secretory granule release from sBG and water and electrolyte secretion from dG. Supported by NIH-NS-16340.

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Pyrazine-Mediated Neural and Secretory Activity in the Olfactory Mucosa of the Salamander. T.V. Getchell, B. Zielinski & M.L. Getchell (Department of Anatomy & Cell Biology, Wayne State Univ., Detroit, MI 48201).

Pyrazines are odorants which have low human psychophysical thresholds and are important constituents of food products. We have examined the effects of 2-methoxy-3-isobutyl pyrazine on the neural activity recorded from the olfactory mucosa and on cytological characteristics of the secretory elements. The compound evokes graded, monophasic negative slow voltage changes when delivered to the mucosa in the vapor phase. The transient shows slowly adapting properties and exhibits the property of fatigue. The compound was also applied in the fluid phase in concentrations of 10^{-5}, 10^{-4} and 10^{-3}M in 1 ml aliquots in 0.15 M NaCl into the nasal sacs. After 15 min, the animal was perfused and the tissue fixed, plastic-embedded, sectioned and stained. We noted effects on sustentacular cells (SC), superficial Bowman's glands (sBG) and deep glands (dG). The two main effects on SC were vacuolations in the apical cytoplasm at 10^{-5}M, and apical migration and aggregation of secretory vesicles in the supranuclear region, leading to protrusions into the mucociliary matrix at the higher concentrations. The main effect on sBG was a concentration-dependent depletion of secretory granules from the acinar cells. Three effects on dG were most prominent at 10^{-4}M: apical vacuolations in the acinar cells, lumen dilation and slight granule depletion. Also, goblet cells in the adjacent respiratory epithelium showed cytological signs of mucus release. Our results indicate that the pyrazine has multiple effects on cells in the olfactory mucosa: it elicits neurophysiological activity indicating that olfactory receptor neurons were stimulated and it induces changes in SC, sBG and dG indicating that secretory mechanisms were also activated. NIH-NS-16340; the pyrazine was supplied by IFF.

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Handedness, Sex, and the Individual Nostrils in the Odor Perception of Normal Humans. AVERY NELSON GILBERT (Monell Chemical Senses Center), MARK S. GREENBERG (Department of Psychiatry, Harvard Medical School & New England Deaconess Hospital, Boston, MA), and GARY K. BEAUCHAMP (Monell).

Olfaction is an exception to the general rule that the external world is represented contralaterally in the brain. The relation of olfactory perception to handedness has been a matter of speculation since at least the turn of the century. At issue are two distinct questions 1) Are the two nostrils functionally symmetrical? and 2) Is olfactory perception (including possible nostril asymmetry) correlated with handedness? Few previous studies simultaneously controlled for side of nostril stimulated, handedness, and sex of subject. Yet these are all variables known to be involved in lateralization of cognitive processes in humans. We have tested the null hypothesis that the perception of odor is functionally equivalent in the two nostrils in normal, healthy adults. We also tested the null hypothesis that left- and right-handers do not differ systematically in their perception of odor. We found differences in olfactory perception, which appear to be related to sex and handedness. Forty subjects were tested. Handedness was assessed by the Edinburgh Handedness Inventory. Handwriting posture and familial sinestrality were also assessed. Subjects rated the hedonic quality and intensity of four concentrations each of eugenol and butyric acid. Each odorant was presented to a single nostril six times by means of self-administered squeeze bottle technique. Nonnumerical, nonverbal intensity estimates were obtained via a turned-away tape measure. Hedonic ratings (a nine point scale) were obtained on two nonverbal subscales (pictorial and written). Preliminary data analysis suggests a three-way interaction between sex, handedness, and side of nose. Sex differences appear to be more marked among lefthanders. Aysmmetries in nostril function appear to be largest among lefthanded women.

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Gustatory Neurons and Stimuli can be Arranged along a Single Dimension. JAMES M. GILL II, Department of Psychology, Duke University*.

In all sensory systems when a neuron's response is plotted along its stimulus dimension, an orderly bell-shaped arrangement results. The form of this relation, termed the neural response function (NRF), remains relatively constant across modalities. We are reporting a simple method for obtaining NRF's in gustation.

When the absolute differences in evoked activity (neural mass differences), summed across all responding neurons and calculated for each stimulus pair, are subjected to multidimensional scaling analysis, the stimuli which generally give large responses are plotted at the edges of the space, far from poorly responsive stimuli such as H_2O. This suggests that the magnitude of the response, or intensity, may account for part of the MDS solution. Thus, there may be a point in the space which corresponds to zero intensity; an ageusic point. If this is so, then it should be possible to represent each point in the space in polar coordinates, with zero at the ageusic point; this would be analogous to the color circle, with grey in the center. The length of the vector would then represent the intensity of a stimulus, with the angle between two vectors representing differences in quality. Thus for a two-dimensional space (our present hamster PTA data), gustatory quality could be accounted for by a single dimension. In general, this method will reduce the dimensionality of a space by one when intensity is a parameter.

We have plotted the responses of neurons from the hamster PTA against the angle from an arbitrary axis, centered on a hypothetical ageusic point. We found a firm relationship similar to the NRFs derived for other sensory systems. The method was validated using data from color vision (human receptor wavelength absorption), for which the fit was excellent.

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About 1500 impulses are necessary for discrimination in the rat NTS. J.M.GILL II and R.P.ERICKSON (Duke Univ.)*

Both for coding purposes and for the construction of multidimensional spaces, we have proposed that the nervous system uses the absolute differences in responses between stimuli (neural mass differences, or NMDs) as a metric for measuring differences. In order to test this hypothesis it is necessary to obtain these differences, and to compare them with differences in behavior. Towards this goal we report the absolute differences in 32 neurons between 14 stimuli in the rat NTS.

Two sets of data are necessary to generate these differences, numbers of neurons and the NMD/neuron. First, based on numbers of neurons seen by the recording electrode, we estimate that there are approximately 150 responsive neurons spread quite evenly through the nucleus. Secondly, we measured single unit activity across the nucleus to obtain a representative sample of neurons, and thus their NMDs. The rostral and middle portion of the nucleus is generally more responsive to NaCl and HCl, while in the caudal 300 mu the general level of activity was lower, and sucrose and NaSacch were the more effective stimuli.

To estimate the NMDs between stimuli in number of impulses, we multiplied the difference per neuron by the number of neurons. For example, the difference per neuron in the first second of response for 0.1M KCl and 0.5M sucrose was 43 impulses. Thus the total NMD between these two stimuli in one sec. is 6450 impulses (43 x 150). Scott (1974) estimated that it takes a rat 311 msec. to discriminate 0.3M KCl from 1.0M sucrose; thus as an approximation (because of the intensity differences between Scott's stimuli and our's) there are about 2006 (0.311 x 6450) impulses difference developed in this period. The HCl/KCl discrimination requires about 995 impulses (12 x 150 x 0.553). Because we do not know what proportion of these neurons contribute to the behavioral discrimination, we feel that these represent maximum NMD values.

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A Behavioral Method for Evaluating Perceived Intensity of Glucose Solutions in the Behaving Rat. B. K. GIZA and T. R. SCOTT (Dept. of Psychol. and Institute for Neurosci., Univ. of Delaware, Newark, DE 19716).

Several experiments have demonstrated that satiety signals may inhibit gustatory-evoked activity. It follows that decreases in the perceived intensity of taste solutions should accompany the application of satiety factors. To test this, it is valuable to have a behavioral technique that accurately measures perceived intensity changes in the rat. We used a conditioned taste aversion paradigm to measure percent suppression across a range of glucose test concentrations (0.0 - 4.0 M), including that of the CS (1.0 M). By this means we developed a suppression gradient of perceived sweetness intensity. Twenty-one female rats were maintained on ad lib food and 22 hr water deprivation. They were given 10 min daily access to water in a test chambe for 3 weeks to establish a stable lick rate. Following training, rats were divided into saline (S) and conditioned taste aversion (CTA) groups, presented with 1.0 M glucose for 15 min and injected intraperitoneally with physiological saline (S) or 127 mg/kg LiCl (CTA). Following recovery each concentration of glucose was presented for 15 sec in a random sequence, followed by a 3 sec rinse. The number of licks made to each concentration was analyzed off-line using a PDP-11 computer. Percent suppression was calculated by the formula (1-CTA/S) x 100. Test concentration had a significant effect on percent suppression ($p < .01$). Post hoc analysis showed that each 0.2 M increase in concentration produced a significant increase in percent suppression up to 0.8 M. While suppression continued to increase up to approximately 1.4 M, these increases were not significant. The procedure by which this gradient of suppression was developed can be used to measure intensity difference thresholds or to study changes in perceived intensity which may result from the administration of putative satiety factors.

This experimental paradigm evolved from discussions with Dr. Linda M. Bartoshuk.
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Intravenous Glucose Loads Decrease Sweet Intensity Judgements in Behaving Rats. B. K. GIZA and T. R. SCOTT (Dept. Psychol. and Institute for Neurosci., Univ. of Delaware, Newark, DE 19716).

In an earlier experiment we showed that intravenous injections of glucose depress activity evoked in rat NTS by oral application of glucose. It follows that decreases in perceived intensity of glucose solutions should accompany glucose loads. Human psychophysical experiments have consistently demonstrated decreases in the perceived pleasantness of sugars following satiety but experiments relating to intensity have produced variable results. We therefore sought to determine whether glucose loads result in decreases in intensity judgements in behaving rats. A conditioned taste aversion to 1.0 M glucose was developed in 10 female rats by pairing it with an intraperitoneal injection of LiCl. Experimenters blind to the gradient of suppression generated in the preceding study then measured percent suppression to a range of glucose concentrations (0.0 - 4.0 M) following intravenous glucose infusion through indwelling venous cannulae. All training and test procedures were identical to those used in the previous experiment. Subjects showed a significant decrease in percent suppression ($p < .01$) relative to the control gradient generated previously. Significant effects were also obtained for test concentration ($p < .01$) and the interaction between test concentration and the intravenous injection ($p < .05$). Analysis of the simple main effect of injection across test concentrations revealed that the glucose load significantly decreased percent suppression for all concentrations between 0.6 and 2.0 M ($p < .05$). Suppression at concentrations beyond this range was unmodified by the iv glucose load. Approximately 2.0 M glucose was required to reach the asymptote obtained at 1.4 M in control rats. Thus at the critical intensities surrounding that of the CS, iv load rats required higher test concentrations to produce suppression equivalent to those in the control condition. These data are consistent with the idea that glucose loads decrease the perceived intensity of glucose solutions in rats.

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The Effect of Intravenous Insulin Injections on Responsiveness of Taste Neurons in the Rat Nucleus Tractus Solitarius. B. K. GIZA and T. R. SCOTT (Dept. Psychol. and Institute for Neurosci., Univ. of Delaware, Newark, DE 19716).

Intravenous glucose injections suppress evoked taste activity in the rat nucleus tractus solitarius (NTS). However high blood glucose is also associated with an increase in endogenous insulin. We therefore studied the effect of intravenous insulin infusions on NTS responsiveness to determine whether insulin levels affect taste sensitivity. We induced surgical levels of anesthesia in 22 undeprived female rats with Ketaset and advanced tungsten electrodes (500KΩ) into NTS until we encountered robust taste responses. Stimuli were 1.0 M glucose, 1.0 M fructose, 0.1 M NaCl, 0.03 M HCl and 0.01 M QHCl. We applied each stimulus four times over a 30 min. period to monitor the stability of the recording and to establish a pre-injection response level. At time T = 0 we injected 0.5 U/kg regular insulin (N = 11) or an equivalent volume of the rat's own plasma (N = 11) into the jugular vein and continued to monitor multiunit activity for up to 90 additional min. Activity was integrated and analyzed off-line using a PDP-11 computer. The evoked response to glucose stimulation was suppressed from a pre-injection value of 20.8% above spontaneous to 13.8% at 14 min post-injection. This was significant relative both to pre-injection levels ($p < .005$) and to plasma controls $p < .005$). Fructose-evoked responses were significantly depressed during the same interval relative to pre-injection levels ($p < .025$) and to controls ($p < .05$). Responses evoked by NaCl, HCl and QHCl were unmodified. These data are consistent with recent reports that infusions of physiological doses of insulin decrease food intake. The selective suppression of responsiveness to the more appetitive tastes may provide a neural counterpart to the decreased appeal of food associated with satiety in the rat.

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Eyestalk Lesions Induce Spontaneous Courtship Displays in the Blue Crab, Callinectes sapidus: Possible Hormonal Modulation of Pheromone-Mediated Behavior. RICHARD A. GLEESON (C. V. Whitney Laboratory, University of Florida and Monell Chemical Senses Center)*

Courtship displays by males of C. sapidus are normally triggered by a pheromone present in the urine of pubertal females. In experiments to examine the effects of bilateral eyestalk ligation on male receptivity to this pheromone, treated males were found to exhibit frequent bouts of spontaneous display behavior in the absence of the pheromone stimulus. Onset of this behavior occurred five to six days following ligation and continued for the 14 day duration of the experiment with a peak in activity on days seven and eight. Ligated males did not respond to the pheromone, suggesting that olfactory pathways in the eyestalk ganglia are important for pheromone processing.

Correlated with the induction of spontaneous display behavior was a marked hypertrophy of the androgenic glands in ligated males. Histological examination revealed an over 400% increase in gland size relative to controls, at least part of which was attributable to hypertrophy of individual cells. This hypertrophy is likely due to loss of an eyestalk neurosecretory factor which normally moderates androgenic gland activity.

Based on the known actions of the androgenic gland in controlling the development and maintenance of both primary and secondary male sexual characteristics in crustaceans, it is hypothesized that the spontaneous display behavior observed in the present study results from the actions of androgenic hormone(s) which effects a lowered threshold in CNS pathways involved in the control of male courtship behavior.

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Chemosensory Dysfunction Following Upper Respiratory Illness. R.B. GOODSPEED, J.F. GENT, and F.A. CATALANOTTO. (UConn School of Medicine & Dental Medicine; Connecticut Chemosensory Clinical Research Center).

Among the first 311 patients presenting to the Taste and Smell Center of the CCCRC, the third most common etiology for chemosensory dysfunction occurred in 59 patients (18%) as a result of a viral-like upper respiratory illness (post-URI). The post-URI etiology is assigned to patients who have 1) no evidence of nasal/sinus disease (NSD) on examination or sinus x-rays; 2) no evidence of neurological disorder on examination and CT Scan; 3) no temporally related head trauma; 4) and have associated the problem wih an URI. The post-URI group appears to be distinct from patients in other etiologic categories in several interesting ways. The post-URI group has a greater proportion of hyposmia (52%) than anosmia (36%) and a higher percentage of taste problems than any other group (44% function loss, 20% dysgeusia). The post-URI group is predominantly female (78%) and older (mean age 58.8 yrs) than the overall clinic population (mean age 50.8 yrs). Patients in the post-URI group more frequently report having had previous temporary chemosensory dysfunction during an URI (44%) than patients in other etiologic groups (e.g. NSD 16%). The mechanism for the pathogenesis of post-URI dysfunction has not been identified. It does not appear to be a chronic inflammatory process such as chronic sinusitis. Corticosteroids are potent inhibitors of inflammatory as well as immune processes such as autoimmune disease (e.g. Sjogren's) and immune hypersensitivity (allergy). None of the post-URI group reported olfactory improvement with corticosteroid treatment as compared to 78% in the NSD group. There is no association between post-URI and several other indicators of chronic inflammation or allergic processes such as elevations of the Erythocyte Sedimentation Rate, blood eosinophils, serum Immunoglobulin E levels and serum α2-macroglobulins. Although the influenza viruses have been implicated, there has been no identification of which viruses are involved in the post-URI etiology. Supported by NS16993.

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The Use of Sinus X-rays In Finding A Cause For Olfactory Dysfunction. R.B. Goodspeed, G. Leonard, F.A. Catalanotto, (UConn Schools of Medicine and Dental Medicine, Connecticut Chemosensory Clinical Research Center).

Paranasal sinus x-rays are frequently used in the diagnostic evaluation of nasal symptoms. We evaluated the utility of sinus x-rays (XRAY) in establishing a nasal/sinus disease (NSD) etiologic diagnosis for olfactory dysfunction. The study population included 201 patients with olfactory complaints who received x-rays. Olfactory testing determined 58% of these patients to be anosmic, 38% hyposmic, 4% normosmic. Twenty percent of the patients reported parosmia. A total of 108 (54%) of these patients had XRAYS positive for sinusitis. Among the 95 patients who were found to have nasal polyps and/or polypoidal changes on nasal examination, 83% had positive XRAYS. It is clear that patients with NSD on examination do not require sinus x-rays to make the etiologic diagnosis. If all patients with negative examinations receive XRAYS the expected rate of positive XRAYS is 27%. If only patients with olfactory function scores $\leq$25 (100=normosmic, 0=no function), receive XRAYS, the expected rate of positive XRAYS increases from 22% to 29%. In fact, all of our information to date is consistent with a greater probability of the presence of sinus disease with lower olfactory scores. In the present study the mean olfactory score for patients with bilateral positive XRAYS was 14.4 as compared to 31.6 for patients with negative XRAYS.

In summary, to establish NSD as the etiologic diagnosis for olfactory dysfunction sinus XRAYS should be use as follows: Patients with positive nasal exams do not require XRAYS to establish the etiology of the olfactory deficit. Patients with negative nasal exam should have XRAYS performed, particularly when the olfactory function is $\leq$ 25.

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Characteristics of Neurophysiological Responses of Insect Olfactory Receptor Neurons Under Different Stimulation Regimes. A.J. GRANT (Worcester Foundation for Experimental Biology, Shrewsbury, MA), R.W. MANKIN and M.S. MAYER (U.S.D.A., Insects Attractants, Behavior and Basic Biology Research Laboratory, Gainesville, FL).

The frequency and time course of action potentials in an insect olfactory receptor neuron is strongly affected by odorant composition, concentration and the time course of the stimulation. Investigation of the temporal characteristics of neural activity from insect olfactory receptor neurons during stimulation is complicated by difficulties associated with odorant presentation. To fully characterize neurophysiological and behavioral effects requires that the stimuli be precisely defined and reproducable, especially at low odorant concentrations. To investigate these effects, we have designed a stimulus delivery system that presents a well-mixed, uniform odor pulse with a relatively sharp onset and offset.
Single-cell recordings were made from olfactory sensilla on the antenna of Trichoplusia ni (Hübner), the Cabbage Looper Moth, to the major component of the sex pheromone, (Z)-7,dodecen-1-ol acetate. Here we compare the neurophysiological responses to stimulation with this system for several different stimulation regimes, including: pulses of 600 sec duration, pulses of 3.0 sec duration and series of pulses of 0.3 sec duration. During pheromone stimulation of high intensity, the temporal pattern of neural activity was characterized by an initial phasic component (200-300 msec) followed by a potentially longer tonic component. At low intensities, the phasic component was reduced or absent. In a limited sample from different sensilla preparations, variation was observed in the magnitude of the phasic component. We also examined the latency between the arrival of the stimulus and the first impulse. Finally, we consider hypotheses about how these neurophysiological effects are correlated with behavioral changes under different stimulation regimes.

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Determinant Factors in the Formation of Olfactory Glomeruli: preliminary studies. GRAZIADEI, P.P.C., HECKROTH, J.A., MORRISON, E.E. and MONTI GRAZIADEI, G.A. (Department of Biological Science, Florida State University, Tallahassee, Fla 32306)

The mechanisms followed by the olfactory sensory axons leading to their organization into discrete glomerular structures are largely unknown.

Several experiments in our Laboratory have shown that the specific target is irrelevant in the formation of these terminal structures (Graziadei et al. Neuroscience, 1979). In fact, following bulbectomy, we have observed in rodents the formation of glomeruli in the neocortex as well as in transplanted slabs of occipital and cerebellar cortexes. Moreover, in frogs entire olfactory organs, transplanted to several locations of the cranium or on the dorsal aspect of the animal, send their axons to diencephalic, myelencephalic or spinal cord regions where, invariably, these axons terminate in discrete, globose structures with the characteristics of glomeruli (Magrassi and Graziadei, Neuroscience, 1985). On the other hand, when only portions of the sensory sheet are trasnplanted in mammals, the olfactory neurons survive and grow large bundles of axons, but they consistently fail to form glomeruli.

In order to clarify this appearent discrepancy we transplanted entire olfactory organs (olfactory pits from E12 rat embryos) into the cortex of neonatal rat pups, following the same technique used in the transplant of the portions of olfactory mucosa (Morrison and Graziadei, Brain Res. 1983). From the pit transplants large bundles of olfactory and vomeronasal axons originated from the corresponding epithelia. These axon bundles terminated both in the brain parenchima or in the brain ventricles, where they formed a fiber plexus similar to the fibrous layer of the olfactory bulb; finally, the sensory axons arranged themselves in discrete, well recognizable glomeruli.

Our results suggest that glomeruli can only form when axons originate from the entire olfactory sheet but not from portions of it. Possibly, the glomerulus is the result of the convergence of axons from different groups of receptors discretely arranged throughout the olfactory sheet. Convergence of the axons and recognition of complementary units through the plexus seems to be the essential prerequisite for theorganization in a single unit, i.e. the olfactory glomerulus. In agreement with our hypothesis is the recent demonstration by immunocytochemical techniques, in several laboratories of subpopulations of receptor neurons and the observation that axons converging in one glomerulus may have originated from spatially distributed receptor groups (Shepherd, 1981).

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The Effect of ℓ-Menthol on Perceptions of Warmth and Heat Pain. BARRY G. GREEN (Monell Chemical Senses Center)[1].

It was discovered previously in this laboratory that depending upon the duration of exposure, low concentrations of menthol either enhanced or inhibited oral perceptions of warmth. The experiments reported here extend those findings to include the influence of higher menthol concentrations and longer exposures on the range of sensations from the threshold of warmth to the threshold of heat pain. Using the method of limits to estimate thresholds and a matching paradigm to measure warmth intensity, it was learned that 2.0% ℓ-menthol (in mineral oil) applied for 2 min or more to the vermilion border of the lip (1) raised the threshold for warmth significantly; (2) reduced warmth intensity over the low range of suprathreshold temperatures; (3) steepened the psychophysical function at higher temperatures; (4) did not affect the threshold for heat pain. These results indicate ℓ-menthol may selectively reduce the responsiveness of warm receptors while leaving polymodal and/or heat nociceptors unaffected.

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A Quantitative Golgi Analysis of Granule Cell Development In the Neonatal Rat Olfactory Bulb. CHARLES A. GREER (Sec. Neurosurgery & Neuroanatomy, Yale Univ. Sch. Med., New Haven, CT 06510)

Local circuits in the external plexiform layer (EPL) of the adult olfactory bulb (OB) are composed, in part, of reciprocal dendrodendritic synaptic interactions between interneurons, the granule cells (GCs), and primary neurons, the mitral and tufted cells. As part of a study examining the ontogeny of sublaminar organization within these local circuits, the development of GC dendrites and spines was assessed utilizing quantitative Golgi procedures.

Sprague-Dawley rats were processed for Golgi-Kopsch staining at 0, 3, 6, 9, 12 and 21 days postnatal. Serial transverse sections were cut at 100um and GCs reconstructed with camera-lucida at 100X oil immersion. Sampling of cells was restricted to the postero-medial quadrant of the main OB.

At day 0 there were well developed GC dendrites extending into the EPL. In addition, spines, although few in number were present as were varicosities along the dendritic shafts. During the next two weeks there was a dramatic increase in the area occupied by GC dendrites within the EPL. Furthermore, there was an overproduction of spines which was particularly evident at 12 days postnatal. During the third week spine number decreased which may reflect a stabilization of reciprocal synaptic contacts between GCs and the mitral and tufted cells. A significant heterogeneous distribution of GC EPL dendrites did not appear until 21 days. Between 0 and 6 days the GC somas are deeply placed within the granule cell layer and their dendrites extend the entire width of the EPL. At later stages, beginning around 9 - 12 days, a trend towards a differential innervation of the EPL appears and reaches statistically significant levels by 21 days. At this time the adult pattern is observed with deeply positioned GCs innervating the deeper portions of the EPL and superficially located the GCs superificial portions of the EPL.

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Fatness and Taste: Longitudinal Studies in Familial Obesity. JOEL A. GRINKER, A. SINGLETON, J. GROPMAN (University of Michigan)

Studies of adult obese individuals while failing to reveal significant differences in sensory function report both decreased and increased hedonic responses to sweet tastes. Recent studies suggest that complex natural stimuli (high fat-CHO) may be highly preferred by obese ss and may in fact be implemented in the development of obesity. Thus, attention has focused on infant feeding practices and taste responses. We examined contributions of infant and maternal fatness (prepreg. wt. > 20% ideal) to taste responses using a pressure sensitive nipple to very small volumes (2 ml) of sucrose or dextrose (1/16M-1/2M). Healthy term infants from obese (O) (n=20) and normal weight (NW) (n=20) mothers received 4 concentrations of sucrose or dextrose and distilled water midway between feedings. While infants from O mothers were larger, they responded similarly to NW infants. No differences were observed to different concentrations of dextrose but linear changes to sucrose (↑ # sucks, ↓ rate) were observed. These changes, however, were unrelated to any measure of infant or maternal fatness. Since these results cannot exclude the possibility of later differences in maternal behaviors or infant responses to high fat-CHO foods, infants were reexamined at 4 months.

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Temporal Bitterness and Astringency Upon Repeated Stimulus Ingestion. J-X. GUINARD, R. M. PANGBORN, and M. J. LEWIS (University of California, Davis)

The effect of repeated stimulus ingestion on time-intensity (TI) of bitterness in beer and astringency in wine was investigated via a computerized system. Three concentrations (0, 15, and 30 ppm) of iso- α - acids in beer and three concentrations (0, 250 and 500 ppm) of tannic acid in wine were evaluated in triplicate. Three sets of data were read from the TI curves: maximum intensity of sensation, total duration of sensation fron onset to extinction, and time to reach maximum intensity. For both bitterness in beer and astringency in wine, the total duration of the sensation increased significantly upon repeated ingestion, whereas maximum intensity remained unchanged. Time to maximum intensity of bitterness in beer increased significantly between the first and subsequent ingestions.

A theory combining taste adaptation, stimulus dilution and dissociation by saliva is proposed to explain the observed changes in sensitivity to bitterness upon repeated ingestion. It is assumed that precipitation of mouth proteins by wine tannins and resultant drying of the mucous membranes may account for the observed changes in sensitivity to astringency upon repeated ingestion.

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Vomeronasal Stimuli Can Be Reinforcing. MIMI HALPERN, LOUISE SCRIBANI and JOHN L. KUBIE. (Downstate Medical Center, 450 Clarkson Avenue, Brooklyn, NY 11203)

Garter snakes (Thamnophis sirtalis) will follow prey trails (water washes of earthworms) for prey rewards (pieces of worm) in a maze (Kubie & Halpern, 1975). If lesions are made of the vomeronasal nerves, prey trailing immediately falls to chance (Kubie and Halpern, 1979), but prey attack and reward ingestion extinguish over time. Typically a snake will ingest worm bits for several trials, will then strike the bits and spit them out, and will finally ignore worm bits altogether. These findings suggested that the vomeronasally-mediated stimuli arising from the prey trail and/or the prey bits are intrinsically reinforcing. To test this hypothesis, two groups of 5 snakes each were trained to make a visual discrimination (dots vs stripes) in a Y maze. One group received earthworm bit rewards for correct responses, the other group received prolonged contact with a known vomeronasally-mediated stimulus - dried earthworm wash (Kubie & Halpern, 1979). All members of both groups of snakes learned the discrimination within 70 trials (criterion for acquisition was 2 consecutive 10 trial blocks at 80% correct or better) and four snakes in each group learned a second discrimination, a reversal of the first task, to criterion. These findings support the idea that appropriate stimulation of the vomeronasal apparatus can serve as a reward for conditioning an arbitrary response and thus may have intrinsic reinforcing properties.

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Odor-Elicited Spike Patterns and Related Synaptic Potentials of Mitral/Tufted Neurons. K.A. Hamilton and J.S. Kauer (Dept. of Neurosurgery, Tufts Univ.- New England Medical Center, Boston, MA).

The use of intracellular recording techniques permits both the spike activity of a neuron and small fluctuations in membrane potential to be monitored. Thus, in the olfactory bulb of the tiger salamander, intracellular recordings can provide information about how the odor-elicited spike patterns which previously were studied extracellularly (Kauer, J.S, 1974, J. Physiol., Lond., 243, 695) might be controlled by synaptic interactions.

Intracellular recordings were obtained from mitral/tufted neurons in response to defined odor pulses ranging in concentration from 10^{-3} to 10^{-1} times vapor-phase saturation. Some tests were conducted while hyperpolarizing current was passed through the intracellular electrode. The results show that periods of depolarization and hyperpolarization occur which are related to the spike pattern and which are influenced by odor quality, by odor concentration, and by the level of injected current. In a single cell, different odorants and changes in odorant concentration can induce changes in the timing of the periods with respect to each other and relative to the onset of odor stimulation. The changes in timing indicate that periods of depolarization and hyperpolarization are to some extent independent.

These intracellular recordings provide direct evidence that the odor-elicited spike patterns of mitral/tufted cells are generated by excitatory and inhibitory synaptic interactions within the circuits of the olfactory bulb.

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Brainstem Projections of the Superior Laryngeal Nerve in the Hamster. TAKAMITSU HANAMORI and DAVID V. SMITH (Department of Psychology, University of Wyoming, Laramie, WY 82071).

The superior laryngeal nerve (SLN) is known to innervate taste buds on the epiglottis of several mammalian species. Afferent fibers of this nerve project into the nucleus of the solitary tract (NST) and efferent fibers arise from cells within the solitary nucleus and the nucleus ambiguus (NA). Because of the increasing information about the physiology of the gustatory system of the hamster, we investigated the brainstem projections of the SLN in this species. Crystallized HRP was applied to the proximal portion of the cut SLN or to one of its five distal branches. The animals were allowed to survive for 2 - 4 days and the brains were then processed for HRP reaction using the TMB method. Applications of HRP to the whole SLN revealed afferent fibers projecting into the ipsilateral solitary tract (ST) from 0.3mm to 2.7mm caudal to the dorsal cochlear nucleus (DCN), with the major area of termination in the NST between 0.8mm and 1.4mm caudal to DCN. Afferent fibers crossed the midline to terminate contralaterally within the NST between 1.7mm and 2.1mm caudal to DCN. Efferent cell bodies were labeled within the NA from 0.4mm to 2.0mm caudal to DCN. There were also labeled cell bodies within the more rostral portions of the NST, from 0.1mm rostral to DCN to 0.9mm caudal to DCN. There were five identifiable distal branches of the SLN, which we've termed A1, A2, M1, M2 and P, from anterior to posterior. NST afferents were carried in A2 and P, whereas efferent fibers from the NST and NA were carried in all five branches, with the heaviest projection from the NA in the two middle branches (M1 and M2) and from the NST in the posterior branch (P).

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A Bioassay to Determine Chemical Signal to Noise Ratios Required for Lobster Feeding. LINDA S. HANDRICH and JELLE ATEMA (Boston University Marine Program)*

To investigate the importance of signal to noise ratios in food localization and feeding behavior we developed a behavioral bioassay modeled after the natural situation of lobsters preying on mussels. Stimuli are presented in "fake mussels": cleaned mussel shells filled with cotton and glued back together. Stimulus solutions injected into the cotton leach out through 2 small holes drilled in one shell. A small, unrestrained lobster (carapace 45-55mm) sits in a shelter at one end of a rectangular 3 l aquarium. A fake mussel, attached to a thread, is lowered gently through a darkened tube and rests in a corner under one of 2 seawater inflows (flow rate=200 ml/min). The fake mussel provides a naturalistic prey which stimulates the lobster's mechanoreceptors just as a live mussel would, down to pulling the mussel from its bissus attachment (the thread) before crushing and eating it. The slow flow rate and small tank size enable us to easily substitute altered background water for the normal flow of fresh seawater, thus controlling the amount and type of chemical background noise in the lobster's environment. By also controlling the stimulus in the fake mussels we are able the alter both the "signal" and the "noise" and thus the signal to noise ratio.

Observations continue for 10 min after introduction of a mussel. Lobsters generally alert to noticeable stimuli within five minutes. Behaviors which correspond best to a dose-dependent response are: latency to alert, latency from alert to first touch, time spent out of the shelter, and time spent handling the mussel. These are rating data which lend themselves well to construction of dose-detectability curves based on signal detection theory. Selective lesions of smell or taste organs will enable us to study the effects of different signal to noise ratios on the remaining receptor organ(s). In turn, this may be informative of the role of narrowly tuned receptor cell populations in these organs.

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Maltose Taste Threshold Estimation in Mice from a Combination of Free-Preference and Conditioned Taste-Aversion Procedures. DAVID B. HARDER, MICHAEL E. RASHOTTE, JAMES C. SMITH, GLAYDE WHITNEY (Psychology Department, Florida State University, Tallahassee, FL. 32306).

Maltose detection thresholds were estimated for 10 inbred mouse strains using 48 hr preference ratios from 2-bottle tests with a descending concentration series. Both unconditioned free-preference testing and taste-aversion conditioning were found to be necessary to adequately assess the maltose tasting ability of each strain. Several threshold estimation criteria were applied to the data from the 10 strains. A combination of four criteria indicated that 6 strains avoided 10^{-1}M & 10^{-2}M maltose (but not 10^{-3}M) while the other 4 strains avoided only 10^{-1}M. For 2 strains, similar thresholds were obtained when each maltose concentration was presented to an independent group as its first test, suggesting no substantial test order effects. Genetic variation, as the basis for the observed strain differences, was suggested by the lack of effects for environmental factors (e.g. diet history) and by results from reciprocal F1 crosses of 2 of the strains.

This research was supported in part by NINCDS grant NS 15560

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Responses to changes in odor concentration and quality in identified cell types of rat olfactory bulb. THERESA A. HARRISON and JOHN W. SCOTT (Emory University, Atlanta, GA 30322)

Different morphological types of neurons in the rat olfactory bulb have different response properties to electrical stimulation of the olfactory nerve (Schneider & Scott,1983). To further examine functional differences between cell types in odor processing, response patterns of extracellularly-recorded OB units were examined in relation to morphological type, odor concentration and odor quality in Nembutal-anesthetized rats.

Units were presumed to be mitral cells if they were antidromically activated from posterior piriform cortex, tufted cells if activated from olfactory tubercle or lateral olfactory tract but not pPC, and interneurons if not activated from any of these sites. A stimulus run was 5-10 "sniffs" of an odor at one concentration. Unit responses were studied over at least one intensity series of up to 6 concentrations, with repetitions and other odors tested as possible. Although there were some indications of response pattern varying with cell type (eg. the only non-phase-locked responses were seen in some presumed tufted cells), many of the response patterns were observed in all cell types. Despite poor response to olfactory nerve shocks, mitral cells often responded vigorously to odors.

Systematic changes in response pattern with increasing stimulus intensity were usual, but mean firing rate measures were inadequate to quantify them. Decreasing latency of response components, or excitation/inhibition reversals were common responses to increased intensity. Initial data using different odors indicate wide variability in the range of odors to which different cells respond. While further work is necessary to determine if the range of adequate odor stimuli correlates with cell type, it is clear from records of cells whose responses change dramatically with intensity that erroneous judgements of the cell's response to odors can be made if a very limited concentration range is used.

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Molecular characteristics of stimulants for the crayfish amino acid and pyridine receptor. Hanns Hatt,Physiol.Inst. der Technischen Universität 8000 München 40, W.Germany

Discharges from single chemoreceptive neurons on the walking leg of crayfish A. torrentium were recorded using microsuction electrodes. The effect of more than 100 pyridines, amino acids respectively were determined to characterize the sensitivity and specificity of the receptors. The rank order of efficacy was the same for all units tested. Several characteristics show that these units represent a single type of receptor: an amino acid and a pyridine receptor. For both receptor types structural requirements of an optimal stimulatory molecule could be estimated. Conclusions on the structure and geometry of the receptive area were proposed.
Recently we have identified several ortho-substituted pyridines as reversible, competitive antagonists at the pyridine receptor site. The results with antagonists include distinct differences in the potency of binding of the receptor as well as in the activation of the receptor. Additionally, they confirm the earlier findings, on the basis of which 2 subsites in the pyridinereceptive area were postulated, which can interact with the nitrogen of the ring or with a specific substituent in a particular position on the ring of pyridine molecule.

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Simultaneous Recordings of the Transepithelial Lingual Potential and Integrated Neural Response of the Rat. G. L. HECK, M. E. WELTER, J. A. DeSIMONE (Dept. Physiol. & Biophys., Medical College of Virginia, Richmond, VA 23298).

We have previously reported *in vitro* transepithelial potentials and short-circuit currents across the lingual mucosa of dogs and rats in response to various salts and other gustatory stimuli. Changes in these electrophysiological variables with NaCl concentration parallel those observed neurophysiologically. In additional agents which selectively suppress the *in vitro* electrophysiological response to NaCl, show parallel suppression of the neural response *in vivo*. The basic assumption upon which these correlations rest is that similar transepithelial potentials develop *in vivo* and that their time course is commensurate with the neurophysiological response. We have developed an *in vivo* rat preparation in which to test this assumption. A special chamber is affixed to the dorsal surface of the rat tongue by vacuum. The chamber contains input and output ports which permit test solutions to bath the tongue. It also contains two salt bridges: one for measuring potential, the other for passing current. Two additional bridges are placed in the tongue muscle. Neural recordings are made from the chorda tympani. We find that transepithelial potentials can be recorded *in vivo* and that their stimulus-evoked changes are at least as fast as the development of the neural response. In general the response times of the potentials are faster than *in vitro*. We have also successfully voltage-clamped the preparation. This preparation permits us to follow the neural response under conditions of fixed transepithelial potential. Accordingly we shall be able to investigate the role of this potential in the response to various stimuli and to more precisely establish its role in the overall transduction process. Supported by NIH NS13767.

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Effects of Gymnemic Acid on the Chorda Tympani Proper Nerve Responses to Sweet, Sour, Salty and Bitter Taste Stimuli in the Chimpanzee. G. HELLEKANT, C. HÅRD af SEGERSTAD, T. ROBERTS (Department of Veterinary Science), H. van der WEL, J. N. BROUWER (Unilever Research), D. GLASER (Anthropologisches Institut).

In man gymnemic acid is able to abolish the sweet taste. Also in man, the neural correlate of that effect is a disappearance of the response to sweet stimuli in the taste nerves, as indicated by the observations of Diamant et al. (1965). Although a variety of other mammals also show neural responses to sweet-tasting compounds, the corresponding effect of gymnemic acid has not been demonstrated.

This study presents chorda tympani proper nerve recordings from the chimpanzee before and after gymnemic acid. On the chimpanzee tongue, application of 2 ml gymnemic acid, (3-10 mg/ml) for 3-4 min, completely abolished the taste responses to 0.0035 mol/l acesulfam-K, 0.0018 mol/l aspartame, 0.015 mol/l D-tryptophan, 0.02% monellin, and 0.02% thaumatin, reduced by 75% the response to 0.3 mol/l sucrose, and by 50% that of 0.76 mol/l xylitol. No decrease was recorded in the responses to 0.001 mol/l quinine, 0.1 mol/l NaCl, 0.02 and 0.04 mol/l ascorbic acid, 0.02 and 0.04 mol/l citric acid. The response to the sweeteners recovered with time and the recovery was complete or nearly complete after one and a half hour. It was also found that after application of 2 ml miraculin, 3 mg/ml for 3 min, to the tongue the neural response to acids was about 1½ times as large as before. Gymnemic acid applied before miraculin prevented this enhancement, and gymnemic acid after miraculin depressed the enhancement by miraculin of the response to citric and ascorbic acid.

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The Cathodal OFF Response of Electric Taste in Rats. M. SCOTT HERNESS (The Rockefeller University, New York, NY 10021)

The cathodal OFF response in electric taste, the production of a taste sensation at the break of a microampere cathodal current, was studied electrophysiologically in the rat chorda tympani nerve. Previous work in electric taste has centered on ON responses to both anodal and cathodal currents. The cathodal OFF response, like ON responses, increased with increasing current intensity until a saturated response level was achieved. Unlike previously reported ON responses, the OFF response did not show a sensitivity to the ionic composition of the fluid bathing the tongue making this the first electrophysiological report of ion insensitivity in electric taste. The cathodal OFF response was sensitive to the duration of the pulse preceding it. Longer pulses produced larger OFF responses, until with very long pulses (seconds) a saturated response level was achieved. The half maximal response occurred at 12.5 msec. These results have been interpreted to mean that the cathodal OFF response has an origin other than the microvillus membrane, the site most often implied for ON responses, due largely to its ion insensitivity. A probable location may reside with ion channels transversing the basal membrane which are transiently excited at the break of the current resulting in excitation at the receptor-afferent synapse.

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Preferences of Hamsters for Solutions of Chemicals with Sweet, Salty, Sour, Bitter, Sulfurous, Soapy, Alkaline, or Combined Flavors: Analytic Hedonic Processing. THOMAS P. HETTINGER & MARION E. FRANK (University of Connecticut Health Center, Farmington, CT 06032).

Two-bottle preferences for groups of ten hamsters to numerous flavorous chemicals were measured. Of sweet compounds, the 0.5M sugars sucrose, lactose, maltose, D-glucose, D-fructose, D-galactose, D-mannose, L-rhamnose, L & D-arabinose and alpha-methyl-D-glucoside were preferred, L-sorbose was rejected, and D-xylose was not distinguished from water; Na saccharin (.001,.01M) and L-proline (.5M) were preferred, while aspartame (.003,.03M) was not discriminated ($p < .05$). Other preferred compounds were ethanol (.1,1M) and nonvolatile sulfurous Na 2-mercaptoethanesulfonate (.01,.1M), while odorous sulfurous dithiothreitol (.001 M) and DL-methionine (.001,.01M) were rejected. The .1M salts NaCl, $NaNO_3$, KCl, tetraethylammonium chloride and $MgCl_2$ were rejected, but Na benzoate was not discriminated. Also rejected were soapy Na oleate (.01M), sour citric acid (.005,.01, .02M), bitter quinine HCl (.001M), and odorous pyridine (.01,.1M). L-Histidine (.001, .01,.1M) was not discriminated, nor was alkaline NaOH (.01M). Substances tended to be preferred only if sweet. Addition of sucrose to unpalatable solutions of pyridine, dithiothreitol, NaCl, citric acid, quinine HCl, or mixtures of NaCl, citric acid and quinine HCl resulted in a uniform increase in palatability. Mixtures of two aversive stimuli were generally more aversive than components, but mixtures of two preferred stimuli were not necessarily more preferred. Preferences to simple mixtures can usually be predicted by responses to components, suggesting that the mixtures lack unique hedonic properties.

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Standardization Of Methods For The Clinical Evaluation Of Olfactory Function. PETER G. HEYWOOD AND RICHARD M. COSTANZO (Medical College of Virginia, Richmond, VA 23298).

The recent development of standard methods for the clinical evaluation of smell permits the comparison of test scores from different populations throughout the country. One method developed by the Connecticut Chemosensory Clinical Research Center (CCCRC) includes tests for odor threshold and odor identification. We conducted an independent assesment of this method to determine: 1) its ability to identify normosmic (control) subjects and, 2) the susceptibility of test scores to variations in test procedures. We have analyzed the results of control subjects tested under several conditions. These conditions included: 1) a group tested using the exact CCCRC protocol, 2) a group that was presented with a familiarization trial prior to the CCCRC protocol, 3) a group in which the interval between stimuli was strictly controlled, and 4) a group that was retested after a 5 minute interval.

A comparison of the distribution of test scores was made and variables that influenced these scores were identified. In our population of control subjects, odor threshold scores were lower than those recently reported by the CCCRC (Am. J. Otolaryngol., 1983). Differences in the population sampled and variations in test procedures may account for the variability of test scores. Acceptance and implementation of standardized methods for the evaluation of olfactory function is essential for comparison of clinical data.

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Effects of Early Exposure to a Low-NaCl Diet on Rat Chorda Tympani Taste Responses. DAVID L. HILL (Dept. Psychol., Univ. Toledo, Toledo, OH 43606)

Environmental influences on rat neurophysiological taste responses occur when experimental procedures are imposed during early development. Exposure to a NaCl-free diet from 3 days gestation to 28-45 days postnatal led to flattened NaCl response-concentration functions compared to those in controls.

To learn whether similar alterations occur when rats are fed a low-NaCl diet, multifiber chorda tympani responses were recorded after exposure to a 0.03% NaCl diet for the the same period as the earlier study. Additional recordings were made to learn of concomitant changes in receptor membrane components and to determine if exposure to a NaCl-replete diet after deprivation would result in responses similar to controls. As found in rats fed the NaCl-free diet, NaCl response-concentration functions (0.01M-0.5M) in rats fed the 0.03% NaCl diet were flattened compared to controls; NH_4Cl and KCl response-concentration functions were unaffected. Responses to a concentration series of NaCl after lingual application of amiloride (500 μM), suppressed NaCl responses in both deprived and control rats but the magnitude of suppression was disproportionate between groups. The response-concentration functions, expressed relative to the respective 0.1M NaCl response, for both deprived and control rats after amiloride application were similar to those in deprived rats before amiloride. Finally, response-concentration functions for NaCl in rats fed the 0.03% NaCl diet to 28 days and then fed a sodium replete diet for at least 15 days were similar to controls.

These results demonstrate that specific neurophysiological taste response alterations occur to NaCl when rats are fed a 0.03% NaCl diet during early development. Response changes were similar to those in rats fed a 0% NaCl diet. A possible mechanism for the changes may relate to increased numbers of functional amiloride-sensitive membrane components. Moreover, the gustatory system is "plastic" in that responses change with changing environmental conditions.

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Detection and Food Search Thresholds of *Macrobrachium rosenbergii*. Kim Holland (Hawaii Institute of Marine Biology)

The freshwater prawn *M. rosenbergii* is an important aquaculture crop in Hawaii and Asia. However, little is known about its chemosensory physiology or natural food preferences. A research program is currently being conducted to rectify this situation.

Prawns are tested individually in aquaria constructed to permit artifact-free introduction of chemical stimuli and unobtrusive observation of behavioral responses. Detection thresholds are defined as the stimulus concentrations which will elicit a statistically significant increase in antennular flicking rate in 50% of prawns tested. Food search thresholds are defined as the stimulus concentrations which elicit onset of generalized walking or rheotactic swimming (where neither existed in pre-stimulus control periods) in 50% of prawns tested. Freeze-dried extract of freshwater smelt (FDSE) is used as the standard stimulus with which all other stimuli are compared. A range of molecular weight fractions and pure compounds are being tested. Preliminary analysis of the data yields the following threshold values:

Detection thresholds: glycine, taurine, <1,000 M.W. FDSE ($2X10^{-7}$ gm/1); argnine, TMA, TMAO, FDSE ($2X10^{-6}$ gm/1); MSG ($2X10^{-4}$ gm/1); >1,000 MW FDSE (>$2X10^{-4}$ gm/1).

Food Search thresholds: glycine, <1,000 M.W. FDSE ($2X10^{-6}$ gm/1); FDSE, TMA, isoleucine ($2X10^{-5}$ gm/1); MSG, Taurine ($2X10^{-4}$ gm/1). These data exhibit both differences and similarities to data from other crustaceans. Investigation of chemosensory cues in consummatory behavior is currently under way.

This research is being supported by Sea Grant (Hawaii) and state of Hawaii funds.

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Contributions of Smell and Taste to Overall Intensity: A Model. David E. Hornung and Melvin P. Enns. (St. Lawrence University, Canton, N.Y. 13617)*

A model is proposed to describe mathematically the integration of olfaction and gustation in producing the sensation of overall intensity or flavor. The basis of the model is the premise that the sensation of overall intensity is composed of the summation of the estimates of the intensities of smell and taste. However, since the sum of the estimates of smell and taste has been consistently shown to be greater than the estimates of the intensity of flavor, the additive model is modified by factors which "reduce" the psychophysical functions of smell and taste. The model seems to describe accurately all the published data concerning the contribution of smell and taste to the intensity of flavor.

The predictive capacity of the model is shown by the results of an empirical test using the Two-Module Delivery System (Chemical Senses, 9: 97-106, 1984) to present the odorant ethyl butyrate and the tastant sucrose. First magnitude estimates of the olfactory components of the tastant (referred smell) and the gustatory component of the odorant (referred taste) were determined for each subject. Then, using all combinations of distilled water and three concentrations of the tastant, combined with distilled water and three concentrations of the odorant, subjects used the method of absolute magnitude estimation to scale the intensities of smell, taste, and flavor. The model predicted accurately the estimates of overall intensity (flavor), reported by the subjects, from the intensity ratings they gave to smell, taste, and referred smell and taste.

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Airflow Patterns in a Human Nasal Model.

D.E. HORNUNG, D.A. LEOPOLD, S.L. YOUNGENTOB, P.R. SHEEHE, M.M. MOZELL, F.D. THOMAS, J.H. GREENBERG
(SUNY-Upstate Olfactory Clinical Research Center, Syracuse)

Various patterns of airflow distribution through human nasal models have been suggested in the literature. This airflow through the nasal cavity could have an effect on olfaction, nasal breathing, and somatosensory sensitivity.

Nasal airflow patterns were studied using radioactive xenon-133 gas, a scintillation camera, and a plastic model of the human nasal cavity. The model was produced by filling the nasal cavity of a human cadaver with plastic embedding material. This impression was used as a "negative" with which to make a "positive", anatomically correct, clear plastic model of the human nasal cavity from the external naris to the nasopharynx. A wide-diameter tube connected the nasopharynx to a vacuum pump, which maintained a continuous flow of room air through the model at three different flow rates. The radioactive xenon-133 was infused at a rate of 1 ml/min through a small catheter positioned just inside the nostril at three different sites, such as the nasal sill, and the central or lateral portion of the external naris. By imaging the resultant labeled airflow in the saggital plane the data were organized to show the number of radioactive decays in six contiguous regions of the mid-nose. The protocol of this experiment was built around a randomized blocks design for the 3 catheter positions. Three presentations of three different flows were randomized in each catheter position block. Analysis of the data involved grouping the six regions of the nose into five different spatial configurations of response pattern (e.g., front vs. back, top vs. bottom, etc.) for all the different combinations of catheter position and flow rate. The experiment showed that the spatial configurations were affected by changes in flow, and that these flow effects changed with the different positions of xenon-133 release.

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Innervation and Structure of Taste Buds in Hamsters following Unilateral Chorda Tympani Neurectomy. LIEN-TUAN HOU, THOMAS P. HETTINGER, & MARION E. FRANK (University of Connecticut Health Center, Farmington, CT 06032).

After the chorda tympani nerve is transected, taste buds in fungiform papillae degenerate but reform if the nerve fibers regrow into the anterior tongue. To prevent reinnervation, the chorda tympani segment within the middle ear was unilaterally removed and the nerve stump devitalized with formocresol. From 4 to 7 weeks later, recordings from nerves, dissected from the tympanic bulla to the lingual nerve ipsilateral (n=6) and contralateral (n=6) to neurectomy, showed that fibers had not regenerated inside the epineural sheath of the chorda tympani and regained function. All ipsilateral nerves remained silent whereas all contralateral nerves were activated by stimulation of the tongue with NaCl (.1,1M). Within the transparent epineurium of the ipsilateral chorda tympani, a few OsO_4-stainable filaments were seen; the filaments always joined the lingual nerve from the superior (acute) aspect of the chorda tympani, suggesting they were of proximal trigeminal origin. No chorda tympani nerve contralateral to neurectomy responded to chemical stimulation localized to the side of the tongue ipsilateral to neurectomy, indicating numerous fibers had not sprouted across the midline. Most fungiform papillae on the side of the tongue contralateral to neurectomy contained taste pores that could be stained by the electrophoretically applied, cationic dye methylene blue; most fungiform papillae on the ipsilateral side did not. Nerve fibers within recognizable taste bud vestiges seen in electron micrographs of fungiform papillae 50 days after chorda tympani neurectomy were likely lingual nerve fibers.

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Some Consequences of Two Chorda Tympani Nerves in One Peripheral Field. STEPHEN E. HUGHES and BRUCE OAKLEY (Neuroscience Lab. Bldg, Univ. of Michigan, Ann Arbor, MI 48109).

The right chorda-lingual nerve of the gerbil was connected to the left lingual nerve via a nerve splice. Since the left (native) chorda tympani remained intact the regenerated right (foreign) chorda tympani nerve hyperinnervated the left side of the tongue. The tongue was stimulated with 0.5M sucrose, 0.3M NaCl, 0.3M KCl, 0.3 NH_4Cl, 0.01 M HCl, 0.01M quinine hydrochloride, 0.3M $CaCl_2$ and concentration series of sucrose and of NaCl. Successive recording from each chorda tympani, where it passes through the middle ear, revealed that both nerves functionally innervated taste buds. The foreign chorda tympani respond to all chemical stimuli that elecited a response in the native chorda tympani. The receptive field of the right chorda appeared to be restricted to the left side of the tongue. We conclude the foreign chorda tympani can make functional contact with existing fungiform taste buds innervated by the native chorda tympani nerve; at the level of the taste bud there is no system of axon exclusion analagous to that found in twitch muscles. One of the main differences between the responses from the two nerves was the more sluggish onset and offset of the taste responses of the foreign chorda tympani. For responses of comparable magnitude to the same chemicals the rise time to peak and the fall time to baseline were typically greater by more than a factor of 10 for the foreign nerve. We infer from analysis of the prolongued post-rinse activity that during a response profound physiological changes occur in the taste bud which often last many minutes after the taste stimulus has been removed from the tongue surface. Preliminary histological results indicate that fungiform taste buds are restricted to the left side of the tongue. Some extra taste buds may be present. Supported in part by NIH Grant NS07072. We thank Linda Morton for assistance.

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Obtaining Human Fungiform Papillae Taste Buds. JAFEK, BW (Rocky Mountain Taste and Smell Center, University of Colorado School of Medicine, Denver, Colorado); FISHER, TA; JAFEK, RK; ELLER, P; MORAN, D

Study of the ultrastructure of the taste buds of human fungiform papillae is complicated by the fact that only approximately one of three papillae actually contains a taste bud. Routine electron microscopic processing of papillae is extremely time-consuming with a random failure rate of 2/3. The random failure rate of obtaining a positive (taste bud-containing) biopsy of 30%, 44%, or 67% is predicted, depending on whether 3, 2, or 1 papillae are sampled and processed.

A technique to increase the yield of positive biopsies was devised by identifying "promising" single fungiform papillae by modification of the fine drop tastant testing of single papillae of Cardello and Arvidson; confirmatory vital staining with an acid vital dye with microscopic identification of stain in the taste pore under 25 or 40 power magnification; and atraumatic biopsy.

The evolution and application of the technique will be discussed in detail along with a preliminary presentation of light and electron photomicrographs of the human fungiform papillae taste buds obtained.

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Suppression of the Rat's Chorda Tympani Responses by Taste Inhibitors. PATRICIA BLOCHAVIAK (Lehman College, CUNY) WILLIAM JAKINOVICH, JR. (Lehman College, CUNY)

DeSimone reported sodium taste responses in the rat are affected by amiloride, and that there may also be amiloride-sensitive currents mediating sugar responses. With this in mind, we conducted experiments using amiloride as a potential inhibitor of the sugar taste response in the rat. We continually applied 10^{-4}M amiloride solutions over the rat's tongue, and, after ten minutes found that 0.05M NaCl, 0.3M sucrose and 1.0M glucose responses were suppressed, while 0.1M KCl responses were unaffected. Upon washing the tongue with deionized water for quite some time, normal NaCl responses were restored but those to sucrose and glucose were not. These concentrations were chosen as they produced nearly equivalent neural responses. These results suggest that there are, indeed separate and distinct amiloride-sensitive channels mediating salt and sugar responses in the rat.

In a second set of rat experiments, we used some recently discovered inhibitors of the gerbil's sucrose response, i.e., DiCl-Gal, PNP-Glu and CA*. These were mixed with sucrose (0.3M) and with NaCl (0.05M), and solutions were applied and rinsed immediately from the rat's tongue. We observed that only sucrose taste responses were suppressed. These results suggest that the rat's sucrose taste mechanism is similar to that of the gerbil.

In summary, we feel that based on these rat amiloride experiments, as well as some preliminary results involving the gerbil, the sugar gustatory mechanisms of the rat and gerbil are generally similar. However, the gerbil's sucrose response does not appear to be affected by amiloride as much.

With regard to the other inhibitors, having in mind a competitive inhibition model, we were suprised that these compounds were so effective in suppressing the rat's sucrose response. Much more work is needed to completely understand the mechanism of taste inhibition.

*DiCl-Gal=0.1M methyl 4,6 dichloro-4,6-dideoxy α-D-galactopyranoside, PNP-Glu=0.03M p-nitrophenyl α-D-glucopyranoside, CA=0.015M Chloramphenicol.

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Gustatory Recipient Zone of the Nucleus of the Solitary Tract in the Hamster: Light Microscopic Observations. TAICHANG JANG and BARRY J. DAVIS (Univ. of Alabama at Birmingham)

The nucleus of the solitary tract (NST) receives gustatory afferents from the anterior and posterior tongue via the chorda tympani (CT) and glossopharnygeal (IX) nerves, respectively. The CT averages 70μm in diameter and contains about 1050 fibers; 65% of these fibers are unmyelinated and average 0.5μm in diameter; the remaining 35% are myelinated and average 1.2μm. Similar analyses of the IX nerve are in progress. The transganglionic transport of HRP shows that the CT terminates in a compact zone in the rostral NST that is about 200W x 200L x 350Dμm and contains about 1350-1900 neurons. This CT innervation zone is centered 1.0-2.1mm anterior to the obex, about 1.1mm lateral and up to 350μm below the level of the obex. The IX nerve terminates in a zone that partially overlaps but is considerably larger and more diffuse than the CT zone. The IX nerve zone averages 270W x 550L x 320Dμm, contains about 4800-6600 neurons and is about 0.8-1.5mm anterior, 0.8mm lateral and up to 320μm deep, all relative to the obex. The neuron counts in the CT and IX zones were determined by counting neurons in representative 5μm thick plastic sections of known cross-sectional areas and by calculating the total volume of the CT or IX zone visualized by TMB reaction product. Most of the gustatory zone related to the IX nerve is more caudal, dorsal and medial than the CT. Our morphometric and Golgi impregnated material suggest two populations of NST neurons. 80% are large and most output neurons belong to this group; the remaining 20% are small and are good candidates for interneurons. The cross-sectional area of the larger group averages 147μm^2 (12 x 16μm); the smaller group averages 83μm^2 (9 x 12μm). These studies help define the gustatory zone of the NST, quantify its inputs and neuronal types, and provide basic morphological information about the primary relay nucleus of gustation.

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Mixture Effects in Primary Olfactory Receptor Cells in the Lobster. B. R. JOHNSON and J. ATEMA (Boston University Marine Program, Marine Biological Laboratory).*

The lateral antennular filament from the lobster Homarus americanus functions as an olfactory organ (Devine, D.V. and Atema, J., Biol. Bull., 163:144, 1982). Many of the chemoreceptors surveyed from the lateral filament of Homarus are narrowly tuned to either hydroxy-proline (OH-Pro) or taurine (Tau) and show a suppressed response to their best stimulus when presented within a mixture of 15 compounds in equimolar concentrations (10^{-5} M) (Johnson, B.R. and Atema, J. , Neurosci. Letts., 41:145, 1983). Here we examined mixture effects over 4 decades of the response range of the OH-Pro and Tau cells, cross-adaptation between OH-Pro, Tau and the other mixture components, and the mixture components responsible for response suppression at 10^{-5} M. Single OH-Pro or Tau cells were identified electrophysiologically and tested with ascending concentrations of 10^{-7}-10^{-4} M OH-Pro or Tau and the complete mixture. The OH-Pro cells were suppressed across their entire response range (10^{-6}-10^{-4} M). In contrast the Tau cells were suppressed only at the highest test concentrations (10^{-5}-10^{-4} M) and gave a greater response to the mixture at the lowest test concentration (10^{-7} M). The response of OH-Pro or Tau cells to their best stimulus was compared before and after lateral filaments were perfused for 3 minutes with the mixture minus the best stimulus. The responses to both OH-Pro and Tau were reduced by prior exposure to the mixture minus OH-Pro or Tau. We examined the suppressive components by testing OH-Pro or Tau alone and with binary combinations of OH-Pro or Tau plus one of the mixture components. Suppressive components varied from cell to cell for both OH-Pro and Tau cells. The most effective suppressants for the OH-Pro cells were arginine, glutamine, glycine and proline but no single mixture components were effective Tau cell suppressants. Thus, mixture effects in lobster chemoreception include not only suppression but also enhancement. The effects are concentration dependent and vary from cell to cell.

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Effects of chemical cues, social factors and nutrition on reproductive development in California voles. ROBERT E. JOHNSTON (Cornell University), EMILIE RISSMAN (Cornell University)

Many species of voles are uniquely dependent on their social and physical environment for reproductive development. In nature, young California voles of both sexes are delayed in their reproductive development at high population densities -- perhaps an adaptive response to less than optimal conditions for breeding. We have shown in the laboratory that young male voles show delayed development when exposed to chemical cues from their own families, particularly mothers. This delay in development is not observed, however, if supplemental greens are provided in the diet. Thus a stimulatory nutritional environment may override suppressive social cues. The reproductive development of females is also influenced by both social cues and nutritional variables. Adding greens to the diet of young virgin females accelerates their reproductive development when they are housed in clean bedding or in bedding soiled by males. When females are exposed directly to males, however, their reproductive development is maximally accelerated and is not further influenced by the presence of greens. This type of interaction between social and environmental factors is likely to be both very widespread and extremely important for the reproductive biology of many species.

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Gustatory Centers Exist in the Telencephalon and Diencephalon of Catfish: Support for Homology with Mammalian Forebrain. J.S. KANWAL, (Zool. & Physiol., LSU)*, T.E. FINGER (Dept. of Anat., Univ. of Colo. Hlth. Sci. Ctr.) and J. CAPRIO*.

We report the existence of a telencephalic gustatory center and its diencephalic connection in the channel catfish, Ictalurus punctatus. Although Herrick (1905) first proposed the existence of a gustatory center in the diencephalon of fish, we determined its exact location. HRP injections were made in the posterior region of the diencephalon. The presence or absence of retrogradely filled cells in the secondary gustatory nucleus helped to localize the diencephalic taste nucleus. This ventro-medial posterior nucleus is similar to the thalamic gustatory center of mammals on the basis of topology and connectivity.

Recent studies on the general organization of the telencephalon in actinopterygean fishes suggest homologies with pallial and sub-pallial structures of land vertebrates (Northcutt, 1981). Auditory, visual and mechanosensory (lateral-line) projections to distinct targets in the telencephalon have been previously documented. After HRP injections into the presumed thalamic gustatory nucleus we observed labelled cell bodies in the ventral portion of the area dorsalis pars medialis of Nieuwenhuys (1963) in the telencephalon.

Our anatomical observations were followed by electrophysiological localization of the thalamic and telencephalic gustatory centers. The telencephalic area with the thalamopetal projection is located medially and extends from 1.2 to 2.0 mm below the surface. Results from these studies coincide well with the anatomical data. We have obtained preliminary data on single unit responses to chemical (amino acids) and tactile stimuli from cells in the thalamus and telencephalon of the channel catfish. The response profile of telencephalic gustatory neurons, like the cortical gustatory responses in mammals, is complex in nature.

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Pore Tubules as Possible Pathways for Odor Molecules in Insect Olfactory Sensilla.

THOMAS A. KEIL (Max-Planck-Institut für Verhaltensphysiologie, Gruppe Kaissling, D-8131 Seewiesen, West Germany)

Single-walled olfactory sensilla of insects are characterized by numerous pores in their cuticular hair walls. Each pore gives rise to several "pore tubules", 10-20 nm in diameter, which consist of a channel traversing the cuticle, being continuous with a tubulus-like structure mostly reaching for 100-200 nm into the hair lumen. The pore tubules are thought to be the pathways by which odor molecules can enter the hairs, and are often seen to contact the membranes of the olfactory dendrites running inside the hairs. During morphogenesis, these dendrites grow out into the hairs only after the cuticular structures have been completed by the trichogen cell, and have to establish the contacts de novo. By application of cationic markers, it could be demonstrated that pore tubules as well as dendrite membranes bear polyanionic surface coats which seem to be necessary for the formation of contacts. In basiconic sensilla, dendrite branches are intensely coiled and often get very close to the hair walls, thus contacting large numbers of pore tubules. In the pheromone-sensitive trichoid sensilla of the male silkmoth Antheraea, contacts of pore tubules and the 2-3 coiled, unbranched dendrites are relatively sparse. In trichoid sensilla of the male hawkmoth Manduca, the 2 unbranched dendrites form almost regular, alternating swellings, thus bringing the dendrite membranes close to the inner hair wall and rendering tubule-membrane-contacts possible.

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Differences in the Temporal Characteristics of Simple and Complex Taste Reaction Times.

STEVEN T. KELLING (Department of Psychology) BRUCE P. HALPERN (Department of Psychology and Section of Neurobiology and Behavior) (Cornell University, Ithaca NY 14853 USA).

Simple taste reaction time (RTs) is the shortest time interval between any detectable taste change and a response; complex taste reaction time (RTc), between a taste change and a response to a particular aspect of the taste. Five subjects made RTs and RTc to 500 mM NaCl and 2 mM NaSaccharin (NaSac) presented at 50 msec, 100 msec, 300 msec, 1000 msec, and 2000 msec intended durations. Durations and solution presentations as in Kelling and Halpern, Science:219 (1983). Responses were spoken words detected with a throat microphone: for RTs, "NOW"; for RTc, a description of the taste change [quality identification (RTci)] or a judgment of the intensity [magnitude estimate (RTcm)]. RESULTS: Median RTs for NaCl were 542 msec, 533 msec, 532 msec, 544 msec, and 519 msec from 50 msec to 2000 durations; for NaSac, 819 msec, 760 msec, 731 msec, 751 msec, 757 msec; all s.e. <35 msec. RTci for NaCl were 871 msec, 810 msec, 810 msec, 769 msec, and 754 msec, with descriptions >90% "salty"; for NaSac, 1048 msec, 984 msec, 965 msec, 923 msec, and 936 msec, with descriptions >90% "sweet"; all s.e. <64 msec. RTcm for NaCl were 1467 msec, 1522 msec, 1664 msec, 1991 msec, and 2107 msec; for NaSac, 1657 msec, 1639 msec, 1640 msec, 1853 msec, and 1836 msec; all s.e. <200 msec. Estimated magnitude increased by approximately 8-fold between 50 msec and 2000 msec durations. CONCLUSIONS: Taste reaction time increases by about 200 msec between RTs and RTci, almost doubles between RTs and RTcm. For NaCl and NaSac, RTs, RTci, and RTci-descriptions show little change as duration increases, but RTcm magnitude estimates become much larger.

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3-D Reconstructions of Nerve Fiber Arborizations and Patterns of Synaptic Connectivity in Murine Taste Buds.

J.C. KINNAMON and T. SHERMAN (University of Colorado)

Using High Voltage Electron Microscopy (HVEM) and 3-D computer reconstructions from serial thick sections we have examined sensory nerve arborizations and synaptic connections in mouse vallate taste buds. Nerve fiber contours and their synaptic foci have been traced and digitized into computers using previously described 3-D reconstruction programs. To date we have reconstructed 2 nerve fibers and their synaptic connections.

Nerve fibers enter the taste bud at the base and course tortuously up to within 6 um of the taste pore. A single nerve fiber may have up to 7 synapses with taste cells. In all instances taste cells are the presynaptic elements. One nerve fiber has synapses associated with two dark cells and one intermediate cell. The two dark cells synapse repeatedly onto the sensory nerve fiber. The second nerve fiber has synapses associated with a light cell and an intermediate cell. None of the above-mentioned taste cells synapse onto other nerve fibers.

Currently we are reconstructing more nerve fibers to determine if there is sufficient evidence to suggest a type of synaptic specificity in which a particular sensory nerve fiber would have synapses associated with only intermediate/ dark cells, whereas another nerve fiber might have synapses with only intermediate/light cells.

This study was supported in part by grants from NIH and Procter & Gamble, as well as the Department of Engineering Sciences, Colorado State University.

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Vomeronasally Mediated Earthworm Chemoattractant for Snakes is an Invertebrate Collagen-like Substance.

DONALD M. KIRSCHENBAUM and MIMI HALPERN (Downstate Medical Center, 450 Clarkson Avenue, Brooklyn, NY 11203)

Surface washings of earthworms (Lumbricus terrestris) contain a vomeronsasally-mediated response-eliciting chemoattractant (CA) for garter snakes (Thamnophis sirtalis). The CA is a glycoprotein with a molecular mass in excess of 65,000 Da. It is very resistent to heating at neutral pH, moderately labile in hot acid and very labile in hot alkali. Amino acid analysis of the active fraction of CA yielded the following: hydroxy proline was found in a quantity greater than 4-fold when compared with proline, on a residues per 1,000 residues basis. Serine and threonine were present in large amounts. No hydroxylysine and no cystine were present. More than 1/3 of the residues were glycine. The amino acide profile of earthworm CA closely resembles the amino acid profiles of earthworm cuticle collagen and earthworm cuticle gelatin. A water extract of cuticles manually removed from earthworms had chemoattractant activity and when placed on a column of AcA 44 produced an elution profile very similar to the elution profile of earthworm wash. In addition, earthworms used to prepare CA could not be used to prepare additional CA after two washes at 60 degrees C. Similarly, earthworms from which the cuticles had been manually removed did not yield a CA solution. Cuticle collagen purified by the method of Murray et al. (1982) had strong CA properties. These studies provide strong support for the idea that the CA in earthworm wash is a fragment of earthworm cuticle collagen.

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Delimination of Rat Gustatory Cortex. E. KOSAR, R. NORGREN AND H.J. GRILL (Monell Chemical Senses Center, Philadelphia, PA, Hershey School of Medicine, Hershey, PA and Univ. of Penn., Philadelphia, PA.

Until recently, taste cortex has been incorrectly defined as granular insular cortex due in part to reliance on single methods of investigation. Using a combination of techniques along with an analysis of cytoarchitecture, we have definitively localized this functional region to agranular insular cortex immediately subjacent to the area traditionally described as gustatory. Multi-unit responses were recorded along 97 electrode penetrations positioned parallel to the lateral convexity of the brain. Recording began within somatosensory cortex and as the electrode proceeded ventrally, there was a gradual shift in tactile receptive fields from the face into the mouth and then onto the tongue. Further ventrally, tactile responses were replaced by lingual temperature and subsequently by gustatory responses. Marking lesions were placed at sites of transitions in functional properties and reconstructed with respect to cytoarchitecture. Ventral granular insular cortex previously defined as gustatory has instead in this study been shown to be responsive solely to tongue temperature. Shifts in oral receptive fields were observed as one traversed the rostro-caudal extent of gustatory cortex. Rostrally, neurons were responsive to stimulation of the anterior tip of the tongue whereas further caudally the receptive fields shifted to more posterior portions of the oral cavity. In general, the position of gustatory cortex shifted caudally with respect to the bregma skull suture as rats increased in size. To identify the zone of gustatory thalamocortical projections, small injections of ^{3}H leucine were placed within the physiologically defined taste relay. The resultant labeling in agranular insular cortex confirmed the cortical location of taste sensibility determined physiologically. The boundaries of gustatory cortex were thus derived by 2 independent means, an analysis of thalamocortical connectivity and of physiological transitions, both of which coincided with identical transitions in cortical cytoarchitecture.

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The Effect of Bilateral Sectioning of the Chorda Tympani and the Greater Superficial Petrosal Nerves on Feeding Behavior and the Sweet Taste in Rats. ROBIN KRIMM, MOHSSEN S. NEJAD, JAMES C. SMITH, and LLOYD M. BEIDLER, The Florida State University

For thirty years the evidence has been that bilateral sectioning of the chorda tympani nerve has no effect on sucrose drinking in the rat. Recent electrophysiological evidence has been presented showing that the greater superficial petrosal nerve, which innervates the palate, may play an important role in the "sweet taste" of the rat. In the experiments reported here rats were tested for sucrose preference both before and after bilateral sections of the chorda tympani and greater superficial petrosal nerves. Some rats received long term (24 hour) two bottle sucrose vs. water tests and others received short term (150 second) single bottle sucrose tests. When the rats were tested with the long term preference tests the eating and drinking patterns following the surgery were so disrupted it was impossible to infer anything about the "sweet taste". The rats no longer ate and drank in discrete "bouts", but behaved much in the same manner as a desalivated rat, nibbling at the food and taking small drinks almost continuously throughout the 24-hr. period. With the short term tests there seemed to be a profound effect on sweet taste behavior. Prior to surgery the rate of licking on the sucrose solution increased in a linear fashion as the concentration of the sucrose was increased. Following the surgery, there was a marked decrease in the licking rate to the higher sucrose concentrations. It appears that sectioning both of these nerves profoundly effects the sweet taste in the rat. Further work is in progress to test the effect of sectioning only the greater petrosal nerves.

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Information Processing in Taste:Quality and Intensity. James T. Kuznicki (Procter & Gamble Co.).

In a series of experiments, subjects were asked to classify tastes by quality (salty, sour, sweet, bitter) or intensity (high or low intensity). In a speeded classification task, subjects responded to a small volume of stimulus solution dropped on their tongues by depressing a key to indicate which taste quality or intensity they experienced. The dependent variables were how long it took to respond, i.e., reaction time, and number of errors. When subjects were asked to discriminate between sweet and salty tastes, reaction times and errors increased if sweet and salty were mixed with sour and bitter. This was true regardless of whether sweet and salty were mixed in a correlated or orthogonal fashion with sour and bitter. If subjects were required to discriminate high sweet from low sweet, reaction time and errors increased when high and low sweet were mixed in a correlated manner with high and low salty; performance did not change, relative to the control condition (high vs. low, no mixtures) when the mixtures were formed orthogonally. When similar tasks are performed using complex stimuli formed from auditory, visual, and tactile sensations, subjects are able to include or exclude components of the complex stimulus depending upon whether or not they are needed to successfully perform the task. The present data suggest that subjects are not able to optionally include or exclude components of a complex taste from attention. In this sense, taste qualities are not as different from one another as are, for example, visual and auditory sensations.

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Human Psychophysics and 2-DG Reveal How and Where Suppression with Odor Mixtures Occurs. DAVID G. LAING, G.A. BELL and H. PANHUBER (CSIRO Division of Food Research, P.O. Box 52, North Ryde NSW 2113 Australia)

We recently reported that the perception of an odorant in a binary mixture is dependent on its intensity not its quality, and that suppression of intensity is the most common result of interactions between odorants. To determine if suppression is a peripheral phenomenon we have conducted two studies. With humans we have investigated the interactions between the hydrocarbons limonene and pinene whose epithelial regions of maximum responsivity in the salamander, for example, are sited posteriorly and perhaps overlap, and between these odorants and propionic acid whose region(s) of maximum responsivity is likely to be on the anterior epithelium. The results showed that a large reciprocal suppression had occurred between limonene and pinene; the hydrocarbons suppressed the perception of propionic acid, but the acid had little or no effect on the perception of the hydrocarbons. The results suggest suppression between the hydrocarbons and the acid is due to competition for receptor cells whilst that between the hydrocarbons is due to competition for cells and possibly receptor sites. In the second study rats were injected with [^{3}H]-2-deoxyglucose(2-DG) and presented with limonene, propionic acid, or a mixture of these odorants in which humans had only perceived limonene. The resulting bulbar pattern of 2-DG uptake showed a significant diminution of the activity in glomeruli that normally show high 2-DG uptake following stimulation with propionic acid alone, whilst the pattern of uptake for limonene was normal. The results indicate suppression had occurred at the receptor epithelium or at the glomeruli possibly by lateral inhibition.

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The Characteristics of Human Sniffing Behavior that Provide Optimum Perception of Odors. DAVID G. LAING (CSIRO Division of Food Research, P.O. Box 52, North Ryde NSW 2113 Australia)

Laing (1982) described the characteristics of human sniffing episodes during odor perception and suggested the techniques used by individuals may be close to those providing optimum perception. Later work (Laing 1983) indicated it was very difficult to improve on the efficiency of natural sniffing techniques and that humans achieve optimum perception during threshold and intensity measures using their natural multi-sniff technique or with a single natural sniff. More refined studies, however, have now shown that near-perfect identification of odors is achieved by subjects using the shortest sniff they can physically produce (0.42 sec), whilst optimum perception of intensity occurs with a sniff of between 0.39 and 0.64 sec duration. Since these studies have described the characteristics of human sniffing behavior and defined the conditions under which odors are perceived optimally, they provide a basis for developing standard olfactory test procedures and instrumentation for studies of the human sense of smell.

LAING, D.G. Perception 11, 221-230, 1982.
LAING, D.G. Perception 12, 99-117, 1983.

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Odorant-Sensitive Adenylate Cyclase in Olfactory Cilia. DORON LANCET, JUDITH HELDMAN, ZEHAVA CHEN and UMBERTO PACE (Dept. of Membrane Research, The Weizmann Institute of Science, Rehovot, Israel).

It has been previously proposed on the basis of electrophysiological evidence that cyclic AMP may serve as a second messenger in olfactory transduction. In order to provide direct evidence for this hypothesis, we measured adenylate cyclase levels in a previously described preparation of isolated frog olfactory cilia (cf. Chen and Lancet, PNAS 81, 1859 (1984)). The sensory organelles are found to contain extremely high specific activity of the enzyme, 15 times higher than brain or whole olfactory epithelial membranes, and 100 times higher than respiratory cilia. An important finding is that adenylate cyclase of olfactory cilia is stimulated by various odorants at physiological concentrations. This effect is observed only in the presence of GTP, whose hydrolysis is known to be necessary for receptor-enzyme coupling in vision and in hormone and neurotransmitter reception. The GTP-binding coupling protein (G-protein) of olfactory cilia is identified by its specific labelling with bacterial toxins, and is possibly homologous to but distinct from the hormonal stimulatory G-protein (Gs). Our findings strongly support the involvement of adenylate cyclase in odorant reception and point out the molecular similarity of olfaction to other neuronal and sensory transduction mechanisms. Odorant enhancement of ciliary adenylate cyclase constitutes the first cell-free assay for olfactory reactivity. We currently use this assay to study the interaction of the identified transductory enzymes with ciliary surface glycoproteins that may constitute odorant-binding receptor molecules. The most prominant candidate is gp95, a major integral membrane glycoprotein specific to olfactory cilia (Chen et al., Soc.Neurosci.Abst.10, 861 (1984)). We examine the effect of lectins and antibodies, which bind gp95 specifically, on odorant activation of ciliary adenylate cyclase. The non-covalent association of olfactory G-protein with gp95 is also being probed. In parallel, we study ciliary protein kinase activity and phosphoproteins that may be involved in cyclic AMP modulation of ion channels.

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Olfactory Bulb Responses to Familiar Odors Early in Life MICHAEL LEON, ROBERT COOPERSMITH and SUZANNE LEE. University of California, Irvine.

Young rats become attracted to the odors of their mother, facilitating necessary reunions when the young become mobile enough to leave the nest. Pups will also develop a similar attraction to arbitrarily-selected odors, such as peppermint. In addition to this special behavioral reponse to familiar odors, we recently reported that familiar odors elicit a special neural response in young rats. Specifically, there is an enhanced uptake of 2-DG in specific areas of the glomerular layer in response a familiar odor, compared to the response to a novel odor.

We now report additional data indicating that differential sniffing and its associated difference in stimulus presentation does not seem to cause the enhanced neural response. We have also found that exposure to one odor (cyclohexanone) does not potentiate the response to another (peppermint). Cyclohexanone experience, however, does result in an enhanced glomerular response upon subsequent presentation of cyclohexanone. Again, this neural response does not rely on differential stimulus exposure.

Odors that have attained a special behavioral relevance to young rats do not necessarily develop an enhanced neural response. Pups receiving aversive associations with odor experience actually have a suppression of the glomerular response to the odor. There are again no differences in respiratory pattern that could explain these data.

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Inhibition of Chemosensory Responses of the Ciliate, Tetrahymena, by Calmodulin Antagonists. M. LEVANDOWSKY (Haskins Laboratories, Pace University, New York, NY 10038)

The ciliate protist Tetrahymena is attracted to capillaries containing certain amines and amino acids (Levandowsky et al 1984, Biol. Bull. 167, 322; Almagor et al 1981, Cell Motility 1, 261). Since this response is Ca^{++}-dependent (Gardner and Levandowsky 1983, J. Protozool. 30, 13A) we have investigated the effect of calmodulin antagonists on it. Chlorpromazine HCl and Trifluoperazine HCl, added to experimental preparations at .02mM and .2mM, respectively, were not toxic and appeared to have little effect on normal swimming behavior, but inhibited the chemosensory response to N-acetyl-DL-methionine, normally a potent attractant. This suggests the possibility that calmodulin may be an element in the transduction system for this response.

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Convergence of Olfactory and Vomeronasal Pathways in the Amygdala. GARY LICHT AND MICHAEL MEREDITH. Department of Biology, Fl. State University, Tallahassee, FL. 32306.
Chemoreceptor pathways from the vomeronasal organ (VNO) and main olfactory system (OLF) are known to be separate as they pass into the brain, at least until the level of the amygdala. The pathway from the VNO projects to the posteromedial cortical nucleus (PMCN) and medial nucleus (MN). The OLF pathways have terminations in the posterolateral cortical nucleus (PLCN), and anterior amygdaloid nucleus (AN), both of which project to the PMCN and MN. The anatomy thus suggests that the PMCN and MN are sites for convergence of input from the OLF and VNO pathways but it is not known whether the two pathways can activate the same cells.

As part of a study of convergence of VN and OLF inputs we have recorded field potentials and single units in the amygdala while electrically stimulating the main olfactory bulbs (MOBs) and the vomeronasal organ or vomeronasal nerves. Recordings of field potentials were made with twisted wire bipolar electrodes and later referred to histological studies of serial sections of the tissue to determine the location of the electrodes. The area within which field potentials were generated was defined by the presence of a distinct turnover point. Field potentials elicited by vomeronasal stimulation were confined to the PMCN, but field potentials elicited by olfactory stimulation extend over most of the amygdala and into the pyriform cortex. Using the VN field potentials as a guide to electrode placement, single units in the PMCN were recorded with MOB and VNO stimulation. Units could be driven with constant latency by MOB stimulation and by VNO stimulation. In the preliminary experiments 3 single units were found that were driven by both types of input, indicating convergence onto the same cell.
Twisted wire bipolar electrodes were placed in each VNO and anterolateral portion of each MOB to insure that the current from a stimulating electrode in the VNO/AOB system had no stimulatory effect on the MOB.
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Olfactory Epithelium with a Developmentally Synchronized Population of Receptor Cells. MICHAEL S. LIDOW, STEVEN J. KLEENE, and ROBERT C. GESTELAND (Northwestern University).

Normal olfactory epithelium contains receptor cells of different ages. There is no method yet to determine how cells of each age contribute to the electrical properties of the epithelium. To study this question, we are producing frog olfactory epithelia in which the receptor cells are all close in age. We first ablate the epithelium by perfusing the nasal cavity with 0.15 M $ZnSO_4$ for 3 min. Then we allow the epithelium to regenerate for several days. After this, we suppress the generation of new cells by continuously flowing 50 mM hydroxyurea in Ringer (0.41 ml/day) into the nasal cavity. Thus the epithelium should contain only those receptor cells which originated during the short period of time prior to hydroxyurea treatment. (Previously we showed that hydroxyurea treatment as described above suppresses mitosis in olfactory epithelium without affecting non-dividing cells.)

We needed to determine how long to let the epithelium regenerate before suppressing mitosis. The time must not be so long as to compromise the synchronization, but long enough to give a sufficient number of cells for electrophysiological recording. Olfactory epithelia in 6 groups of 10 frogs each were ablated and allowed to regenerate for 4, 5, 6, 8, 10, or 12 days. For the remaining time up to 18 days after ablation, all epithelia were subjected to continuous hydroxyurea treatment. Then we tried to obtain EOG and single-unit recordings. Finally, the epithelia were examined microscopically. We found some olfactory neurons when 6 days of regeneration was allowed before hydroxyurea treatment. EOG and single-unit activity could first be recorded from epithelia which regenerated for 8 days before hydroxyurea treatment. A 10-day period of regeneration followed by hydroxyurea produced synchronized epithelia which could be used for electrophysiological recordings. In this case most of the receptor cells originated within a 5-day period.

This work was supported by NIH grants NS18490, NS07223, and NS14663 and by NSF grants BNS8117075 and BNS8316827.

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Clinical Investigation of Threshold Sensitivity for NaCl in Depressed Patients. NAOMI E. LOHR (University of Michigan), ANDREA L. JACOBS (Washington University in St. Louis), and DOUGLASS KING (Vanderbilt University).

Reported taste loss, a sensitive and specific diagnostic marker for melancholia, is being investigated by means of psychophysical measurement in a group of psychiatric inpatients.

Data from the laboratory evaluation of taste and olfaction function in depressed inpatients and age congruent control subjects are presented. Olfaction is assessed by means of the odor identification test developed at the John B. Pierce Foundation laboratory. Neither the diagnosis of depression nor the presence of a complaint of smell loss correlated with Smell Jar Identification test scores.

Taste function is assessed in terms of threshold sensitivity. Thresholds are established for NaCl by means of the Staircase-Forced Choice Method (Bartoshuk, 1978), which requires patients to make a series of judgments between pairs of stimuli, each pair consisting of a cup of NaCl concentration and a cup of deionized water. The depressed patients appear to have higher thresholds for the recognition of NaCl than non-depressed controls, and within a group of melancholics, patients who complain of taste loss tend to have higher thresholds for the recognition of NaCl than do melancholics who report no loss of taste perception.

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Studies on the Morphological Changes in the Diencephalon of Xenopus laevis, following Olfactory Placode Transplantation. MAGRASSI, L. and GRAZIADEI, P.P.C. (Department of Biological Science, Florida State University, Tallahassee, Fla 32306)

The effect of olfactory placode transplantation has been studied on the differentiation of the optic vesicle and stalk in *Xenopus laevis* embryos. Host embryos, stages 23-24 received the transplant of an olfactory placode from same stage donors, in place of a removed optic vesicle. All tadpoles were sacrificed at stage 47-50. At sacrifice a lobar mass of nervous tissue, continuous and protruding from the diencephalic wall was penetrated by the olfactory nerves from the transplanted placode and a well defined glomerular layer was present at the entrance zone of the olfactory nerve. The lobar protrusion contained a normal ventricular cavity connected by a foramen to the third ventricle.

To investigate the origin and cause of this protrusion we transplanted homotypic, genetically marked placodes from tetraploid (4N) normal pigmented *Xenopus laevis* to diploid (2N) periodic albino (a^p, a^p) *Xenopus laevis*. All transplants were performed at stage 23-24. In all succesfull animals the resulting protrusion was anatomically the same to the protrusion obtained using transplants between normal, pigmented diploid (2N) embryos. From the exam of the experimental animals it results that the protrusion is formed in large part by host neurons (diploid cells without pigment granules). Only few donor cells (macrophages) were observed in the protrusion 12 hrs and 20 days after the transplantation. A morphologically well defined protrusion was already present 12 hrs after transplantation (stages 31-32), while only at this stage the olfactory fibres begin to enter their normal and experimental target territories. The temporal sequence of the appearance of the protrusion followed by the appearence of the olfactory fibres makes it very unlikely that the transplanted placode could exert its major influence by means of contact by the ectopically grown olfactory axons. However, the presence of a supranumerary, ectopic placode was essential for the occurrence of the protrusion.

The mechanisms by which the placode exerts its effects on the host's diencephalon are still to be determined.

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Taste Responses to an Extended Stimulus Array in the Rat Nucleus Tractus Solitarius. G. P. MARK and T. R. SCOTT (Dept. Psychol. and Institute for Neurosci., Univ. of Delaware, Newark, DE 19716).

Micropipettes were used to record responses from 42 single neurons in the nucleus tractus solitarius (NTS) of acute anesthetized rats. Stimuli were 16 compounds chosen to represent a subset of the subjects' natural gustatory environment. The first issue was whether the taste system is composed of neurons whose response profiles fall into a discrete number of categories ("neuron types"), or whether the response profile of each cell is unique. Hierarchical cluster analyses and multidimensional scaling techniques were employed to determine the extent of similarity among response profiles of the units. The data were analyzed from two perspectives: one analysis was based on responses to all 16 stimuli while another involved a condensed data set of responses to the four prototypical stimuli, viz. NaCl, sucrose, HCl and quinine. The results indicated that while neuron types seem evident when only a few stimuli are used, their existence becomes equivocal when more compounds are employed. In both analyses however, the possible existence of sweet and non-sweet neuron types was noted. The second issue related to identifying the stimulus attributes to which the gustatory system is sensitive. Multidimensional scaling was also used for this analysis. While attempts to relate such characteristics as pH and molecular weight were unsuccessful, the biologically relevant attribute of toxicity was coded in gustatory afferents. Finally, the potential value of time course in the discriminability of stimuli was examined. Results indicated that temporal information not only provided a reliable means of distinguishing among sapid compounds, but for some stimuli may have supplied the most salient information needed for discriminability.

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Sodium and Potassium Preferences in Pyridoxine Deficient Rats. SUSAN MARRA & CHARLES N. STEWART (Franklin & Marshall College, Lancaster PA 17604), YAIR KATZ & ROSE M. THREATTE (Monell Chemical Senses Center, Philadelphia PA).

Pyridoxine deficient rats were tested on five NaCl concentrations in two-bottle 24 hr preference tests (distilled water vs. NaCl). Deficient rats demonstrated a significant increase in 0.15 M, 0.30 M, and 0.45 M NaCl intake. A significant sex difference in both groups for NaCl intake was found but this did not interact with deficiency status. When comparable preference tests were conducted with KCl, deficient rats showed a significant increased preference for 0.01 M, 0.15 M and 0.30 M.

In order to minimize post ingestional consequences, daily 20 min two-bottle preference tests were conducted. Intakes of both electrolytes increased significantly at concentrations of 0.30 M (NaCl & KCl) and 0.45 M (NaCl) which are not normally preferred by rats.

A significant increase in urinary K (but not Na) output and concentration was found. Adrenal gland involvement is suggested by the hypertrophy of these structures along with an elevation of plasma aldosterone levels.

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Structure and Neural Responses of the Facial Lobe of the Japanese Sea Catfish. T. MARUI (Oral Physiology, Kagoshima Univ.*), J. CAPRIO (Zool. & Physiol., LSU), S. KIYOHARA (Biol. Inst., Kagoshima Univ.) and Y. KASAHARA*.

We report here an extraordinary development of the medullary facial taste nucleus (facial lobes=FL) of the Japanese sea catfish, Plotosus anguillaris ("Gonzui"). The FL in Gonzui are more differentiated than those of the North American ictalurid catfishes in that fiber fascicles divide each lobe into five highly distinct lobules, constituting five longitudinal columns through the FL (the Ictaluridae show three less-defined columns; Finger, 1976). Electrophysiological recordings in the FL indicate superimposable taste-tactile (TT) neural maps organized in a somatotopic manner. Each of the first four lobules (medial to lateral) process TT information from a separate barbel: medial mandibular, lateral mandibular, maxillary and nasal barbels, respectively. The tip to base axis of each barbel is represented in the rostro-caudal axis of each of the FL columns. Facial TT input to the fifth lobule is from the face and flank. As in ictalurids (Marui and Caprio, 1982), the FL volume of Gonzui that processes barbel TT information is much larger proportionately than the corresponding body regions. The distribution of the amino acid sensitive units were limited to smaller areas of the electrode tracks in comparison with that of the only mechanically sensitive neurons (i.e. not responsive to amino acids). Neurons in the region below the five lobules, which possibly corresponds to the intermediate nucleus, responded to mechanical stimulation only and characteristically had large receptive fields ranging from 25mm^2 to the whole body surface.

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Gustation and Nutrition. Richard D. Mattes (Monell Center)

Taste disorders have been implicated in the etiology and manifestations of pathologies with a nutritional component. These associations, however, are based upon assumptions that, (a) patients with a particular disorder (e.g., obesity) consume diets abnormal with respect to the intake of selected constituents (e.g., sucrose) characterized by a particular taste quality and (b) taste function is an important determinant of an individual's dietary intake. Nutritional and epidemiologic studies do not support the first assumption and an earlier study[1] failed to reveal any significant relationship between responses to sweet or bitter stimuli and various indices of dietary intake. This study replicates aspects of the first and expands the analysis to salty and sour tastes.

Recognition thresholds (determined by a forced choice staircase procedure or ratings of the contribution of each of the "4 basic" taste qualities to the overall taste of samples); suprathreshold sensitivity (assessed via a magnitude matching procedure) and taste preferences (determined by a modification task) were evaluated in 25 healthy adults. Tastants included sucrose, NaCl and citric acid in aqueous solutions as well as cherry flavored beverage, tomato juice and lemonade respectively. Seven-day diet records corroborated by food frequency questionnaires were the source of dietary data.

Comparison of 11 dietary and gustatory measures obtained in this and the previous study revealed only a single statistically significant difference (thresholds for cherry beverage, $p = 0.002$). Neither single or combinations of taste measures could be used to predict: (a) total caloric intake, (b) the intake of nutrients consumed by subjects at a level less than 2/3 of the RDA (i.e., vitamin D, folic acid, copper) or (c) the percent of calories contributed by protein, carbohydrate, fat or foods rated by subjects as primarily sweet, salty or sour at better than chance levels. Taste quality specific associations (e.g., salt taste measures and Na intake or intake of foods with a high Na density), were also not significant. Either the taste measures employed were not adequate descriptors of taste function or taste played a subordinate role to other determinants of dietary intake in this population. In either case, claims that taste abnormalities, as measured by current methodologies, exacerbate or play an etiologic role in various pathologies via induced dietary modifications must be viewed with caution.

[1] Mattes, R.D. Am. J. Clin. Nutr. (In press).

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Failure To Find Specific Anosmias In Rats With Olfactory Bulb Lesions.
SHARON A. McBRIDE, BURTON M. SLOTNICK, SUSAN J. GRAHAM (The American University)*, and PASQUALE P. C. GRAZIADEI (The Florida State University)

Unilaterally bulbectomized rats had the rostral 1/2 - 2/3 (n=3), dorsal 1/4 (n=3), lateral 1/2 (n=2) or none (n=3) of the remaining olfactory bulb removed after preliminary training on odor detection tasks. After surgery all rats were tested for detection of amyl acetate, butanol, geraniol, caproic acid, acetic acid, pyridine, citral, carnation (perfume), ethyl acetate, 4-methyl valeric acid, ethyl acetoacetate, and butyl acetate (in that order). For each odor, intensity was set at a value just above the experimenter's detection threshold. Behavioral results demonstrated: 1. All rats were able to detect all odors although there was considerable variability in the number of errors to reach criterion on different odors among experimental animals. 2. For most experimental rats performance improved over the test series (demonstrating acquisition of a learning-set) and thus, in this study, problem difficulty and problem sequence were probably partly confounded. 3. Rats with the dorsal 1/4 of the bulb removed performed as well as controls. 4. Rats with the rostral 2/3 of the bulb removed made many more errors in acquisition of the amyl acetate, geraniol, and (especially) the acetic acid detections. 5. Rats with the lateral half of the bulb removed performed poorly only on the caproic acid detection test. However, performance was also related to amount of olfactory bulb spared by these lesions: For experimental rats the Spearman's Rho rank correlation between error scores (range: 19-389) and the amount of the mitral cell layer remaining (range: 40.9-6.5% of intact control bulb) was 0.86. The relationship between performance and the surviving projections from the olfactory bulb to the olfactory cortex [as revealed by transneuronal transport of WGA-HRP (Shipley, submitted)] are described.

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The Ontogenic Development of Serotonergic Fibers in the Rat Olfactory Bulb. J.H. MCLEAN, M. LAZOFF, E.B. SIELOFF, W.T. Nickell, and M.T. SHIPLEY. (University of Cincinnati College of Medicine).

We have shown that serotonergic raphe neurons project heavily to the glomeruli of the rat main olfactory bulb (Schumacher et al., 1984). This suggests that raphe neurons may have a marked influence on olfactory information processing. Here we have examined the ontogenic development of serotonergic fibers in the main olfactory bulb (MOB) of the newborn rat.

Immunocytochemistry was used to detect the presence of serotonin (5-HT) in MOB of Sprague-Dawley rats aged 1, 2, 5, 8, 14, 22, 28, 37 days and adults. An image analysis system (Magiscan) was used to enhance the visualization of the fibers and to plot their arborization patterns.

The distribution and extent of 5-HT fibers in the MOB undergo a dramatic transition from the neonate to the adult rat. In the first week of life 5-HT fibers are located in all layers of the MOB. Beginning with day 8, there is a progressive redistribution of fibers to the glomerular and internal part of the external plexiform layer (epl). In addition, there is a steep overall increase in the number of 5-HT fibers in all layers. From day 14 - 37 the fibers become progressively concentrated in the glomerular layer; a sparce innervation remains in epl.

The dramatic redistribution of developing 5-HT fibers suggests that there is transition from non-specific to specific 5-HT fiber deployment during the first weeks of life. The basis for this redistribution is unknown. It is possible that fibers die off in the deep layers. The initial presence of 5-HT fibers in the deep, proliferative layers of the bulb could mean that 5-HT plays a trophic role during neurogenesis and migration as suggested by Lauder et al (1982). Alternatively, early arriving 5-HT fibers may contact their definitive target cells from the outset; the redistribution of 5-HT terminal arbors may reflect the comigration of terminals and target neurons from proliferative zones to their definitive locii in superficial layers.
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Isolated Taste Cells from the Mudpuppy MARTHA MCPHEETERS, SUE C. KINNAMON, STEPHEN D. ROPER (Rocky Mountain Taste and Smell Center, University of Colorado Health Sciences Center, Denver, Colorado 80262).

Taste transduction involves the generation of a voltage change across the membrane of the taste cell, i.e. a receptor potential. The events leading to the receptor potential are unknown. To characterize these chemosensory transduction events, we have developed a technique for isolating individual taste cells. This will allow us to identify single membrane channels and their role in transduction. Mudpuppies, *Necturus maculosus*, were used for this study because the taste cells are large and can be impaled readily with microelectrodes. To visualize taste buds *in situ* and to identify isolated taste cells, mudpuppies were placed in a 0.025% solution of methylene blue for 16 hours at 4° C. The blue vital dye was selectively taken up by taste cells; in particular, the dye was found within vesicles in the apical processes of the taste cells. Following decapitation, the lingual epithelium was removed and incubated in a 1% papain solution (in amphibian physiological saline) for 2-3 hours at room temperature. Single taste buds were identified and with gentle suction drawn into micropipettes which had fire polished tips (diameter ca. 200 um). The tissue fragments were dissociated with gentle trituration and single cells were plated on polylysine-coated coverslips. Single cells were impaled with microelectrodes. Resting membrane potentials from -20 to -40 mV were recorded from the methylene blue- stained cells. By trypan blue exclusion, we determined that at least 50% of the cells isolated in this manner were living.

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Cytoarchitectural Diversity in the Main Olfactory Bulb: Are there Olfactory Foveas ? E. MEISAMI & S.EMAMIAN (Physiol-Anat, U.Calif. Berkeley,Ca.& Inst.Biochem.Biophys.,U.Tehran.)

LM analysis of complete frontal sections of rat olf. bulb(OB) reveals that cytoarchitecture of OB is not uniform in the various regions. In dorsal & ventral surfaces, glomeruli (gl) form a single row and perigl. cells are sparse while in lateral & medial surfaces gl appear more densely, sometimes packed in 2-3 tiers and the perigl. cells are more abundant. When gl, mitral & tufted cells are counted per unit length of a line parallel to OB layers, the density in fuller regions (e.g. lateral) is ca. 2X higher than that in the saprse regions(e.g. dorsal). Also the olf. nerve layer is proportionally thicker in denser regions. However, the proportion of gl-to-mitral-to-tufted was found to be identical (1:20:45) in both regions, indicating, quantitatively, a fundamental uniformity of design, regardless of heterogenous cytoarchitecture. This particular numerical proportion of gl-mitral-tufted may serve as a basic structural module, packed as"columns" in the cortical sheet of OB. In cellularly fuller regions, packing density is high, providing for a more complex structure & function, while in sparse regions, packing is light, providing for a simpler structures & function. These findings were observed identically in right & left OB. These differential structural arrangements may underlie regional differences in spatial integration of incoming olf. signals or relay of these signals to higher centers. Thus the complex organization of lateral surface may explain why active EEG foci described by W.J.Freeman to occur in OB during conditioned odor stimulation are generally seen in the lateral surface and rarely in dorsal region. Similarly the more complex nature of lateral and medial areas might explain why active metabolic foci observed in OB by G. Shephard & colleagues in 2DG studies of odor stimulation are so often located in these areas. Indeed the structurally dense regions of OB, being well developed and complex, may functionally act as olfactory " foveas " , sites utilized by the animal for and during olfactory "searching" and "focusing".

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Membranes versus Cytoskeleton; their Respective Roles in Olfactory Reception. B.Ph.M. Menco & A.I. Farbman (Neurobiology & Physiology, Northwestern University, Evanston, IL 60201, U.S.A.)

It is commonly believed that the primary receptor sites for odorants are associated with cilia of olfactory epithelial cells. In this presentation we shall provide ultrastructural evidence that the membranes of olfactory epithelial cells in vertebrates and invertebrates contain special entities probably associated with chemoreception, irrespective of the cytoskeletal structure supporting the cell extension. I. Olfactory receptive membranes are supported by ciliary axonemes, but can also be supported by other types of cytoskeletal elements as is, e.g., the case with vomeronasal microvilli. II. In some vertebrate species olfactory cilia have cytoskeletal features similar to those of non-olfactory cilia, i.e., all axonemal equivalents required for ciliary motility are present. Other species have strongly reduced axonemes. However, in both groups the ciliary membranes have similar ultrastructural features (see III). Variations in axonemes in invertebrates resemble those in vertebrates. III. With freeze-fracture methods we found that olfactory cilia have membrane-bound entities not found in non-sensory cilia. In insects such entities are concentrated in regions of ciliary membranes adjacent to antennal exoskeletal pores. IV. Olfactory cilia in some species, e.g., insects, are most likely modified primary cilia, i.e., they originate from the centrioles involved in cell division. In vertebrates on the other hand the olfactory cilia originate from secondarily formed basal bodies. Despite these ontogenic differences, the olfactory cilia in both groups serve similar functions. In Summary, the olfactory receptive membranes of vertebrates and invertebrates tend to have a similar morphology, although the cytoskeletal elements supporting them vary widely both in appearance and origin. On the basis of the above four lines of ultrastructural evidence we conclude that the structure and function of the membrane are of primary importance in odorant reception, and that the structure of the supporting cytoskeleton is of considerably lesser importance.

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Tasty Shells: Mechanisms of Shell-Surface Calcium Detection by Hermit Crabs. KAREN A. MESCE (Dept. of Zoology, University of Washington, Seattle, WA 98195).

Hermit crabs can be very selective about the shells they choose to inhabit. It was found that the hermit crab species Pagurus hirsutiusculus h. uses shell-surface calcium as a cue to recognize and select gastropod shells. The present study examines the sensory mechanisms involved in the hermit crab's detection of calcium. P. hirsutiusculus brings its setaceous minor cheliped into extensive contact with the shell surface during shell exploration behavior. Electrophysiological recordings from neurons innervating the chelar setae demonstrate that these sensilla are bimodal; sensitive to mechanical and chemical (calcium) stimulation. Scanning and transmission electron microscopic studies were also undertaken to reveal modality-specific structures that may underlie stimulus transmission. In each sensillum the sensory dendrites number between 20-23 and are continuous throughout the hair lumen extending up to the hair tip. One dendrite in particular contains an extremely dense array of microtubules and may function as the mechanotransducer in each sensillum. Although a terminal pore is present in each seta, dye penetration studies indicate that it is not necessary for chemical entry. A large number of minute canals, however, were found to transect the distal regions of each sensillum and may be responsible for stimulus entry. Strategies for amplification of the shell-surface calcium signal above background chemical noise will be discussed. These include the specific arrangement of setae into dense clusters and the bimodal nature of each sensillum.

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Salt Preference and Salt Appetite of Fischer-344 Rats. ELEANOR E. MIDKIFF, ILENE L. BERNSTEIN, DOUGLAS A. FITTS, & JOHN B. SIMPSON. (Dept. of Psychol., Univ. of Washington, Seattle, WA 98195.)*

Our previous research has indicated that Fischer-344 rats, unlike other strains, fail to prefer NaCl solutions (.01M to .3M) to water. The present study examined sodium appetite and metabolism in F-344 rats compared to outbred Wistars. To assess sodium appetite, animals received either a sodium-deficient or sodium-sufficient diet for 12 days. NaCl (.4M) was then made available, and intake was measured at 1 and 24 hours. In Wistar animals, maintenance on a sodium-deficient diet was associated with a significantly higher intake of NaCl than in controls. In contrast, intake of NaCl by F-344 rats was very low, and did not differ as a function of sodium content of the diet. In a second study, sodium appetite was induced by the injection of furosemide, a diuretic which provokes natriuresis. Animals were maintained overnight on a sodium-deficient diet, without saline or water; they were then given both .3M NaCl and water, and intakes were measured at 1 and 24 hours. Wistars drank significantly more NaCl than F-344's . To assess whether differences in their sodium metabolism might be associated with F-344 rats' depressed ingestion of NaCl, two other studies were run. In the first, plasma sodium and hematocrit levels were examined for both strains maintained on sodium-sufficient diets; no strain differences were found. In the second, F-344 and Wistar animals were given intragastric infusions of .15M NaCl and .3M NaCl. Urine output was measured for 5 hours following each infusion; total urinary sodium output did not differ for the two strains. Since Fischer-344 rats appear to respond normally to challenges which require them to excrete sodium, obvious abnormalities in their sodium metabolism would not appear to be the basis of their NaCl aversion and attenuated sodium appetite.

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Decreased NaCl Response of Lingual Epithelium in Vitro in Spontaneously Hypertensive Rats. SHEELLA MIERSON, MARY E. WELTER, JOHN A. DESIMONE (Dept. Physiol. & Biophys., Medical College of Virginia, Richmond, VA 23298).

The rat dorsal lingual epithelium in vitro is less sensitive to hyperosmotic NaCl in spontaneously hypertensive rats (SHR) than in Wistar-Kyoto (WKY) controls. Priehs and Bernard (AChemS Absts., No. 116, 1983) have reported that adult SHR show increased preferences and decreased chorda tympany responses to NaCl and KCl when compared with WKY. Ferrell and Gray (The Physiologist, 25: 223, 1982) found that weanling SHR have higher preferences for NaCl and KCl compared to WKY; the two strains show no differences in neural sensitivity to NaCl, however KCl elicits less integrated neural activity relative to NaCl in SHR than in WKY. We wished to test the hypothesis that the decreased neural sensitivity could be due to modification of the ion transport system of the lingual epithelium. Hence we used a modified Ussing chamber to investigate the response of the voltage-clamped lingual epithelium in vitro from adult SHR and WKY, using short-circuit current (I_{sc}) as the response measure. NaCl and KCl solutions on the luminal side were tested in ascending series from 0.01 to 2.0 M, before and after treatment with ouabain on the blood side to inhibit the Na,K-ATPase. The response to NaCl in the untreated tissue from SHR was significantly less than in WKY at all hyperosmotic concentrations. The response to KCl in the untreated tissue showed no change; however the ouabain-insensitive I_{sc} was decreased in SHR compared to WKY, though this change was statistically significant only at the highest concentration used. Tissue resistance did not change between SHR and WKY for either salt. Na and K are known to follow different transport pathways across this epithelium (DeSimone, Heck, Mierson, & DeSimone, J. Gen. Phys., 83: 633, 1984). Correlating the responses in vivo and in vitro under different conditions will assist in identifying the transport parameter(s) responsible for stimulating the chorda tympani fibers. Supported by a grant from Virginia Heart Association and NSF Grant BNS 8309135.

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Human Fungiform Taste Bud Number, Density and Distribution. INGLIS J. MILLER, JR. (Wake Forest University)

Knowledge of the spatial density, regional distribution and total number of human fungiform taste buds would be useful in the diagnosis of taste disorders and the study of taste perception. Preliminary studies are underway on tongues from 31 human cadavers as follows: 3 infants, 3 aged 20-39 yrs, 6 aged 40-59 yrs,7 between 60-75 yrs,9 from 75 to 95 yrs and 3 of unknown origin. Photography was used to document morphological features of the surface. Areas of the tongue measuring about 1cm sqr were sectioned serially,mounted on slides, stained with H & E, and examined by light microscopy. Three tongues yielded the following findings.The right tongue tips from two subjects contained,respectively,149 taste buds(Subject A) and 161 taste buds (Subject B) per cm sqr. Subject A (Caucasian,male,79yr) had 153 taste buds on 33 fungiform papillae (range 1-16) for an average of 4.64 s.d. 3.05. Only papillae containing taste buds were used in this calculation, although many without taste buds were observed. Subject B (c, m,56) had 233 taste buds on 56 fungiform papillae (range 1-18) for a mean of 4.16 s.d. 3.05 per cm sqr.These values are similar to those of Arvidson and Freiberg (Science 209, 808, 1980). Incomplete observations from Subject C showed only 5 fungiform taste buds on a region 0.5 cm sqr (half a block). He was an apparently healthy,young male (22 yrs) who died in an auto accident. A mid-region (2 cm caudal to the tip) from Subject A contained 103 taste buds on 26 papillae for a density of 69 taste buds per cm sqr. There were 3.96 s.d 2.19 taste buds (range 1-9) per papilla. The difference between the tip and mid-region in Subject A was a lower density of papillae and none with 10 or more taste buds. The highest density of taste buds within any region was found on the edge of the tongue.Small papillae which are inconspicuous by gross inspection bear taste buds. We plan to look for differences in morphology (size, shape,distribution) by which to distinguish the gustatory and non-gustatory papillae. Factors such as age, health,gender and race require systematic evaluation.

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Ultrastructure of the Vomeronasal Organ in Man: A Pilot Study. DAVID T. MORAN, BRUCE W. JAFEK, and J. CARTER ROWLEY III, (Rocky Mountain Taste & Smell Center, University of Colorado Health Sciences Center, Denver).

The ultrastructure of the human vomeronasal organ (VNO; Jacobson's Organ) has not yet been described. In this report, we present preliminary data from the first human VNO we have investigated. A single VNO was surgically removed from the nasal septum in the anterior nasal cavity of a consenting patient and prepared for light and electron microscopy. The organ has an opening of 2 mm in diameter that leads to a blind-ended canal that extends some 2-3 mm posteriorly beneath the surface of the nasal cavity. When viewed by scanning electron microscopy (SEM), the lining of the canal presents a uniform appearance unique amongst epithelia observed to date. The epithelial surface resembles a group of tightly-packed hemispheres. The surface of each cell appears convex, and bears a few short microvilli. Transmission electron microscopy (TEM) shows the epithelium to contain a single layer of slender columnar cells that do not resemble ciliated olfactory receptors; neither do they resemble microvillar cells present in human olfactory epithelium. The human VNO epithelial cells bear no strong ultrastructural resemblance to the microvillar receptors consistently observed in a variety of other vertebrate VNO's. Whether these initial observations are true to life--or represent artefacts of fixation--is difficult to say at this early date. The sample size is small, and the fixation, inadequate. More work will be done on properly fixed specimens in the near future.

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Area Postrema, an Internal Chemoreceptor organ: Inputs and Immunocytochemistry in the goldfish. YASUHIRO MORITA and THOMAS E. FINGER (Rocky Mountain Taste & Smell Center, Univ. of Colorado Health Sciences Center, Denver, CO 80262)

The area postrema is the most caudal of the circumventricular organs and is characterized ultrastructurally by fenestrated capillaries. An important function of the area postrema is in the role of a central chemosensory organ which initiates a vomiting reflex or controls osmotic or cardiovascular functions. In goldfish, the area postrema is a midline structure in the caudal medulla, adjacent to the general visceral sensory nucleus, the commissural nucleus of Cajal. Virtually all of the neurons of the area postrema exhibit positive tyrosine hydroxylase-like immunoreactivity. Each immunoreactive neuron possesses two types of primary dendritic specializations. One type of dendrite is a short foot-process which extends between astrocytic processes to reach the basal lamina surrounding the capillaries and perivascular spaces of the area postrema. No synaptic specializations occur on these processes and we surmise that these processes mediate the internal chemoreceptive function. The other class of dendrites of neurons of the area postrema is an elongate, thick dendrite which extends ventrally into the subjacent commissural nucleus. This ventral dendrite receives numerous synaptic contacts both within the area postrema and within the commissural nucleus. The presynaptic terminals that end on the ventral dendrite contain clear, round vesicles with an occassional large, dense-cored vesicle. A few primary afferent fibers of visceral branches of the vagus nerve terminate within the area postrema as well as in the commissural nucleus. Thus, the neurons of the area postrema can act not only as direct chemoreceptive elements, but also receive direct input from other elements of the peripheral and central nervous systems.

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Vomeronasal Organ Transplant in the Rat Brain. MORRISON, E.E., HECKROTH, J.A., MEREDITH, M. and GRAZIADEI, P.P.C. (Department of Biological Science, Florida State University, Tallahassee, Fla 32306)

The vomeronasal sensory epithelium, like the main olfactory epithelium, can replace its neurons normally and is completely reconstituted after VN axotomy or AOB ablation. In an attempt to further understand the plasticity of the organ and its neurogenetic capacity we have utilized the method of intracerebral transplantation of the organ. Complete vomeronasal organs from neonatal rats (P5) were removed and dissected free from the bony capsule, placed via glass cannula or glass rod within the parietal lobe of neonatal rats (P5) and allowed to survive for 15 to 45 days. The animals were then deeply anesthetized, transcadially perfused with Bouin's fluid, the brain embedded in paraffing, serially sectioned and the sections stained with a silver method.

The vomeronasal transplants survived within the ectopic neuronal environment and formed interconnecting vesicles. At 15 days the vomeronasal sensory epithelium was reconstituted and mature receptor cells could be seen. Vomeronasal neurons could also be observed to migrate from the epithelial compartment into the lamina propria and at times into the host's brain parenchima. Vomeronasal axon fasicles arising from the sensory epithelium grew into the host's brain but no glomerular structures were observed. At later survival times (30-45 days) axon bundles from the transplant penetrated the host's brain and were observed along the ventricular walls for a distance of up to 500 microns. Other bundles were observed to converge and form a dense fibre plexus leading to distinct glomerular formations.

Our results demonstrate that when the complete vomeronasal organ is transplanted into the brain parenchima its neurogenetic matrix survives and continues to produce neurons. In addition, their axons maintain the ability to converge and develop their characteristic terminal structures, the glomeruli, even in the absence of the normal target, the accessory olfactory bulb.

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Covalent Modification of Receptor Sites In Vivo. Two Step Labelling of a Schiff Base-Forming Protein and Chemical Blockade of the Sense of Smell. THOMAS HELLMAN MORTON, FAH CHE LEONG, KEVIN W. PLAXCO (Chemistry Department, University of California, Riverside, CA) and J. RUSSELL MASON (Monell Chemical Senses Center, Philadelphia, PA)

Covalent modification by two-step labelling is illustrated by the blocker-fixer sequence, where a protein forms a reversible complex with blocker, which is then converted to an irreversible adduct by fixer. Using the Schiff base-forming enzyme acetoacetate decarboxylase as an in vitro model, the blocker-fixer sequence is exemplified by ethyl acetoacetate (EAA) as blocker and borohydride as fixer. When reaction or removal of unbound blocker competes with protein labelling (e.g., with $NaBH_4$ as fixer), the quantitative expression for the extent of modification $\phi = 1-[K_d/(K_d + S_o)]^m$ is demonstrated, where K_d is the dissociation constant for the reversible protein-blocker complex and S_o the initial concentration of blocker. The value of exponent m is a function of the reaction rate constants. The blocker-fixer sequence EAA-$NaBH_3CN$ is shown to be specific for Schiff base-forming sites. Application of this blocker-fixer sequence to the olfactory epithelia of tiger salamanders selectively impairs detection of ketone-containing odorants [Science, 1984, 226, 1092-4]. Using a behavioral assay [Physiol. Behav., 1982, 29, 709-14], decrements in responding to cyclopentanone or cyclohexanone are observed at the same time as responding to cyclopentanol, ethyl butyrate, or dimethyl disulfide is unaffected. Dose-response studies show an increase in duration (but not profundity) of selective anosmia with increasing fixer concentration. On the other hand, the data do not show an increase in either the duration or profundity of selective anosmia when blocker concentration is increased. These results conform to expectations based on the expression for ϕ above. They are consistent with the supposition that olfactory ketone receptors with bound ligand behave as rod cells in the retina do in the dark; with a small molecule covalently attached by a Schiff base linkage, and with continual secretion of neurotransmitter.

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Demonstration of the Sublaminar Pattern of the Rat Olfactory Bulb External Plexiform Layer with Cytochrome Oxidase Staining. LAURIE MOURADIAN and JOHN W. SCOTT (Emory Univeristy, Atlanta, GA 30322

Recent work has demonstrated that cytochrome oxidase (CO), a mitochondrial enzyme involved in electron transfer, is unevenly distributed in the glomerular and the granule cell layers of the main olfactory bulb (Shipley et al, AChemS 1984;Wysocki et al, AChemS 1984). In rat, we observe a distinct band of dark CO staining in the external plexiform layer (EPL), with lighter staining regions of EPL above and below that band. To test the relation of this band to the laminar distribution of mitral and tufted cell basal dendrites described by Orona et al (JCN,226:346-356, 1984), small iontophoretic extracellular injections of 4% horseradish peroxidase (HRP) were made into the deep EPL of adult Sprague-Dawley rats. Subjects survived one day. Alternate 80 micrometer sections were reacted for either HRP, using a cobalt intensified diaminobenzidine technique, or for CO. Enough cross reactivity was seen in the CO sections to allow tracing of HRP-labeled dendrites through both the HRP and CO reacted sections.

The majority of cells observed to date were mitral cells fitting the definition of type I mitral cells (Orona et al). Reconstructions and examination of cells from two brains show that the basal dendrites of these cells lie in the region of EPL below the CO band. Although apical dendrites passed through the CO band, the basal dendrites rarely entered it. These observations support the division of the EPL into deep, intermediate and superficial zones proposed by Orona et al. In addition, the CO banding suggests that these zones are not uniform in their relative thickness around the circumference of the olfactory bulb, a condition that was suspected but not easily demonstrable in the earlier observations. These results also suggest that cells with basal dendrites ramifying in the intermediate zone of the EPL may have higher metabolic activity reflecting greater neural activity.

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Reversal of Hyposmia in Laryngectomized Patients. M. MOZELL, D. SCHWARTZ, D. LEOPOLD, AND S. YOUNGENTOB (SUNY-Upstate Olfactory Clinical Research Center, Syracuse)

The simplest mechanism for the often reported hyposmia of laryngectomized patients is the loss of normal ability to sniff air through the nose, thus compromising the transport of odorant molecules to the olfactory epithelium. This reduction in airflow could mask the influence of other proposed mechanisms, e.g., changes in the nasal and/or olfactory mucosas and the disruption of neural networks dependent upon laryngeal innervation. To evaluate the contribution of the compromised nasal airflow to laryngectomy-induced hyposmia, we developed a "larynx bypass". By running a tube from the tracheostoma into the mouth, the patient can, with mouth closed, draw odorants into the nose with airflows approximating those of normal subjects. The olfactory thresholds of 16 patients (post-laryngectomy from 2 months to 19 years) were determined both with and without the larynx bypass. In the latter case, the patients had to rely upon whatever strategy they ordinarily used to achieve at least some nasal airflow. A pneumotachograph monitored the airflow entering and leaving the nose under both conditions. A 2-interval forced choice tracking procedure was used to determine thresholds to ammonia (strongly trigeminal) and vanilla (reportedly non-trigeminal) with the successive concentration steps given by 3-fold changes in liquid dilution. Thresholds were also determined for 10 non-laryngectomized subjects. Without the larynx bypass the ammonia and vanilla thresholds of some laryngectomized patients either equalled (4 patients) those of the non-laryngectomized subjects or came very close to them (1 patient). The remaining 11 patients had thresholds averaging more than 4 concentration steps higher than the non-laryngectomized subjects. The restoration of nasal airflow with the larynx bypass dramatically decreased these patients' thresholds, but this improved sensitivity was greater for ammonia than vanilla. With ammonia 10 patients reached the thresholds of the non-laryngectomized subjects, and one came very close. For vanilla 9 patients showed decreased thresholds with five reaching the level of the non-laryngectomized subjects. Support: NIH Grant NS19658.

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Development of a Clinical Test of Olfactory Function in Children. CLAIRE MURPHY (San Diego State University)

Several clinical tests are available for assessing the olfactory function of adults. Although a detection threshold task can be readily adapted for use with children, it is difficult to use any of the currently available identification tests to assess function in children, particularly those without reading skills. In addition to the lack of reading skills, many young children have little or no experience with some of the odorants used in these adult batteries. The present study was conducted to develop a test format which could be used with children who have not yet developed reading skills and to identify a battery of odorants highly familiar to young children for use in identification testing. In a pilot study, ten children, ranging in age from 3 - 11 years participated. Since picture inspection was to be compared to word list inspection and free recall in an identification task, all but two could read. Three modes of odorant carrier (veridical substances, microencapsulated fragrances, and an experimental carrier), three methods of identification, and twenty-four odorants were investigated. Since not all odorants were available in all forms, recognition rate was expressed as a percentage of the total number of samples in the generic category. Subjects performed best at identifying veridical substances (64.9%). The differences in performance using the experimental carrier (40%) and the microencapsulated fragrances (33.2%) were not significant. Picture recognition resulted in performance (48.4% correct) which was significantly higher than free recall (42.2%). Picture recognition and word recognition (47.8%) produced non-significant differences in favor of picture recognition, suggesting that for children picture inspection is at least equal to word inspection. Only five odorants (all veridical) were correctly identified by at least 90% of the children: peanut butter, coffee, play doh, mustard, and cinnamon. In the second experiment, 44 children of kindergarten age were tested for odor identification using the picture recognition method and a total of 15 veridical odorants, based on pilot work. The picture recognition method resulted in a mean identification rate for the kindergarteners of 71% correct, overall. In this age group the five best stimuli were: play doh, coffee, chocolate, bubble gum, and cinnamon. Suggestions for stimuli to be included in a clinical olfactory identification test for children will be made.

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The Effects of Age, Nasal Airway Resistance, and Nasal Cytology on Olfactory Threshold for Butanol. CLAIRE MURPHY (San Diego State University)*, KIRSTY NUNEZ (San Diego State University), and ALFREDO A. JALOWAYSKI (UCSD Medical Center, San Diego)

A considerable literature now exists on age-associated changes in olfactory threshold sensitivity to a variety of odorants. Not only does threshold increase with age, but elderly people typically show greater variability in threshold, as a group, than do young subjects. We sought to determine whether other variables, indicative of nasal disease or anatomical obstruction might contribute to increases in threshold or to increases in variability seen in the elderly. We tested 48 persons, twelve males and twelve females, in each of two age groups: 18-26 years (M=21) and 65-84 years (M=73). All subjects were active, community-dwelling persons who reported good to excellent health and no hospitalizations in the preceding year. Olfactory threshold for butanol was measured using a two-alternative, forced-choice staircase method. Nasal airway resistance was calculated from simultaneous measurements of nasal inspiratory flow rates and pressures utilizing the active, uninasal, anterior, rhinomanometric technique described in Jalowayski et al. (Laryngoscope, 93: 341, 1983). Nasal mucosal samples were taken from the mid-inferior portion of the inferior turbinate by a gentle scraping using a disposable plastic probe. These samples were examined for the presence of cells indicative of allergic rhinitis, bacterial infection, and upper respiratory viral infection.

Analysis of Covariance with age as independent variable, threshold as dependent variable, and nasal airway resistance and a composite index of cytological findings as the covariates confirmed the presence of an age effect ($p < .00001$) on olfactory threshold in addition to an effect of nasal airway resistance ($p < .05$) and suggested the importance of exploring the influence of other variables in studies considering the effects of aging on the chemical senses.

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Evaluation of Canine Olfactory Function in Health and Disease by Innate Behavioral and Electrophysiological Techniques. L. J. Myers, L. A. Hanrahan, K. E. Nusbaum, and L. J. Swango (Auburn University)

Olfactory function of 47 clinically normal, mixed breed dogs was investigated by behavioral and electrophysiological techniques. Normative values were obtained for the electroolfactogram in response to ethyl butyrate and for the electroencephalographic/ electromyographic response and innate behavioral response to 14 concentrations of eugenol and benzaldehyde diluted in propylene glycol.

These techniques were then utilized to examine olfactory function in dogs presented to the Electrodiagnostics Laboratory at Auburn University and in dogs presented to the Small Animal Clinic. Cases of motor seizure, Cushingoid condition, distemper, canine parainfluenza, and ischemic brain disorder were found to be associated with an abnormally high olfactory threshold as assessed by electroencephalographic and behavioral response. Only canine distemper was found to be associated with significant abnormalities of the electroolfactogram. Inoculation of distemper antibody-free dogs with vaccine strains of canine distemper demonstrated similar abnormalities.

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Chorda Tympani Fiber Receptive Fields: Size and Salt Responses in Fetal and Postnatal Sheep. T. NAGAI, C. MISTRETTA, and R. BRADLEY. (University of Michigan, Ann Arbor, MI 48109)

During development in sheep, there are changes in summated salt taste responses from the chorda tympani nerve. Relative to NH_4Cl, responses to NaCl progressively increase. To elucidate the neural basis for these changes, we have examined peripheral receptive fields of single chorda tympani fibers. Sheep in three age groups have been studied: fetuses aged 128 - 132 days of gestation (term=147 days), perinatal sheep aged 145 days of gestation to 5 days postnatal, and lambs aged 5 - 11 weeks after birth. The number and location of fungiform papillae innervated by single fibers were determined by electrically stimulating single fungiform papillae with 3 - 5 μamp anodal current. Chemosensitive responses from the entire receptive field to 0.5 M NaCl and NH_4Cl also were recorded.

In initial experiments, 27 fibers from 19 animals have been studied: 6 from 130 day fetuses, 7 from perinatal sheep and 14 from lambs. Average receptive field sizes for the three age groups were: 8.9 papillae ($\pm$2.9), 8.3 ($\pm$7.2) and 7.6 ($\pm$6.4). These field sizes were not significantly different. However, examination of the range of field sizes suggests a possible developmental difference (4.5 - 14 papillae in fetuses; 1.0 - 20 in perinatal sheep; 1.0 - 25 in lambs). The percentage of fibers maximally responsive to NaCl was greater in lambs (50%) than in perinatal sheep (29%) and fetuses (20%). For all fibers across age groups, receptive field size correlated negatively with the $NaCl/NH_4Cl$ response ratio ($r = -0.71$; $p \leq 0.01$). Thus higher sensitivity to NaCl correlated with smaller receptive fields. Furthermore, in lambs, fibers responding maximally to NaCl had smaller receptive fields (3.5 papillae $\pm$1.9, n=7) than those responding maximally to NH_4Cl (12$\pm$6.7, n=7) ($t = 2.96$, $p \leq 0.01$). Our preliminary data indicate that: in fetal sheep, some receptive fields already are quite large; during development, the percentage of fibers maximally responsive to NaCl increases; and receptive field size relates to salt response characteristics. (Supported by NSF Grant BNS 8311497)

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Neural Activities of the Greater Superficial Petrosal Nerve of the Rat in Response to Chemical Stimulation of the Palate. NEJAD, M.S., BEIDLER, L.M. (The Florida State University)

The rat's greater superficial petrosal (GSP) nerve innervates a slightly higher number of taste buds of the palate than the number of fungiform taste buds innervated by the chorda tympani (CT) nerve. A comparison of the integrated responses to a number of taste stimuli was studied. The GSP nerve of the rat was highly active and extremely responsive to the chemical stimulation of the oral cavity. Among the four basic taste qualities, 0.5M sucrose produced the highest neural response in the GSP nerve, whereas, 0.1M NaCl induced the highest neural reponse in the chorda tympani (CT) nerve. The GSP nerve integrated responses to 0.5M sucrose solution was approximately three times as great in magnitude as that to a 0.1M NaCl solution. The neural response profile of the GSP and CT nerves to some chemical stimuli representing the four basic taste qualities were as follows: GSP nerve; 0.5M sucrose> 0.02M Na-saccharin > 0.05M citric acid>0.1M NaCl> 0.01M quinine-HCl. CT nerve; 0.1M NaCl>0.05M citric acid>0.02M Na-saccharin> 0.01M Quinine-HCl>0.5M sucrose. The response profile of the GSP nerve to 0.3M chloride salt solutions was: $LiCl > CaCl_2 > NaCl > NH_4Cl > KCl$, whereas the response profile of the CT nerve to the above salts was: $LiCl > NaCl > NH_4Cl > CaCl_2$ KCl. All 0.5M solutions of the selected sugars (Sucrose, Rhamnose, Galactose, Lactose, Fructose, α-Methyl-D-glucoside, Xylose, Mannose, Arabinose, Maltose, Sorbose and Glucose) evoked neuroral responses in both GSP and CT nerves. The relative response magnitude of the GSP nerve to all tested sugars appeared higher than those of the CT nerve. The response profile of the GSP nerve to the selected sugars appeared similar to that of the CT nerve.

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Separation of the Effects of Sweetness and Viscosity of Sucrose on Perceived Sweetness, Viscosity, and Bitterness of Vermouth. A. C. NOBLE (University of California, Davis), D. J. W. BURNS (DSIR, Auckland, New Zealand)

The separate effects of sweetness and viscosity of sucrose on the sensory properties of vermouth were evaluated in systems varying in sucrose (and in viscosity), in viscosity produced by Polycose, a non-sweet polysaccharide, or at constant viscosity, but varying sucrose concentrations. Twenty-one trained judges rated oral viscosity, sweetness and bitterness, while physical viscosity of the systems was measured by capillary viscometry. Both perceived sweetness and oral viscosity increased, while bitterness decreased as sucrose concentration and/or the physical viscosity increased. Samples in which viscosity was increased by the non-sweet Polycose were rated sweeter and less bitter than vermouth solutions of the same sucrose concentration but lower physical viscosity. Similarly, when vermouths of the same viscosity were compared, those with higher sucrose concentration were rated more viscous. Viscosity alone contributed 20 - 30% of the perceived increase in sweetness due to sucrose addition. The effect of viscosity in reducing bitterness was of the same magnitude. The increase in perceived viscosity caused by addition of sucrose is attributable equally to physical viscosity and to sweetness of sucrose.

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How One Insect Smells in Millivolt Units. DALE NORRIS (University of Wisconsin, Madison, WI 53706)

Log moles of each of several 1,4-naphthoquinones required to yield >99% avoidance by adult male *Periplaneta americana* in a behavioral assay were related linearly to log maximal millivolt (mV) shift induced in the polarographic $E_{1/2}$ value of proteins (including primary receptor) solubilized from the plasma membrane of involved chemosensory neurons in t insect's antennae. Log percent maximal inhibition of standardized EAG by each 1,4-naphthoquinone was so highly correlated to the log maximal mV shift in the $E_{1/2}$ that only one of these two parameters is required i a model which predicts behavior (repulsion vs. attraction) attributable to treatment. A 5 mV shift $E_{1/2}$ proved equivalent to 8% inhibition in EAG. As little as a 5 mV shift in $E_{1/2}$ was shown to be associated with a change in whole insect behavior (repulsion vs. attraction). In this chemoreception, CNS only needs to connect involved primary sensory neurons to muscles required for dictated behavioral expression. Conversion of an energy state in a 1,4-naphthoquinone messenger into a predictable insect behavioral response can be expressed mathematically i an equation for a straight line.

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Experiments on the Development of Rat Vallate Taste Buds BRUCE OAKLEY (Univ. of Michigan), MARK A. HOSLEY (Brown Univ.) and STEPHEN E. HUGHES (Univ. of Michigan). Neuroscience Lab. Bldg. Univ. of Michigan, Ann Arbor, MI 48109.

In normal rats, taste bud numbers and both the area and the volume of gustatory epithelium logarithmically increase in parallel from birth to 90d p.p. (post-partum). Consequently, taste bud density reaches a plateau by 21d p.p., suggesting that the continued normal addition of over 300 taste buds from 21 to 90d p.p. is density-dependent. We removed or crushed one or both IXth nerves in various combinations and at various ages. Our results indicate that taste buds are neurally induced because, when nerves are absent from the vallate epithelium during a 0 to 10d p.p. sensitive period, taste buds never form. The number of taste buds is non-linearly dependent upon the number of axons since i) only 37% of the taste buds develop when 50% of the axons are present and ii) at low levels of innervation doubling the numbers of axons quintuples the number of taste buds. After early neonatal IXth nerve crush, the small number of bilaterally maintained taste buds can be estimated from the stochastic probability of overlap among myelinated axons of the right and left IXth nerves. In regeneration or turnover new taste cells arise from stem cells that are trophically reactivated by regenerating taste axons. From this premise and on the basis of several paradigms of nerve interrruption we propose a model of the sequence of neurally mediated steps leading to development of the taste bud, namely: progenitor cell ⟶ prestem cell ⟶ stem cell ⟶ taste receptor cell. The first step occurs in developmental induction, the last in development, regeneration or cell turnover. A rate-limiting step of prestem to stem cell accounts for the development of numerous taste buds after 45d p.p. in normal animals and in eight experimental groups with partially denervated papillae which develop taste buds for many weeks afer 45d p.p. Supported in part by NIH Grant NS07072. We thank Linda Morton for assistance.

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Effects of oral sensory field loss on taste scaling ability. K.M. OSTROM, F.A. CATALANOTTO, J. GENT, University of Connecticut Health Center and L. BARTOSHUK, The John B. Pierce Foundation Laboratory.

Patients with regional losses of taste sensitivity of the tongue and/or palate perform reasonably well on the whole mouth scaling task, (sip and spit, suprathreshold magnitude matching taste test using 5 concentrations each of sodium chloride-NaCl, sucrose-S, citric acid-CA and quinine hydrochloride-QHCl) in use at the Taste and Smell Center. This clinical observation prompted us to measure taste function after producing known temporary oral sensory field losses with local anesthesia. Subjects were tested immediately before and after three experimental treatments: (1) unilateral mandibular nerve block, producing anesthesia of the chorda tympani nerve, n=21; (2) bilateral mandibular nerve block, n=13; (3) bilateral mandibular nerve block plus bilateral palatal infiltration, producing anesthesia of the palatal taste receptors, n=9. Loss of taste sensitivity was confirmed by applying the most concentrated of each of the four chemicals tested to the anesthetized areas. After (1), magnitude estimates for 8 of the 20 solutions were increased, $p<0.05$ (1 NaCl, 3 S, 2 CA and 2 QHCl). After (2), pre- and post-anesthesia magnitude estimates were similar for all but for 3 NaCl solutions which were reduced, $p<0.05$. Similarly, (3) produced no significant changes in sensitivity for S, CA and QHCl, but a significantly decreased response to all 5 concentrations of NaCl. The increase in taste magnitudes after (1) is consistent with a release of inhibition similar to observations of Halpern and Nelson (*Am. J. Physiol.* 209:105-110). The decreased taste magnitudes of only NaCl solutions after (2) and (3) is consistent with some spatial localization of sensitivity to this salt to the sensory fields of the VII Cranial Nerve.

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Use-dependence of ziziphins actions on taste receptor cells.
E. S. PETERS, Jr. and L. M. KENNEDY (Clark University).

Ziziphins (Zs) (from *Ziziphus jujuba*) selectively suppress human sweetness perception (Meiselman et al,1976), inhibit army worm feeding (Canney & Halpern,1980) and alter fly behavioral and receptor cell action potential responses to sucrose. The neurophysiological alteration is biphasic: First firing is suppressed; then the firing rate becomes increased and irregular (Kennedy & Halpern,1979,1980). After Zs treatment, the onset of the second phase occurs sooner when sucrose stimulation is continuous than when sucrose is presented at intervals over time. Thus the second phase may be facilitated by receptor cell responding (Peters & Kennedy, 1984). We tested use-dependence of the second phase in fly (*Phormia regina*) taste receptor cells. After a 1 min water treatment and after a 1 min Zs (2% aqueous leaf extract) treatment, single sensilla were rinsed with water and then stimulated for 5 min with sucrose (50mM in NaCl 50 mM). Action potential responses were tip-recorded. Ratios were formed of the numbers of spikes in 100 or 500 msec excerpts taken at 1 min intervals from responses in the Zs trial to the numbers of spikes in 100 or 500 msec excerpts taken at the same 1 min intervals from responses in the water treatment trial for each fly. Median ratios were initially 0.67 then increased to 1.7 by 5 min after treatment. The increase over the 5 min was significant ($p<0.01$,Kramer ANOVA). Control flies were treated with Zs, rinsed, exposed to a non-stimulating carbohydrate (glycerol 50 mM in NaCl 50 mM) for 5 min, then rinsed and tested with sucrose. Other controls were treated with Zs, rinsed, left in air for 5 min, then tested with sucrose. In both control groups, responses to sucrose were suppressed (medians 0.45,0.68) at 5 min after treatment. Finally, a group of flies were stimulated for 5 min with 500 mM sucrose after water or Zs treatment. In this group, the time required to reach ratios ≥ 1 was significantly shorter than for the group stimulated with 50 mM sucrose ($p=0.036$,Mann Whitney). These data indicate that the onset of the second phase is facilitated by receptor cell use.

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Orofacial Responses to Gustatory Stimulation in the Hamster.
DAVID H. PETTY and DAVID V. SMITH (Department of Psychology, University of Wyoming, Laramie, WY 82071).

Although much is known about the physiology and anatomy of the hamster gustatory system, little is known about the role of taste in the control of this animal's behavior. Orofacial and other bodily responses to taste stimulation have been described in some detail for the rat (Grill & Norgren, 1978), but not for the hamster. The present study examines the orofacial responses of the hamster to stimulation with 0.01 - 1.0 M sucrose, 0.003 - 0.3 M NaCl, 0.0003 - 0.03 M HCl and 0.0001 - 0.01 M quinine hydrochloride (QHCl). Five concentrations of each of these stimuli were delivered to the oral cavity in 50 ul volumes via an intraoral cannula. Responses were recorded on high-resolution videotape for frame-by-frame analysis. Unlike the rat, most of these responses were of the orofacial musculature, with the only body response component being face washing, which occurred only rarely. Responses to all stimuli began with rhythmic mouth movements (RMM), followed by observable movements of the tongue, both anterior and lateral, within the mouth (internal tongue movements, ITM), which were usually followed by external tongue protrusions (ETP), both anterior and lateral. For sucrose, the number of ETPs was most directly related to concentration. For NaCl, these movements decreased at higher concentrations. The number of ITMs was directly related to concentration for HCl and QHCl and the number of RMMs before the first ITM was strongly related to QHCl concentration. In addition, the animals consistently showed a response to the highest QHCl concentration consisting of very rapid rhythmic movements of the chin. Unlike the rat, no gapes were elicited by any of the stimuli.

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Purification and Characterization of a Putative Olfactory Receptor for Odorant Pyrazines.
JONATHAN PEVSNER, ROSARIO R. TRIFILETTI, STEPHEN M. STRITTMATTER, PAMELA B. SKLAR and SOLOMON H. SNYDER (Department of Neuroscience, The Johns Hopkins University School of Medicine, 725 North Wolfe St., Baltimore, MD 21205).

The potent odorant (3H)2-isobutyl-3-methoxypyrazine [(3H)IBMP] binds specifically, saturably and reversibly to rat and cow nasal mucosa. In rat, binding is localized to tissue that displays olfactory marker protein-like immunoreactivity. Binding was not detected in any other tissue assayed. We have purified a soluble protein from bovine nose which binds pyrazine odorants. Purification to homogeneity was achieved by ammonium sulfate fractionation followed by DEAE and hydroxylapatite column chromatography. Protein and binding activities coelute following hydroxylapatite, and specific binding activity remains constant following gel filtration. The pure protein has a molecular weight of 19,000 daltons by polyacrylamide gel electrophoresis and appears as the only band on the gel. The sedimentation coefficient $S_{20,W}$ of the protein is 3.2 ± 0.1 S (n=4), the Stokes radius from gel filtration is 2.7 ± 0.1 nm (n=4), and the apparent molecular weight assuming a partial specific volume of 0.74 cc/g is 37,000 daltons. This suggests that the protein is a dimer in its native form. Equilibrium binding of (3H)IBMP to purified protein reveals a high affinity binding site (K_D=10 nM, B_{max}=135 pmol/mg protein) and a low affinity site (K_D=3 μM, B_{max}= 25 nmol/mg protein). Dissociation experiments also reveal two binding sites. Because of the much greater number of low affinity than high affinity binding sites we examined the binding affinities of a homologous series of pyrazine derivatives at the low-affinity site. The five most potent pyrazines (IC_{50}=3×10^{-6} M to 1×10^{-4} M) also have the lowest human odor detection thresholds. Ten pyrazines with higher thresholds have binding affinities >1mM. Unrelated chemicals that are not odorants do not inhibit binding. These results suggest that the purified protein may be a physiologically relevant olfactory receptor.

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Complete But Not Partial Olfactory Bulbectomies Block Suckling Behavior in Neonatal Rats.
JUDITH M. RISSER and B.M. SLOTNICK (The American University)

Seven-day-old pups were anesthetized in an ice bath and subjected to aspiration of all or different parts of the olfactory bulbs. All pups remained isolated from the dam for the first 24 hours after surgery. They were then weighed, tested for nipple attachment (Teicher and Blass, 1979), and replaced with the dam. Pups were weighed daily and those which lost more than 4.5g were sacrificed immediately by perfusion with formalin. Remaining pups were perfused at the end of six days. Brains were embedded in 12% gelatin, cut at 60u on a freezing microtome, and stained with thionine. Exp.1 examined the effects of sham surgery, complete or partial bulbectomy, and frontal cortical (control) lesions. Pups in Exp. 2, received smaller lesions confined to the antero-medial, postero-lateral, or postero-medial (including the area of the modified glomerular complex) portions of the bulb.
Sham operated animals in both experiments gained weight on each day after rejoining the dam, but completely bulbectomized pups (Exp. 1) lost weight, became moribund, and had to be sacrificed on Day 4 or 5. Pups with incomplete bulbectomies lost weight for the first 2-3 days and remained at this lower weight. Pups with cortical lesions also lost weight for the first 2-3 days, but then gained weight at a rate equal to that of controls. In Exp 2, pups in all lesion groups lost weight for 2-3 days, but the losses did not differ among groups and weight changes paralleled those of pups with cortical aspirations. All animals of the sham and neocortical control groups showed nipple attachment within 15 seconds, but none of the completely bulbectomized animals attached within the 120 second test period. Attachment data of the other experimental groups were more variable and not predictive of subsequent weight gain. Results support the following conclusions: Olfactory bulbectomized rats show no nipple attachment or nursing. Pups with remnants of olfactory bulb show severe, but not complete, deficits. Small transient deficits occur after discrete olfactory bulb or cortical lesions, but these probably reflect non-specific post-operative trauma. Of particular interest is that small lesions of the postero-medial part of the bulb which include the modified glomerular complex (and varying amounts of the accessory olfactory bulb) have no greater effects than discrete lesions of other parts of the bulb. This indicates that the modified glomerular complex, which is particularly active during suckling (Teicher, et al., 1980), is not essential for suckling to occur.

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Larval Release in the Crab Rhithropanopeus harrisii (Gould): Chemical Cues from Hatching Eggs. DAN RITTSCHOF (Duke University Marine Lab), RICHARD B. FORWARD, JR., (Duke Univeristy Marine Lab), DAVID D. MOTT (Duke University).

Decapod crustaceans have rhythmic larval release patterns. In the case of Rhithropanopeus harrisii substances associated with hatching eggs induce ovigerous crabs to exhibit stereotypic larval release behavior involving vigorous abdomen pumping. In this study, the pumping response of ovigerous crabs was used to investigate the chemistry of the substances (pumping factor) that evoke larval release behavior. Pumping was induced by polar substances released into sea water upon egg hatching. Pumping factor was concentrated and desalted by adsorbtion chromatography with Amberlite XAD-7 resin. Size fractionation by cascade pressure dialysis indicated that most of the active material had a molecular weight at less than 500 Daltons. Biological activity was destroyed by incubation of pumping factor with a nonspecific protease. Amino acid analysis of hydrolized factor indicated that arginine comprised approximately 50% of the amino acids. Pumping responses were elicited by high concentrations of mixtures of the two major amino acids (arginine and glycine) in the hydrolysate. These results suggest that pumping factor is a heterogeneous group of small peptides each containing arginine.

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Gustatory responses of single neurons in the orbitofrontal cortex of the macaque monkey. E.T.ROLLS, S.YAXLEY, Z.SIENKIEWICZ AND T.R.SCOTT. (Oxford University, Department of Experimental Psychology, Oxford, England.)

In order to analyze gustatory processing in the primate, the activity of single neurons is being recorded in the macaque monkey (Macaca fascicularis) in regions of the cortex thought to receive gustatory projections. The gustatory stimuli include 1.0mM - 3.0 M NaCl, 1.0mM - 3.0M glucose, 0.01 - 30.0mM HCl, 0.001 - 10.0mM quinine HCl and 20% blackcurrant juice. A population of neurons in the orbitofrontal cortex with taste responses has been found. Recordings from a sample of 15 of these neurons showed that their tuning to gustatory stimuli was much sharper than that of neurons in the gustatory cortex in the frontal operculum, with breadths of tuning (Smith and Travers, 1979) to the four prototypical stimuli 1.0M glucose, 1.0M NaCl, 0.001M quinine HCl and 0.01M HCl of 0.32 $\pm$0.24 and 0.67 $\pm$0.23 respectively (mean $\pm$sd, $p<<0.001$). The individual neurons were tuned to respond best to sweet stimuli (11 to glucose and 4 to blackcurrant juice (20%), with none responding best, and most very little to NaCl, quinine, HCl, or water). The mean spontaneous firing rate of these neurons was 0.6 spikes/s, and the mean response to the best stimulus was 9.7 spikes/s. All responses consisted of an increase of firing rate. In 7 separate experiments, it was found that feeding the monkey to satiety with glucose gradually decreased the magnitude of the neuronal responses to glucose, until when the monkey was satiated, the neurons no longer responded to sweet stimuli. These results provide evidence that there is a secondary gustatory cortical area in the orbitofrontal cortex of the macaque monkey, that tuning here is much sharper than in the taste cortex in the frontal operculum, that the neurons respond primarily to sweet stimuli, and that hunger modulates gustatory processing in this part of the taste system.

Smith DV and Travers JB (1979) Chem. Senses 4: 215-229.

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HRP Applied to Transected Trout Olfactory Nerves Fills Ciliated Receptors, Microvillar Receptors, and Some Basal Cells. J. CARTER ROWLEY III and DAVID T. MORAN (Rocky Mountain Taste & Smell Center, University of Colorado Health Sciences Center, Denver).

The olfactory epithelium of the Brown trout (and many other fishes) contains two morphologically distinct cell types that appear to be olfactory receptors: ciliated olfactory receptors and microvillar cells. Although it is generally agreed that the ciliated cells are indeed olfactory receptors, some question remains as to whether or not the microvillar cells are olfactory receptors. Utilizing modifications of the techniques of Kauer (1981) and Hanker-Yates (1977), we have applied the tracer macromolecule horseradish peroxidase (HRP) to the cut ends of axons within transected trout olfactory nerves. Subsequent examination of olfactory epithelia by light and electron microscopy clearly demonstrated the presence of HRP in ciliated olfactory receptors, microvillar cells, and some basal cells. Ciliated epithelial cells and supporting cells were never observed to contain HRP. These data suggest that microvillar cells bear axons that travel through the olfactory nerve. In addition, the uptake of HRP by some basal cells indicates they may, in the course of differentation into olfactory receptors, elaborate axons before they develop dendrites.

Kauer, J. S., 1981; Anat. Rec. 200:331. Hanker, et al., 1977: Histochem. J. 9:789. Supported by NSF Research Grant no. BNS-8210327 and NIH Program Project Grant no. P01-NS20486.

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Selective Suppression of Sweetness by an Extract from Hovenia dulcis Leaves. L. R. SAUL, L. M. KENNEDY and D. A. STEVENS (Clark University).

Although ziziphins, the taste-altering compounds from Ziziphus jujuba (Rhamnaceae) leaves, are known to be saponins, probably triterpenes (Kennedy & Halpern, Chem. Senses 3, 123, 1980), their chemical structures have not been elucidated. However, chemists have shown that some saponins from H. dulcis (Rhamnaceae) leaves have the same genin structure as the genins of some saponins from Z. jujuba ("jujubogenin") (Kimura et al., Perk I, 1, 1981). Those Z. jujuba saponins might be the ziziphins. If so, then the H. dulcis saponins might have taste-altering activity similar to those of the ziziphins. To test this hypothesis, we studied the effects of an H. dulcis aqueous leaf extract on human perception of the sweetness of sucrose, saltiness of NaCl, bitterness of quinine sulfate and sourness of citric acid, using the method of magnitude estimation. Stimulus solutions were psychophysically matched for intensity to sucrose 80 mM, and a control treatment solution of vanilla extract was selected to be similar to the H. dulcis extract. Median normalized estimates before all treatments were 10. After vanilla treatment, median estimates were 10 for all stimuli. After H. dulcis treatment, median estimates were 10 for all stimuli except sucrose, for which the median estimate was 5. For H. dulcis treatment, differences between stimuli were significant, whereas for vanilla treatment, differences between stimuli were not significant ($p \leq 0.01$, Kramer ANOVAs). Effects of H.dulcis vs. vanilla treatment over all stimuli were not significant ($p > 0.05$). H. dulcis treatment significantly suppressed sweetness in comparison with vanilla treatment ($p < 0.01$), whereas there were no significant differences in H.dulcis vs. vanilla treatment effects for each of the other three stimulus categories ($ps > 0.1$) (Mann Whitney tests). The data indicate a selective sweetness-suppressing principle in H. dulcis leaves. We designate this principle "hodulcin."

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Caffeine Selectively Enhances Taste: Role of Adenosine Receptor. SUSAN S. SCHIFFMAN, JAMES M. GILL, II, TIMOTHY G. BEEKER and CYMANTHA DIAZ (Duke University, Durham, NC).

Caffeine, as well as other methyl xanthines (MX) including theobromine and theophylline, is a potent inhibitor of adenosine receptors. Methyl xanthines applied to the tongue of both humans and rats have recently been found to potentiate the tastes of acesulfam-K, stevioside, NaCl, KCl, and quinine HCl (Schiffman, S. S. et al., Methyl xanthines enhance taste: evidence for modulation of taste by adenosine receptor, Pharmac. Biochem. Behav., 1985, in press). In human studies, two pieces of chromatography paper cut in the shape of half tongues were applied for 4 minutes to the tongue; one was soaked in a solution of 10^{-5}M caffeine and the other in deionized water. Next a standard concentration of a taste stimulus (sweeteners and amino acids) dissolved in 10^{-5}M caffeine and impregnated in a 1.27-cm circle of chromatography paper was placed on the side of the tongue to which caffeine had previously been applied. Test stimuli dissolved in deionized water and soaked in 1.27-cm circles were placed on the non-caffeine side and the concentrations were adjusted to match the perceived intensity of the standard. Caffeine was found to potentiate the tastes of artificial sweeteners (acesulfam-K, neohesperidin dihydrochalcone, d-tryptophan, thaumatin, stevioside, and sodium saccharin). It has no effect on others (aspartame, calcium cyclamate, sucrose, and fructose). It also enhances the tastes of numerous amino acids including L and D phenylalanine, L and D alanine, L and D histidine, and L and D asparagine. Addition of 10^{-5}M and 10^{-4}M adenosine reversed the potentiation.

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Characterization of Putative Paramecium Chemoreceptors. STEPHANIE SCHULZ, ROBIN R. PRESTON, JUDITH VAN HOUTEN (Department of Zoology, University of Vermont).*

Paramecium tetraurelia is able to detect and respond to the presence of chemicals such as folic and acetic acids in its environment. It is likely that Paramecium uses specific receptor sites on the cell body membrane to detect attractants: the cilia are not involved since chemoresponses are observed in deciliated cells. Binding is then transduced by unknown mechanisms to a membrane potential change, which modifies ciliary activity to effect a behavioral response.

We have demonstrated that specific and saturable binding (Kd 30uM) and transport systems for (3H)folate exist in the soma membrane. Specific binding is eliminated in the presence of cAMP and in mutant d4-534, which is not attracted to folate. Application of a solubilized soma membrane preparation to a folate-sepharose affinity column yields 7 proteins that consistently elute with a high folate wash. One of these proteins (~100kd) is absent or non-binding in the mutant.

Electrophysiological studies show that both folate and acetate hyperpolarize paramecia in a dose-dependent manner. Since the magnitude of these responses is sensitive to external Ca, Na, or K concentration, and the membrane potential changes are accompanied by a change in membrane resistance, binding of attractant to the cell membrane would appear to modify membrane potential by selectively opening or closing ion channels. However, membrane responses are seen in the absence of either K or Na, in the presence of TEA (which blocks K channels in Paramecium), and following injection of EGTA to chelate intracellular Ca (and hence block Ca-dependent conductances). These data suggest that the membrane response is brought about by direct entry of the folate and acetate anions, as also supported by pH studies of behavior.

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Chronic Exposure to Bitter Tastes Alters Ingestive Behavior of Rats. G.J. SCHWARTZ (U.of PA.), H.J. GRILL (U.of PA.)

To determine whether the ingestive behavior of rats responding to bitter fluids changes as a function of chronic exposure, rats were maintained on gentian (G), a putative non-toxic organic bitter extract, as their sole source of water. Daily intake, taste reactivity (TR) and body weight were measured throughout chronic G exposure. In TR tests, rats received 1 ml/min intraoral infusions of G. Oromotor responses to G infusions were videotaped and analysed to determine the number and types of TR responses elicited. Rats dramatically altered their ingestive behavior toward G during 16 days of chronic exposure. All rats initially refused to drink much G and lost weight during the first three days of exposure. Rats then consumed G and gained weight at rates comparable to controls maintained on tap water. Taste reactivity to G changed from aversive to ingestive during chronic exposure. At first, G infusions elicited a sequence of purely aversive responses. As the number of TR exposures to G increased, the mean number of ingestive TR responses and the latency to reject the infusion increased significantly. The mean number of aversive responses decreased significantly. The changes in TR from aversive to ingestive responses occurred when rats increased their home cage G intake and began to gain weight. Two bottle preference failed to change; when 24 hrs. water deprived, rats drank significantly more water than G both before and after chronic G exposure. Following chronic exposure to G alone, all rats had chronic access to both tap water and G, and TR to G was measured over the next 10 days. During this period, rats significantly increased the mean number of aversive TR responses and significantly decreased the mean number of ingestive responses elicited by G infusions. Finally, naive rats received G infusions before and after a 24-hr. water deprivation. Gentian infusions still elicited aversive responses following water deprivation. Rats were then given the opportunity to drink only G overnight. All rats drank some G overnight, yet when tested the next day, still failed to shift from a pattern of aversive to ingestive TR responses. The results suggest that: a) ingestive behavior toward non-toxic bitter tastes varies as a function of experience and the physiological consequences of ingestion, and b) appetitive and consummatory aspects of ingestive behavior may be dissociated; TR changes from aversive to ingestive, while water remains preferable to G.

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Gustatory Responses in the Nucleus Tractus Solitarius of the Alert Cynomolgous Monkey. T. R. SCOTT (Dept. Psychol. and Institute for Neurosci., Univ. of Delaware, Newark, DE 19716), S. YAXLEY, Z. J. SIENKIEWICZ and E. T. ROLLS (Dept. of Exp'l. Psychol., Oxford Univ., Oxford OX1 3UD, England).

Glass-insulated tungsten microelectrodes tipped with platinum black and gold chloride were used to record multi-unit and 52 single neuron responses from the nucleus tractus solitarius (NTS) of alert cynomolgous monkeys. Stimuli were glucose, NaCl, HCl and QHCl plus 20% blackcurrant juice. 1) Mean spontaneous activity was 1.2 spikes/sec. Mean evoked responses in spikes/sec measured over a 5-sec post-stimulus period were: deionized water = 2.0; 1.0 M glucose = 4.7; 1.0 M NaCl = 5.6; 0.01 M HCl = 3.5; 0.001 M QHCl = 4.4; 20% blackcurrant juice = 6.1. 2) Intensity-response functions, including neural thresholds to glucose (10^{-1} M), NaCl (10^{-2} M), HCl (10^{-3} M) and QHCl (10^{-4} M) agreed well with psychophysical reports. 3) The NTS is chemotopically organized: neurons most responsive to HCl are more common in the posterior gustatory area while those most responsive to glucose and NaCl are located in anterior NTS. Responsiveness to QHCl is more widely distributed, but tends toward the anterior. 4) Analyses were performed to determine whether gustatory neurons were divisible into a discrete number of types, as determined by their sensitivities to the prototypical stimuli. The only clear distinction emerged from the chemotopia described above, viz. between neurons which did or did not respond well to HCl. 5) Individual neurons were quite broadly sensitive to glucose, NaCl, HCl and QHCl so that, for the typical NTS cell, no one of the four stimuli evoked a majority of the discharges. The mean breadth of tuning coefficient was 0.87 (range = 0.63 - 0.99). 6) Correlations among patterns of activity evoked by the four prototypes indicated that only HCl and QHCl have related taste qualities (r = +0.60).

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Gustatory Responses in Opercular Cortex of the Alert Cynomolgous Monkey. T.R. SCOTT (Dept. Psychol. and Institute for Neurosci., Univ. of Delaware, Newark, DE 19716), S. YAXLEY, Z.J. SIENKIEWICZ and E.T. ROLLS (Dept. of Exp'l. Psychol., Oxford Univ., Oxford OX1 3UD, England).

Glass-insulated tungsten microelectrodes were used to record responses from 162 individual gustatory neurons in dorsal opercular cortex of the alert cynomolgous monkey. Stimuli were the same as those used by us in the study of nucleus tractus solitarius (NTS). 1) Mean spontaneous activity was 1.9 spikes/sec. Mean evoked responses in spikes/sec measured over a 5-sec post-stimulus period were: deionized water = 3.1; 1.0 M glucose = 5.7; 1.0 M NaCl = 5.5; 0.01 M HCl = 4.6; 0.001 M QHCl = 5.0; 20% blackcurrant juice = 7.2. These are 1.0-1.5 times larger than evoked single neuron responses in NTS, in accord with a commensurate increase in spontaneous rate. 2) Neural thresholds were similar to those we saw in NTS which were based on multiunit activity. Cortical thresholds were 10^{-1}M glucose, 10^{-2}M NaCl, 10^{-3}M HCl and 3 x 10^{-4}M QHCl. 3) In gustatory cortex there was no obvious chemotopic arrangement of neuronal sensitivities. 4) Neurons were more narrowly tuned to the basic stimuli than in NTS. The mean breadth of tuning coefficient among cortical neurons was 0.74 (range = 0.00 - 0.99), which is similar to values derived from rodent hindbrain taste cells. 5) Correlations among patterns of activity evoked by the four prototypes indicated that the similarity observed in NTS between HCl and QHCl was preserved in gustatory cortex ($r = +0.57$), while patterns representing glucose and NaCl became significantly correlated ($r = +0.47$). Beyond these, water responses were highly correlated with those evoked by HCl ($r = +0.60$), and glucose established a close correlation with predominantly sweet blackcurrant juice ($r = +0.75$).

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Satiety Does Not Affect Gustatory-Evoked Activity in the Nucleus Tractus Solitarius or Opercular Cortex of the Alert Cynomolgous Monkey. T. R. SCOTT (Dept. Psychol. and Institute for Neurosci., Univ. of Delaware, Newark, DE 19716), S. YAXLEY, Z. J. SIENKIEWICZ and E. T. ROLLS (Dept. Exp'l. Psychol., Oxford Univ., Oxford OX1 3UD, England).

Feeding to satiety decreases the acceptability of the taste of food. To determine whether the responsiveness of gustatory neurons plays a role in this effect, multiunit activity in the nucleus tractus solitarius (NTS) and single neuron responses in frontal operculum (GC) were recorded while alert cynomolgous monkeys were fed to satiety. Gustatory-evoked responses to 1.0 M glucose, 1.0 M NaCl, 0.01 M HCl, 0.001 M QHCl and 20% blackcurrant juice were monitored while monkeys were 18-hr deprived and during and after feeding to satiety with glucose or blackcurrant juice. While behavior turned from avid acceptance to active rejection upon repletion, the responsiveness of NTS and GC neurons to the stimulus array, including the satiating solution, was unmodified. We conclude that the sensitivity of the taste system is not influenced by the normal transition from hunger to satiety. This is in direct contrast with conclusions drawn from responses of hypothalamic neurons which respond to food only when the monkey is deprived. It also has implications which conflict with data from hindbrain taste neurons in anesthetized rats. In the alert monkey, bulbar and cortical taste processes appear to be divorced from motivational state.

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On the Relationship Between Oral and Systemic Glucose Sensitivity. R. GREGG SETTLE (Smell and Taste Center, University of Pennsylvania).

We have previously demonstrated that a subgroup of nondiabetics with a positive history of non-insulin-dependent diabetes have a decreased suprathreshold taste sensitivity to glucose, relative to fructose, when compared to nondiabetics with a negative family history of diabetes. In the present study we examined the relationship between measures of glucose taste sensitivity and circulating levels of both fasting blood glucose and glycosylated hemoglobin. Glycosylated hemoglobin is an integrated average of blood glucose levels over time. A forced-choice transformed staircase procedure was used to measure glucose taste thresholds, and an 80 point rating scale was used to obtain intensity estimates for 6 suprathreshold concentrations of glucose and fructose. Glucose taste sensitivity of nondiabetics with a negative family history of diabetes was related to the systemic level of glucose at the time of testing. However, the glucose taste sensitivity of nondiabetics with a positive family history of diabetes was related only to glycosylated hemoglobin levels -- a measure more closely associated with systemic glucose tolerance (sensitivity).

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Developmental Expression of Transmitter Phenotype in Brain Dopaminergic Neurons. M.T. SHIPLEY, E.G. SIELOFF, M. LAZOFF, and J. MCLEAN. (University of Cincinnati College of Medicine).

The laminar cytoarchitecture of the main olfactory bulb (MOB) makes it an attractive and useful model for studies of the factors that regulate the development of neuronal circuitry. To investigate the relationship between neuronal development and neurotransmitter expression in the MOB, we have studied neurons containing the neurotransmitter dopamine (DA).

In the adult rat, DA is found only in superficial tufted and periglomerular neurons. These neurons are born in the ependymal cell layer and migrate to their destinations in more superficial layers (Hinds, 1968). Three possibilities exist for the developmental expression of the neurotransmitter phenotype under investigation; the phenotype may be expressed: 1) at neuronal birth; 2) as the neurons are migrating from the proliferative zone; or 3) after the neurons are inserted into their definitive circuit matrix.

The presence of tyrosine hydroxylase (marker for DA) in the olfactory bulb of Sprague-Dawley rats aged 1, 2, 5, 8, 14, 22, 28, 37 days and adults was demonstrated using immunocytochemistry. We observe that DA activity is expressed only after neurons reach the glomerular and external plexiform layers. We also observe that the localization and expression of DA neurons in the periglomerular pattern is progressive and coincides with the ingrowth of primary afferents and centrifugal systems. It is known that removal of primary olfactory neuronal (PON) input to the MOB causes a transient loss of DA activity in the bulb neurons (Kawano and Margolis, 1982). The present results suggest that the developmental expression of the DA phenotype is modulated by synaptic inputs. It will be interesting to determine whether the initial expression of DA is triggered by PON fibers or by other centrifugal inputs that are developing coincident with DA expression.

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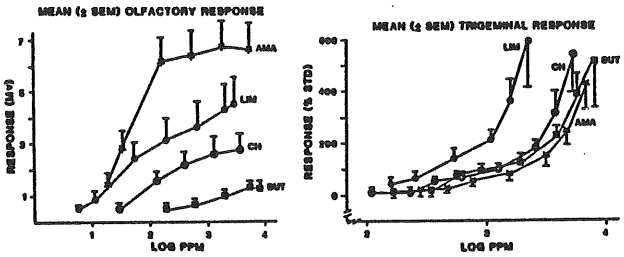
Electrophysiological Comparison of Trigeminal and Olfactory Responses. WAYNE L. SILVER, J. RUSSELL MASON, and ADAM H. ARZT (Monell Chem. Senses Ctr., Phila. PA 19104)*

Trigeminal and olfactory responses to amyl acetate (AMA), cyclohexanone (CH), butanol (BUT), and limonene (LIM) were compared in the tiger salamander. EOGs were used as a measure of olfactory response. For trigeminal recording, small nerve bundles were dissected out as they passed through the orbit of the eye and placed on electrodes to obtain multi-unit responses. Stimuli were delivered at= 100 ml/min for 20 sec (trigeminal) or 10 sec (olfactory).

Concentration-response (C-R) curves (see Figure) differed for trigeminal and olfactory responses. Trigeminal C-R curves rose even at the highest concentration (vapor saturation), whereas EOGs plateaued before vapor saturation was reached. For all four odorants, thresholds (i.e., concentrations (ppm) that first elicited a response above baseline) were higher for trigeminal chemoreception (AMA 450±74: CH 348±80: BUT 671±281: LIM 261±69: $\bar{x}$ ± s.e.m.: n=5) than for olfaction (AMA 12±1: CH 16±1: BUT 114±1: LIM 6±0: n=4).

Trigeminal responses were similar for any given odorant concentration, while olfactory responses were stimulus dependent. This suggests that trigeminal chemoreceptors (unlike olfactory receptors) may not be able to discriminate among these odorants on the basis of quality.



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A Detailed Analysis of Maltose, Fructose, and Glucose Drinking in the Rat. A. C. SPECTOR (Florida State Univ.).

The purpose of this study was to determine to what extent concentration-dependent changes in the ingestional patterns of rats generalize across nutritive sweeteners. Three groups of rats (n=6/group) were presented with water, lab chow, and one type of sugar solution (maltose (M), fructose (F) or glucose (G)) for 23 hours and their eating and drinking patterns were quantified. The concentration of the sugar solution was systematically increased (4%, 8%, 16%, 32%) with a single concentration being presented to rats in 4-day blocks. Total intake (ml) of each sugar solution as a function of concentration was nonmonotonic, reaching a peak at 8%. Calories consumed from sugar increased with concentration, reaching an asymptote at 8% for both G and M, and at 16% for F. As the calories consumed from sugar increased chow intake decreased; this was due primarily to a reduction in feeding bout frequency. Bout drinking rate (ml/min) monotonically increased with concentration reaching an asymptote at 8% for G and at 16% for F and M; this increase is generally consistent with the findings of others employing short-term tests with both intact and gastric-cannulated rats, suggesting that drinking rate is partially under orosensory control. As the concentration of sugar inceased, the day to night ratio of sugar intake approached unity. This was attributed to an increase in the incentive value of the sugar solution, provoking ingestion during the daytime, with postingestional inhibition limiting nighttime intake. Fluid bout volume increased with sugar concentration up to 8% and then either remained the same or dropped when the concentration was raised from 8% to 16% depending on the sugar. All groups decreased their fluid bout volume when the concentration was raised from 16% to 32%. These data suggest that caloric density is an important factor in the limitation of bout volume. Since caloric intake within a sugar drinking bout progressively increased with sugar concentration, the asymptotic portion of the curve describing calories consumed from sugar was attributable to alterations of drinking bout frequency and not drinking bout size. This finding also suggests that caloric load is not the critical factor responsible for the limitation of bout volume.

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Orofacial Motor Behavior-Patterns Induced by Gustatatory Stimuli in Apes. STEINER,J.E. (Dept. Oral Biology, Hebrew University-Hadassah Faculty of Dental Medicine,Jerusalem,Israel), GLASER,D. (Institute of Anthropology, University of Zurich-Irchel, Zurich, Switzerland).

Stimulus-dependent fixed features of motor behavior reliably indicate the quality and hedonics of taste-sensations. Earlier studies demonstrated that these responses can be quantified. More recent observations revealed certain similarity of behavioral taste reactions of some monkey species to the human gustofacial reflex. The present study aimed to focus on orofacial taste reactions of apes. Adult siamangs, gibbons, chimpanzees, gorilla and orangutangs and one 14 month old infant orang were tested. To a total of 14 animals water, sweet, sour, salty and bitter stimuli were presented and the orofacial motor reactions videotaped. The careful analysis of the obtained recordings revealed that: a) water triggers a fleeting drinking-swallowing without any characteristic facial play; b) sweet taste leads to smacking, to protrusion and licking of lips, and to a facial expression of enjoyment with open,sparkling eyes (playface); c) sour induces lip-pursing folding of lower lip, spitting and a facial expression of disappointment; d) bitter taste causes depression of mouth-corners, gaping, vigorous spitting or retching, withdrawal, head-turn and a "sad" expression of the face; while e) the salty taste triggered some features of acceptance and some of aversion. Naive observers in a double-blind setting read well the expressions emitted. The similarity of the orofacial taste reactions in these animals to the human gustofacial reaction is most impressive. It can,therefore be assumed that the neuromuscular arrangement of the face in apes and man render a fine communicational mechanism for reflection of feelings. Taste cues can be considered as unconditioned (natural) stimuli to unlock in a differential manner those action-units which apes and men equally use in reflecting their feelings and moods.

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Effects of Tastants on Oral Irritation Produced by Capsaicin and Piperine. DAVID A. STEVENS (Clark University), HARRY T. LAWLESS (S. C. Johnson & Son, Inc.)*

In Experiment I, twelve volunteers rated the intensity of irritation (burn) produced by capsaicin (1 ppm) and piperine (100 ppm) before, during, and after 15 ml samples of various tastants were sipped every 30 seconds for 8 minutes. The tastants were citric acid (.0056 M), NaCl (.3M), quinine HCl (.0001M), sucrose (.3M), and water. A control condition in which ratings were made with nothing sipped was also used. The design in Experiment II was identical to Experiment I except that only capsaicin, now at 2 ppm, was used, and 24 volunteers were subjects.

The results showed a difference in the course of the intensity of burn over time. Capsaicin's burn decayed following a negatively accelerated function while piperine's burn decayed following a linear function. Generally, the decrease in burn was slowest when nothing was sipped, intermediate when quinine was sipped, and fastest for the other tastants and water. For both irritants the intensity of the burn was momentarily depressed during the sipping of a tastant. This momentary decrease was greater for burn induced by piperine than burn induced by capsaicin.

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Aging Blunts the Perceived Magnitude of Most if Not All Odors JOSEPH C. STEVENS, WILLIAM S. CAIN, AND THOMAS D. MYERS (John B. Pierce Foundation Laboratory)*

Earlier research in our laboratory has established that aging takes a greater toll on the sense of smell than on the sense of taste. Bartoshuk has presented evidence that aging brings about an elevation of the absolute threshold for common taste solutions but little or no change in supra-threshold taste strength. In contrast, aging not only elevates olfactory threshold, it also impairs the ability to identify odors and depresses their perceived strength. Loss of perceived strength holds true for all six odorous compounds we have tested: iso-amyl butyrate, benzaldehyde, d-limonene, pyridine, ethyl alcohol, and iso-amyl alcohol. These were selected for their structural diversity, their hedonic tone, their use in everyday life, and their psychophysical properties. The method was magnitude matching, using five concentration levels of NaCl as the control continuum and five concentration levels of the six odorants, all estimated by each subject in a single test session (20 persons between 70 and 89 years and 20 between 18 and 25). Relative to the estimations of the salt solutions the youngs' estimates of all the odorants exceeded those of the elderly. To a first approximation, age-related olfactory deficiency can be characterized as a constant percent depression of perceived strength across concentration level. Although there are striking individual differences among the elderly in olfactory functioning, on the average age brings about hyposmia to many, if not all, odors.

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Behavioral Classication of Saccharin Taste Qualities in Rats. CHARLES N. STEWART & STACIE A. KRAFCZEK (Franklin & Marshall College, Lancaster PA 17604).

While Na-saccharin is generally regarded as sweet in taste quality, the presence of a second component is well recognized in humans and is generally regarded as bitter. In other species when a conditioned flavor aversion (CFA) is established to saccharin, gerbils generalize the CFA to both sucrose and NaCl while rats and hamsters generalize only to sucrose, suggesting that in these species a secondary component is not present. Because rats have been reported to show some generalization from a quinine CFA to saccharin, the possibility of the second component being quinine-like and concentration dependent was explored in a series of three studies. When a CFA to 0.005 M saccharin was established rats generalized the aversion only to sucrose. At 0.025 M saccharin the generalization to sucrose was slightly weaker but again no generalization to other substances such as quinine sulfate, quinine hydrochloride or sucrose octaacetate occurred. Finally a CFA was established to 0.0001 M quinine HCl following which generalization tests to 0.005 or 0.025 M saccharin were conducted. No significant suppression of intake of either concentration was observed when rats with the CFA were compared with controls. Thus, if saccharin has a second taste component to rats it is not quinine-like and this species would appear to classify this substance as primarily sucrose-like.

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The Topography of Olfactory Epithelium to Olfactory Bulb Projections in the Rat. WILLIAM B. STEWART, PATRICIA E. PEDERSEN, CHARLES A. GREER and GORDON M. SHEPHERD (Yale University School of Medicine).

We have shown previously, using the 2-deoxyglucose method, that specific regions of the olfactory bulb were metabolically active during exposure to odors. Furthermore, different regions were active with different odors. We have also shown, using the horseradish peroxidase (HRP) method, that one of the metabolically active regions in the posterior medial olfactory bulb receives projections from a defined region of the olfactory epithelium. The present experiments were designed to test the hypothesis that another metabolically active region in the lateral anterior olfactory bulb receives its input from a different region of the olfactory epithelium. Therefore, rats had HRP placed in restricted regions of the olfactory bulb by iontophoresis or by direct placement of HRP crystals. The distribution of HRP in the decalcified nose was examined following sacrifice and processing. Placement of HRP in the medial posterior bulb produced labelled receptor cells along the septal wall, posterior dorsal recess and medial turbinals. By contrast, placement of HRP in the anterior lateral bulb produced labelled receptors along the dorsal and lateral turbinals and the anterior dorsal recess, but not the septal wall. These results show that these two regions of the bulb receive input from distinct but overlapping populations of receptor neurons.

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Responses of Single Cells in the Lamb Nucleus of the Solitary Tract to Chemical Stimulation of the Epiglottis. ROBERT D. SWEAZEY and ROBERT M. BRADLEY (Univ. Michigan, Ann Arbor, MI 48109).

We have reported responses from the superior laryngeal nerve (SLN) to chemical stimulation of the lamb epiglottis and described projections of SLN afferents to the brainstem. We have now recorded from second-order neurons in the nucleus of the solitary tract (NST) to compare responses of primary and secondary neurons supplying the epiglottis. Responses were recorded from 20 single neurons in 14 lambs anesthetized with sodium pentobarbitol. Chemical stimuli (0.5 M KCl, NH_4Cl, NaCl and LiCl, 0.01 N HCl, 0.005 M citric acid and distilled water) were flowed over the epiglottis. All stimuli were dissolved in 0.154 M NaCl which also was used as a rinse.
Chemosensitive cells were located in a circumscribed region of the total SLN projection. This area was in the caudal NST 1-4 mm rostral to obex, 2-3.5 mm lateral to the midline and 2-3 mm vental to the brainstem surface. As in the periphery, KCl, NH_4Cl, and HCl excited the greatest number of cells and produced large response magnitudes across NST neurons. Like all peripheral fibers, the majority of NST neurons (95%) responded to a tactile stimulus. In general, these second-order neurons in the brainstem responded to a larger number of the stimuli ($\bar{X}$=5.4 $\pm$ 1.2) than was observed in the periphery ($\bar{X}$=3.9 $\pm$ 1.6). For example, distilled water was a much more effective stimulus in the medulla eliciting responses in 85% of the cells as compared to 50% of peripheral fibers. Fourteen of 20 cells responded to the flow of a rinse solution. In 86% of these flow sensitive cells the rinse following stimulation with distilled water or acids resulted in flow responses two to three times greater than that following the salts. Finally, 10% of the responses observed in NST cells were inhibitory. These inhibitory responses were not seen in the periphery. These results indicate differences in primary and secondary neural responses due to processing of afferent information by cells in the NST.
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Olfactory Nerve Pathways in the Old World Monkey. SDAYUKI F. TAKAGI (Gunma University, Japan)

In the beginning, neocortical olfactory areas were sought electrophysiologically and located in the lateroposterior portion of the orbitofrontal cortex (LPOF) (Tanabe et al, 1975) and in the centroposterior portion of the same cortex (CPOF) (Yarita et al, 1980). Then, the routes of the olfactory nerve pathways to the LPOF and CPOF were examined and found: (1) Olfactory bulb (OB) - prepyriform (PPF)·medial portion of amygdala (MA) - directly to LPOF and in parallel through substantia innominata (SI) to LPOF (extrathalamic pathway) (Naito et al, 1984). (2) OB - PPF·MA - mediodorsal nucleus of thalamus (MD) to CPOF (transthalamic pathway). In addition, an olfactory pathway through the septum (Spt)·nucleus accumbens (Acc) to the lateral hypothalamic area (LHA) was also found (Tazawa et al, 1983). Using unanesthetized monkeys, these investigators studied neuronal responses to odors in the OB, PPF ·MA, LPOF, MDmc, CPOF, and LHA. Although most of the cells in the other areas responded to more than one odor, half or more of the cells in the LPOF and LHA responded to only a single odor. Thus, discrimination of odors was shown most remarkably in these two areas.

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Responses of Taste Cells of Mouse

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The response in mouse taste cells has been investigated further using intracellular recording and dye marking techniques (Procion yellow). In this study, only responses recorded from mouse taste cells with fluorescent cells as observed in subsequent histological preparations were used. Sucrose produced a depolarization response and the response was accompanied by an increase or no membrane resistance change. NaCl produced a depolarization, hyperpolarization or null response and the response was accompanied by a decrease or no membrane resistance change in all cases. Q-HCl and HCl produced relatively variety of response profile and the membrane resistance changes are also varied in each taste cells. The relationship among the response profiles is complicated. Taste cells could be grossly classified into two types, H-cells and D-cells, according to their sucrose responses. The response to sucrose in which a depolarization is accompanied by membrane resistance increase has a more negative reversal potential than the resting membrane potential (H-cell type). The response to sucrose in which a depolarization is not accompanied by a visible membrane resistance change has a more positive reversal potential than the resting membrane potential (D-cell type). When the response profiles are arranged about the D-cell and H-cell type, almost all of hyperpolarization responses to NaCl, Q-HCl and HCl are classified into the H-cell type.

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Effect of Amiloride on Paramecium Chemoresponse. JUDITH VAN HOUTEN (Department of Zoology, University of Vermont), ROBIN PRESTON (Department of Zoology, University of Vermont)*

Paramecia are attracted to Na-acetate (NaOAc) relative to NaCl in T-maze assays. Amiloride hydrochloride (0.5 mM) inhibits this attraction. When amiloride is included in the test solution, cells are repelled from the attractant NaOAc: compare control data showing strong attraction to 1 mM NaOAc + 5.5 mM NaCl vs 6.5 mM NaCl $I_{che} = 0.80 \pm 0.10$ n = 6 to amiloride test data with 1 mM NaOAc + 5 mM NaCl + 0.5 mM amiloride vs 6.5 mM NaCl $I_{che} = 0.19 \pm 0.08$ n = 6. When amiloride is included in both test and control solution, attraction is blocked and cells react to NaOAc as a neutral solution ($I_{che} = 0.56 \pm 0.17$). However, amiloride probably has no direct effect on a component of the chemosensory transduction pathway. The inhibition of attraction is likely to be a secondary effect of the drug for the following reasons: 1) Amiloride itself is a strong repellent in Na solutions, but is neutral in K solutions. Repulsion from amiloride in Na solutions could account for the repulsion from NaOAc in the first set of data above. 2) Amiloride does not inhibit attraction to K-OAc relative to KCl. Apparently Na activates a carrier, which can be inhibited by amiloride. The consequences of this inhibition are depolarization, repulsion from amiloride and interference with chemoresponse to NaOAc (probably by blocking the characteristic hyperpolarization in OAc). In K solutions, there is no activation of the Na carrier and, hence, there is insensitivity of the cell and its chemoresponse to amiloride. Therefore, paramecia apparently do have an amiloride sensitive Na dependent carrier and disruption of its function with amiloride can interfere with chemoresponse. However, chemoresponse occurs normally in K solutions, in which the Na carrier is not activated and amiloride has little effect.

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Inhibition of the Gerbil's Electrophysiological Sweetener Response by Methyl 4,6 dichloro-4,6-dideoxy α-D-galactopyranoside, P-nitrophenyl α-D-glucopyranoside and Chloramphenicol. VASILIKI VLAHOPOULOS (Lehman College, CUNY), WILLIAM JAKINOVICH (Lehman College, CUNY)[1]

In our search for sweet taste inhibitors, we discovered that the gerbil's whole nerve electrophysiological response to sucrose is suppressed by methyl 4,6 dichloro-4,6-dideoxy α-D-galactopyranoside (DiCl-Gal), P-nitrophenyl α-D-glucopyranoside (PNP-Glu) and chloramphenicol (CA). To determine the effect of these compounds on other sweeteners, we prepared mixtures of DiCl-Gal, PNP-Glu or CA with various sweeteners and with sodium chloride. The concentrations for sweeteners (CR_{50}) and for NaCl (0.1M) used in these experiments produced equivalent neural responses. The concentrations of the inhibitors used represented their maximum solubility in water at 25°C (DiCl-Gal=0.1M, PNP-Glu=0.03M, and CA=0.015M).

When we applied these solutions to the gerbil's tongue, we observed the following responses by the chorda tympani nerve:

1) The sweetener taste responses were suppressed in varying degrees by DiCl-Gal, PNP-Glu and CA.
2) The sodium chloride taste responses were unaffected by these substances.
3) With regard to the sugars we tested, the suppression pattern appears uniform and the degree of suppression appears related to the affinity of the sugar, i.e. the most potent sugars are suppressed the least.
4) In the case of the non-sugar sweeteners we tested, the degree of suppression seems unrelated to affinity.
5) Unpredictably, the most potent artificial sweetener, L-4'-cyano-3-(2,2,2)-trifluoroacetamido-succinanilic acid, was a compound completely suppressed by PNP-Glu.

These results, demonstrating differential effects on the gerbil's sweetener taste responses, suggest that each of these inhibitors is interacting at a different receptor site.

[1]This work was supported in part by grants from City University of New York PSC-BHE Research Award Program and the National Institutes of Health.

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Self-adaptation of Receptor Cells in the Lobster: Effects of elevated backgrounds on responses to repeated stimulation. RAINER VOIGT and JELLE ATEMA (Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543)*

The glutamate receptor cells on the walking legs of the lobster, Homarus americanus, form a spectrally homogeneous, mostly narrowly tuned population (JOHNSON et al., J. Comp. Physiol. A155: 593-604, 1984). Under natural conditions these cells have to detect signals in a noisy environment which may change their dynamic response properties (eg. adaptation and disadaptation). We characterized cell responses to standard 1s glutamate pulses in different concentrations of a glutamate background by varying the interpulse interval.
Single cells were identified with a $3x10^{-6}$M glutamate search stimulus. A series of five pulses was applied in one of five interpulse intervals in artificial seawater (ASW); after 3min of adaptation to an elevated glutamate background the series was repeated.
When stimulated in ASW with $3x10^{-4}$M glutamate pulses in intervals $\geq$40s their responses varied by ~20% over 5 successive stimulations (mostly cumulative adaptation). Interpulse intervals of $\leq$20s caused systematically decreasing responses leveling off <50% of the first response. By reducing the stimulus concentration to $3x10^{-6}$M 20s intervals resulted in ~20% adaptation; 10s intervals caused cumulative adaptation to <50%. The process of background elevation to 10^{-4}M glutamate caused responses of variable intensity in different cells. Cells responding strongly to background elevation showed a small first response and only weak cumulative adaptation to $3x10^{-4}$M pulses. In contrast, cells responding weakly during background elevation responded as in ASW to the first stimulus and showed strong adaptation during subsequent stimuli. These results show that the spectrally homogeneous population of glutamate cells separates into subgroups defined by different dynamic response properties. Such differences may be useful in extracting variable signals from variable noise backgrounds.

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Development of the Picture Identification Test (PIT): A research companion to the University of Pennsylvania Smell Identification Test (UPSIT). TERESA A. VOLLMECKE & RICHARD L. DOTY (Department of Psychology and the Smell and Taste Center, University of Pennsylvania)*

To control for temporal parameters related to the administration of the University of Pennsylvania Smell Identification Test (UPSIT), we have developed an analagous Picture Identification Test (PIT) having items representing the 40 odorants used on the UPSIT. The pictures are located in four books identical in format and form to the UPSIT, and hinged so that an equivalent amount of time intervenes between exposure to the stimulus and generation of a forced-choice response. Results of the administration of the PIT to a small group of Korsakoff's psychosis patients demonstrates that their odor identification problem is not the result of short-term memory factors associated with taking the UPSIT. Other applications of this test will be discussed.

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Psychophysical Comparison of Olfactory and Trigeminal Sensitivity to Several Odorants. JAMES C. WALKER (Davidson College), DIANNE B. WALKER (Davidson College)*

Pavlovian conditioning of cardiac acceleration to odor stimuli is being used to compare the sensitivity of the olfactory and trigeminal systems of pigeons to several commonly used odorants. In two to three training sessions, equal numbers of air and odor trials are presented. Only odor trials are terminated with electrical shock. Cardiac acceleration during the two kinds of trials is compared by the formula: (D-P)/P where P and D represent, respectively, the number of heart beats occurring during two 20 sec periods just prior to and during the presentation of clean air or odor. Thresholds for n-amyl acetate, obtained with this procedure, average $10^{-7.6}$ M. Absolute sensitivity to n-butanol, n-butyric acid, benzaldehyde and benzyl amine are being determined. Once thresholds to all odorants have been determined, the olfactory nerve will be bilaterally resected; this surgical procedure prevents reconstitution of the nerves for a period of at least 30 days. Postoperative testing will reveal the sensitivity of the trigeminal system to these same odorants. Those odorants for which olfactory sensitivity far exceeds that of the trigeminal system will be used in subsequent psychophysical comparisons of normal and reconstituted olfactory systems.

*Supported by a Faculty Research Grant from Davidson College.

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Investigations of the Nervus Terminalis in Elasmobranchs. JOEL WHITE and MICHAEL MEREDITH (Department of Biological Science, Florida State University)

The nervus terminalis (NT) is a ganglionated nerve found in vertebrates which connects the forebrain and the peripheral olfactory structures. The nerve has been hypothesized to be chemosensitive but we and others (BULLOCK & NORTHCUTT, '84) have not yet demonstrated sensitivity to chemicals applied to the olfactory epithelium in elasmobranchs. We have used electrical stimulation to determine some of the basic physiological properties of the NT. Compound action potentials containing several different peaks have been recorded in vitro with suction electrodes from the nerves of bonnethead sharks (Sphyrna tiburo), suggesting that there are several distinct populations of fiber sizes making up the nerve. Electron micrographs show that the NT of the bonnethead and the southern stingray (Dasyatis sabina) contain unmyelinated fibers of varying sizes. Additionally, myelinated fibers were found in the NT of both the bonnethead and the stingray. Electron micrographs also confirm the presence of synapses in the NT ganglion of the stingray. Spontaneously occuring action potentials similar to those found by BULLOCK & NORTHCUTT ('84) were recorded in vivo with a hook electrode from the NT of the bonnethead, but we have recorded this activity only in the nerve central to the ganglion. Electrically stimulating one NT elicited several different constant latency spikes recorded from the contralateral nerve. The large amplitudes of these spikes and their relatively short latencies from stimulation suggests that they were conducted by either the myelinated or the larger unmyelinated fibers of the nerve. The spikes could be recorded only from the central portion of the nerve, but could be driven by stimulating either the central or the peripheral portion of the contralateral nerve.

BULLOCK & NORTHCUTT, 1984. Neuroscience Letters. 44:155.

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The Neuronal Architecture of the Solitary Nucleus of the Hamster. MARK C. WHITEHEAD (Dept. Oral Biol., UCONN Health Ctr. Farmington, CT 06032).

This study provides a scheme for subdividing the solitary nuclear complex on the basis of cytoarchitectonic (Nissl and silver staining) and Golgi criteria. Distributions of chorda tympani (CT), lingual/trigeminal (L) and glossopharyngeal (G) afferents, previously traced with HRP, were plotted on the subdivisions.

The central nucleus (CN), the largest subdivision, lies medial to the entire solitary tract (ST). It contains small and medium-sized cells with radiate, or mediolaterally or dorsoventrally oriented dendrites. L, G and CT afferents terminate heavily in CN, the latter two essentially filling it rostrally. The dorsal nucleus (DN) forms a thin, cell-sparse rind, dorsal to the CN, containing small stellate cells, dendrites of CN cells, and sparse L, G and CT inputs. The DN is replaced at rostral commissural levels by the highly densicellular dorsolateral nucleus containing small, round, parvidendritic cells and no primary afferent endings. This nucleus drops out caudally, at the level of the area postrema where the laminar nucleus, containing mediolaterally oriented fibers (including G afferents) and ovoid-fusiform cells, appears. The lateral nucleus (LN), lateral to and within the ST, is characterized by small fusiform neurons with mediolaterally oriented dendrites. The LN receives heavy L input. The ventral nucleus (VN) lies below the CN and contains large polygonal cells with extensive dendrites reaching far medially or into the CN and reticular formation. The VN receives inputs from L (heavily), CT and G (sparsely) fibers. The ventrolateral nucleus (VLN) inserts between VN and LN at caudal, commissural levels; its large neurons send dendrites curving around the ventral aspect of the ST. All three afferent inputs converge in the VLN. The medial nucleus (MN), medial to the CN, expands to form the commissural nucleus. The MN is sparsely populated by small and medium-sized round and polygonal cells with radiate dendrites; it receives sparse G inputs. The magnocellular nucleus (MGN), an intensely stained collection of large, oval cells, is embedded within the MN, dorsal to the vagal motor nucleus. MGN dendritic fields orient mediolaterally and are confined to the subdivision proper which receives no CT, L or G inputs.

This parcellation scheme will facilitate investigations of the types of circuits which comprise the brain stem gustatory system. (Supported by NIH Grant NS16993 and the CT Research Foundation)

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Terminal Nerve Damage Affects Hamster Mating Behavior. C.R. WIRSIG and C.M. LEONARD (University of Florida)

The mating success of many mammals depends on pheromonal access to particular chemosensory systems. Male hamsters, for example, display mating deficits after vomeronasal nerve (VNN) cuts. Recent studies have shown that the terminal nerve (TN) travels within the VNN in the hamster and therefore would be disrupted after VNN damage. To assess the possible contribution of the TN to mating behavior, we developed a means of sectioning the TN after it leaves the VNN. The behavioral protocol of Winans and Powers (1977) was used. Male hamsters were placed with hormone-primed females for 15 min. Mounts, intromissions and ejaculations were videotaped and recorded on a Grass polygraph. Animals were given 3 preop and 3 to 5 postop tests after terminal nerve transections (TNx, n=16), or control lesions of the olfactory bulbs (OBx, n=6) or forebrain (FBx, n=7). Completeness of the TN lesions was histologically verified. Each animal served as its own control. Neither OBx or FBx control group showed a deficit postoperatively. They were grouped together for analysis. The TNx hamsters showed two specific deficits following surgery. Half of the TNx animals failed to mate during at least 1 postop test, but did investigate the female. One control animal failed to mate once. Second, TNx animals required significantly more intromissions (x=4.48) to achieve ejaculation postoperatively (paired t=2.89, p 0.01). These data supply evidence that the terminal nerve provides a substantial contribution to the normal mating behavior of male hamsters. We speculate that it is working in concert with the vomeronasal system. Section of the TN cuts off its afferent connections with the terminal ganglion which sends a considerable projection to the AOB and ventral forebrain. Through these connections the TN may facilitate sexual arousal.

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Categorical Perception. H.N. WRIGHT (SUNY-Upstate Olfactory Clinical Research Center, Syracuse)

The odor of iso-amylacetate has been described as both bananas and nail polish remover. Casual observation suggested that these perceptual categories were related to concentration; that is, weak solutions identified as bananas, and strong solutions as nail polish remover. The purpose of this investigation was to quantify this relationship. Four subjects (2 males, 2 females) were randomly presented iso-amylacetate in a 12-step dilution series from .024% to 50% full concentration and were required to identify each concentration as either bananas or nail polish remover. For all subjects the average percent identification, or perceptual shift, from one category to the other was linear as a function of log concentration. This perceptual shift is interpreted to support the notion that categorical perception does indeed exist in olfaction, as it does in other sensory modalities.
Supported by NIH Grant NS19658

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Olfaction: Stimulus-Receptor Interaction.

R. H. WRIGHT (6822 Blenheim St., Vancouver, V6N 1R7, Canada.)

Olfactory stimulus-receptor interaction takes place when a macrocyclic receptor molecule in a vibrationally excited state makes a quantized transfer of energy to a suitably oriented and vibrationally unexcited stimulus molecule. The de-excitation of the receptor is accompanied by a change in its configuration and volume which results in a lateral movement of electricity within the cilium in whose membrane the receptors are situated. This contributes to the build-up of a generator potential and finally to an action potential in the axon of the receptor cell. The prior excitation of the receptors originates in the mechanical deformations of the flexible cilia associated with normal breathing. The de-excitation of the stimulus molecules following their interactions with the receptors takes place through collisions with other molecules in the environment, so that the stimulatory efficiency of an odorant depends upon the time required for its vibrational relaxation. Neither the stimuli nor the receptors are "used up" in the process which accounts for the extreme sensitivity of the olfactory sense. The process as pictured is consistent with thermodynamic, quantum-mechanical and informational principles as well as with the biological processes of natural selection.

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Septal Organ of Masera: Projections onto the Guinea Pig Main Olfactory Bulb (MOB) Determined by Silver Impregnation and Anterograde Transport of Horseradish Peroxidase (HRP).

CHARLES J WYSOCKI, RHONDA MITTELBERG, LINDA M. WYSOCKI AND GARY K. BEAUCHAMP (Monell Chemical Senses Center, 3500 Market St., Philadelphia, PA 19104)*

The septal organ (SO) is an island of olfactory-like neuroepithelium located on the nasal septum near the junction of the nasal cavity and the nasopharynx. Although responsive to odorants during electrophysiological assessment (Bean, Arzt & Silver, personal communication), little is known about its CNS connectivity. Since the SO is thought to communicate with the caudal part of the MOB and since a branch of the vomeronasal nerve carries some SO afferents, we explored the possibility that the SO projected onto the accessory olfactory bulb (AOB) or to a discrete region of the MOB. In the first set of experiments, the SO of 10 guinea pigs was surgically destroyed. After survival times of 4-7 days, MOB/AOB sections were stained for degenerating fibers using Eagers's method. Destruction of the SO, including the branch of the vomeronasal nerve which traverses medial to it, resulted in staining of glomeruli in both MOB and AOB, whereas superficial destruction resulted in staining of MOB glomeruli only. In the MOB, many glomeruli in the medial and ventral portions throughout much of its rostro-caudal extent were densly stained. Experiments (n=10) with cholera toxin-conjugated HRP (CT-HRP) confirmed these observations. CT-HRP was applied to the surface of the SO and, after 1-6 days survival, tissue was processed using modifications of Maseulm's TMB procedure. In no instance did we observe anterograde transport of CT-HRP to the AOB. We did observe projections of the SO onto the MOB. Many medially and ventrally placed glomeruli were intensely stained for HRP. We conclude that the SO does not project to the AOB and does not have a discrete projection onto the MOB.

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CHEMOSENSORY RECOGNITION OF MOUSE MAJOR HISTOCOMPATIBILITY TYPES BY THE RAT.

KUNIO YAMAZAKI, GARY K. BEAUCHAMP, CHARLES J. WYSOCKI, OSAMU MATSUZAKI (Monell Chemical Senses Center), BURTON M. SLOTNICK (American University) and EDWARD A. BOYSE (Memorial Sloan-Kettering Cancer Center)*

Olfactory discrimination of Major Histocompatibility (MHC) types among mice is apparent in spontaneous mating preferences favoring one MHC type over another, from discrimination of odors of MHC-dissimilar mice or their urine in a Y maze, and from differing incidences of pregnancy block in females exposed to the scent of alien males whose MHC type is similar or dissimilar to the mate. In all these studies the genetic difference was confined to the MHC, or to the H-2 or Qa:Tla regions of the extended MHC, by the use of congenic mice. The multiplicity of genes concerned, and the high polymorphism of H-2, imply that the MHC may be paramount in the chemosensory marking of individuals according to genotype. The present study was conducted to determine whether MHC-associated odors enable members of one species to identify individuals of another species. A genetic component in the scent of human individuals was inferred by Kalmus in his experiments with identical twins and other subjects tracked by dogs, but no particular genetic locus was implicated. As a step in the study of inter-species chemosensory recognition of individuals by their MHC types, we investigated the ability of trained rats to distinguish the MHC types of MHC congenic mice by the scent of their urine. This was demonstrated with an automated testing apparatus designed for the rat.

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Chemosensory Identity is Altered in Radiation Chimera Mice.

KUNIO YAMAZAKI, GARY K. BEAUCHAMP (Monell Chemical Senses Center), JUDITH BARD, LEWIS THOMAS and EDWARD A. BOYSE (Memorial Sloan-Kettering Cancer Center)*

The Major Histocompatibility Complex (MHC) may be paramount in the chemosensory marking of individuals according to genotype.

The use of cell chimeras permits an approach to the question of whether cells of particular lineages contribute to chemosensory identity. Radiation chimeras are especially favorable because virtually the entire hematopoietic system, but no other, is replaced by donor cells making it easy to prove persistent chimerism. The studies reported here sought to determine whether trained mice would respond to urine odors of chimera mice in a manner similar to their response to urine odors of strains of mice which provided the donor cells to the chimeras. C57BL/6 (B6; H-2^b) and congenic B6-H-2^k male mice were given 864 rads whole body irradiation, and received 40-50x10^6 bone marrow cells and spleen cells intravenously, from syngeneric (control) or hybrid (B6xB6-H-2^k) F_1 donors. Eleven weeks later, they were typed for H-2 by cytotoxicity assay of lymph node lymphocytes to confirm that recipients of F_1 donor cells were in fact of the donor H-2 type. Mice were trained in a Y maze to distinguish the odors of urine samples from the control chimera and chimera panels.

The data demonstrated that chimeric mice had likely acquired the H-2 scent characteristics of the donor, expressing this either exclusively or in addition to the scent characteristic of the recipient strain, and that H-2 differences manifest only in hematopoietic cells are sufficient to confer sensory individuality.

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Gustatory responses of single neurons in the insula of the macaque monkey.

S.YAXLEY, E.T.ROLLS, Z.SIENKIEWICZ AND T.R.SCOTT. (Oxford University, Department of Experimental Psychology, Oxford, England.)

In order to analyze gustatory processing in the primate, the activity of single neurons is being recorded in the macaque monkey (Macaca fascicularis) in regions of the cortex thought to receive gustatory projections. The gustatory stimuli include 1.0mM - 3.0 M NaCl, 1.0mM - 3.0M glucose, 0.01 - 30.0mM HCl, 0.001 - 10.0mM quinine HCl and 20% blackcurrant juice. A population of neurons in the insula with taste responses has been found. Recordings from a sample of 65 of these neurons showed that their tuning to gustatory stimuli was sharper than that of neurons in the gustatory cortex in the frontal operculum, with breadths of tuning (Smith and Travers, 1979) to the four prototypical stimuli 1.0M glucose, 1.0M NaCl, 0.001M quinine HCL and 0.01M HCl, of 0.56 $\pm$0.24 and 0.67 $\pm$0.23 respectively (mean $\pm$sd, $p<<0.001$). The individual neurons were tuned to respond best to different prototypical stimuli (13 to glucose, 16 to NaCl, 4 to quinine, 8 to HCl, 5 to water and 19 to blackcurrant juice (20%)). The mean spontaneous firing rate of these neurons was 2.3 spikes/s, and the mean response to the best stimulus was 21.3 spikes/s. All responses consisted of an increase of firing rate. In 7 separate experiments, it was found that feeding the monkey to satiety with for example glucose did not affect the responsiveness of these neurons to glucose or to blackcurrant juice. These results provide evidence that there is a gustatory cortical area in the anterior insula of the macaque monkey, that tuning here is sharper than in the taste cortex in the frontal operculum, and that hunger does not influence gustatory processing in this part of the taste system.

Smith DV and Travers JB (1979) Chem. Senses 4: 215-229.

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Mechanisms of Enhancement by Nucleotides in Rat Taste Responses to Various Amino Acids.
KIYONORI YOSHII, KENZO KURIHARA (HOKKAIDO UNIVERSITY, SAPPORO 060, JAPAN)

We examined rat taste responses to various amino acids in the prsence of and in the absence of nucleotides by recording neural responses from the chorda tympani. 1) The response to 0.1 M Gly was enhanced when the concentration of guanosine 5'-monophosphate (GMP) in the stimulating amino acid solution exceeded 2 uM while the threshold for GMP alone was about 30 uM, suggesting the enhancement is due to a synergetic effect. 2) Addition of either 0.1 mM GMP, 0.1 mM AMP, or 0.1 mM IMP to stimulating solutions of either 0.1 M Gly, 1 mM Arg, or 10 mM MSG enhanced the responses to each amino acid while the addition of 0.1 mM UMP or 0.1 mM CMP did not, suggesting the purine group plays an important role in the synergetic effect. 3) The addition of GMP enhanced the responses to all the amino acids examined (Ala, Val, Leu, Thr, Ser, Pro, His, Lys, Gln, Asn, Asp, in addition to Gly, Arg, MSG). 4) The concentration response curves for Gly, Gln, Arg, and MSG were measured in the presence of and in the absence of GMP. The addition of 0.1 mM GMP lowered the thresholds for all the amino acids: from about 30 mM to about 3 mM for Gly, from about 5 mM to about 0.5 mM for Gln, from about 0.2 mM to about 0.02 mM for Arg. The degree of the enhancement was decreased with increasing concentrations of the amino acids. In particular, the response to MSG, which reached a saturation levels at about 1 M, was not enhanced by the addition of GMP. 5) Analyses of the concentration response curves according to the Beidler equation suggest that each amino acid stimulates two sites (high and low affinity sites) and that GMP increases the affinities of both sites without affecting the number of the sites.

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A Quantitative Analysis of Sniffing Strategies in Rats Performing Odor Detection Tasks.
S.L. YOUNGENTOB AND M.M. MOZELL (Dept. of Physiology, SUNY-Upstate Med. Ctr.)

Using standard operant techniques and a discrete-trials, go, no-go successive discrimination paradigm, the sniffing strategies of rats performing odor detection tasks were quantitatively analyzed. The animal's sniffing strategies were monitored with a pneumotachograph fitted to a specially designed sniffing port which simultaneously allowed quantitative control of the odorant. The results of this study led to several findings. (1) The rat's sniffing performance was not a stable invariant response pattern, but varied for different odorants, different concentrations of the same odorant, and between air and odor trials. (2) These variations in sniffing behavior appeared to stem from changes in such basic descriptors as volume, duration, average flow rate, peak flow rate and sniff number. (3) Except for the finding that all sniffing patterns began with one or two inspirations, individual sniffing patterns varied with regards to the placement in a bout of inspiratory and expiratory sniffs. Although sniffing patterns followed a general rule of alternating inspirations and expirations, multiple successive inspirations did occur. (4) Comparison of earlier and later sniffs in a bout demonstrated a growth towards a maximum in sniff duration, volume, average flow rate and peak flow rate for both expiratory and inspiratory sniffs. (5) The maximum sniffs generally occurred at or near the end of a sniffing bout. These maximum sniffs were on the average twice the volume of the general population of sniffs, and they represented a major percentage of the total inspiratory and expiratory volumes. (6) The movement of air during a sniffing bout resulted in a large net inhalation. (7) The variations in sniffing behavior emphasize the necessity of giving attention to both the inspiratory and expiratory phases. Inspiratory and expiratory sniffs differed with respect to duration, volume, average flow rate and peak flow rate. In addition, inspiratory sniffs were approximately sinusoidal in shape with their peak flow rates occurring about half way into the sniff itself. Expiratory sniffs were generally irregular in shape with a slower rise in volume and flow rate over a major portion of the sniff followed by a sharper, sometimes spike-like, increment to the peak flow rate, which occurred about 70% into the sniff itself. Supported by NIH Grant No. NS03904.

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The Effect of Airway Resistance on Preceived Odor Intensity
S.L. YOUNGENTOB, N.M. STERN, D.A. LEOPOLD, M.M. MOZELL (SUNY-Upstate Clinical Olfactory Research Center, Syracuse)

Due to a wide range of human nasal anatomic configurations, some people sniff odorants against comparatively high resistances. This study was undertaken to determine the relationship between sniff resistance and olfaction. Since subjects were found to tolerate poorly the placement of blockages in their intranasal airways, our first approximation to study the olfactory effect of resistance was to apply that resistance extranasally. Subjects sniffed ethyl butyrate from a still-air odor generator through a face mask fitted with variable resistances composed of nylon mesh monofilament screens. The mesh size of the screens determined the resistances. The still-air odor generator consisted of a glass tube concentric with an inner perforated stainless steel tube. The space between the tubes was filled with silica gel to which a given amount of ethyl butyrate was adsorbed, yielding a predetermined gas phase concentration in the inner tube. The airflow profile of the subjects' sniffs was monitored by a pneumotachograph fitted to the end of the still-air odor generator. Ten subjects without nasal pathology or complaint were asked to estimate the magnitude of ethyl butyrate at each of 4 different concentrations and against each of 4 different resistances. Each subject was presented with four blocks of the 16 different treatment combinations of resistance and concentration. Analysis of variance showed a significant concentration effect and resistance effect upon perceived odorant intensity. There was no significant interaction between concentration and resistance. As expected, perceived intensity increased with concentration, but, more noteworthy was the finding that perceived intensity decreased with increasing resistance. This finding, together with the lack of significant interaction between concentration and resistance suggests an olfactory analogy to the conductive hearing loss seen with middle ear effusion. Support: NIH Grant NS 19658