speed with which a rat tried to escape an unavoidable shock (50 volts, 0.25 ma) served as an index of pain-motivated escape behavior. There was no difference between the escape speed of the groups treated with the two peptides and that of the group given the placebo (Fig. 3). This finding indicates that the behavioral effect of the two peptides was not attributable to alterations in motor and sensory capacities or to changes in escape motivation.

The effects of ACTH fragments on the behavior of 35 male rats was studied in an open-field test 18 hours after each had been given a single injection of either the D-form or the L-form of the peptide or a placebo. The number of fecal boluses, the number of crossings of squares (10 by 10 cm) on the floor of the open-field, any behavior during which the rats were standing on their hind legs (rearing) and the number of washings, lickings, or scratchings of their own body (grooming) were recorded for 3 minutes. There were no differences between the numbers of boluses, explorations, rearings, groomings, or crossings of the rats treated with ACTH 1-10 (7-L-Phe) and those of rats treated with ACTH 1-10 (7-D-Phe).

We have shown that two closely related peptides, differing only in the rotation of the phenylalanine in the 7th position of the amino acid chain 1 to 10 of the ACTH molecule, alter the rate of extinction of a conditioned avoidance response in opposite ways. The site of action of these peptides must be sought in the central nervous system. Whether they act via autonomic nervous transmission or by a direct influence on nerve cells is not known.

The importance of the role of peptides on behavior has been demonstrated by the observation that transfer of conditioned responses from trained to untrained rats can be induced by the administration of brain extracts from trained rats to untrained ones (*6*). The information bearing molecule appears to be a polypeptide with a molecular weight between 1000 and 5000 (*6*) which is well within the range of the molecular weight of the peptides used in our study.

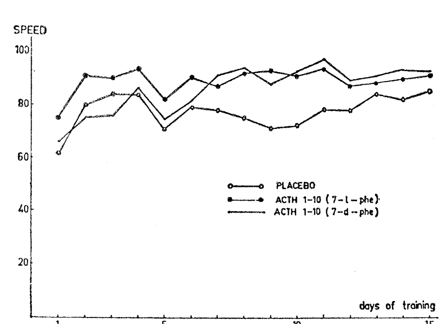

Fig. 3. Effect of ACTH 1-10 (7-L-Phe), ACTH 1-10 (7-D-Phe), and placebo on escape speed (reciprocal of latency) in a runway alley.

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Semiconductor Detectors

The report on the "Application of high-resolution semiconductor detectors in x-ray emission spectrography" by Bowman *et al.* (*1*) must be exciting to everyone who uses x-ray spectrography for chemical analysis. As Bowman *et al.* point out, when the resolution of the x-ray detector is good enough, the diffractor may be omitted from the analytical system with a tremendous gain in simplicity and absolute sensitivity. However, their report seems to leave the impression that the semiconductor detectors have opened up this possibility for the first time. In fact, this method has been used for many years, usually under the name "nondispersive analysis," with the gas-filled proportional counter serving as the detector. For example, nondispersive analysis has already been implemented with gas counters for the various means of excitation mentioned in the report: radioactive sources (*2*), x-ray tubes (*3*, *4*), and electron probes (*5*).

The resolution of gas counters leaves much to be desired, so that analysts have been looking forward to the time when improved semiconductor units would offer substantially better performance even at relatively low quantum energies. It seems likely that the semiconductors will ultimately be quite superior. But there remains the important practical question of the relative merits of the different detectors at the present moment.

A few remarks may help to begin a comparison. For nickel K x-rays, Bowman *et al.* quote a full width at half maximum of 1.3 kev, which is similar to the performance of gas counters. At low quantum energies the gas counters are presently favored by their lesser noise. At much higher energies the semiconductors seem clearly superior in both efficiency and resolution, but in this range one should also consider scintillation counters, which have poorer resolution but are very convenient. One must bear in mind that the capacity to resolve close x-ray lines as visibly separate peaks is no absolute criterion; there may still be severe problems of quantitation at low concentrations, while on the other hand, accurate quantitative analysis may be possible when the pulse spectra are not visibly separate (*4, 5*).

However, the comparison really hinges on factors which are unfamiliar to most analysts because advanced semiconductor technology is not widely known. While gas counters are intrinsically bulky, the semiconductors must be cooled; which system can be maneuvered in general to intercept a larger fraction of the radiation from the specimen? How do the detectors and their electronics compare in reliability, convenience, and cost? I hope Bowman *et al.* will comment on these points, to help us judge if the time has yet come to throw away the gas counters.

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11 April 1966

The purpose of our report was to call attention to the greatly improved performance of semiconductor detectors, particularly in energy resolution, which makes them extremely attractive devices in a simplified x-ray emission spectrograph consisting of a radioactive source of primary radiation and a detector to measure the secondary x-rays. Proportional counters and scintillation counters have been used for this purpose for years and we regret not citing Hall's articles in our report, as well as those of Cameron and Rhodes (*1*), Cook, Mellish, and Payne (*2*), Karttunen and co-workers (*3*), and many others.

Proportional counters have energy-resolving and efficiency characteristics comparable to semiconductor detectors in the range 4 to 15 kev and may have an advantage in sensitivity owing to greater solid angle. But even here recent developments in our laboratory have led to a resolution value of 0.6 kev at 14 kev for silicon diodes, which we believe is better, by a factor of two, than is possible in a proportional counter.

In the 15- to 100-kev range, the line width achieved with proportional counters steadily increases up to 7 kev or higher. Efficiency also drops rapidly, although this can be compensated for somewhat by the use of xenon or high pressure or both. On the other hand, the resolution of the semiconductor detectors is roughly constant (in kev) over the same energy range. The resolution of our original silicon diode system rose 1.1 to 1.5 kev in the 4- to 40-kev range. The germanium semiconductor system gave 1.1-kev resolution at 80 kev. With more recent developments these figures are much lower. Counting efficiency remains $>$ 50 percent over the entire 4- to 100-kev range; the exact values depend on the thickness of the depletion layer.

It may also be worth pointing out that the semiconductor detectors do not have the escape peak effect which complicates the spectrum obtained in proportional counters in some cases. The small size of the semiconductor detectors is a disadvantage which can be compensated for somewhat by designing the apparatus for close placement of source and detector. Future developments may well lead to greatly increased detector dimensions.

The necessity to cool the detector is an inconvenience but has proved to be a minor one in laboratory use. Scintillation counters are convenient when limited energy resolution is sufficient but are not competitive when high resolution is required. Over the past 3 years there has been a substantial shift from scintillation counters to solid state detectors in the field of nuclear spectroscopy. Our laboratory has participated actively in these developments, and we are convinced that the tremendous gain in energy resolution more than offsets the inconvenience of the cooling system. The demands of nuclear spectroscopy have also stimulated great improvements in stability and performance of electronic amplifiers and pulse height analyzers. The availability of this equipment from many manufacturers should facilitate the rapid introduction of semiconductor systems in x-ray analysis.

This short statement cannot cover all the manifold complexities of x-ray analysis. Certainly proportional counters will remain useful in many applications for years to come. However, we retain our original enthusiasm that the combination of high resolution and efficiency over the entire range of x-ray energies plus convenience, compactness, reliability, and stability make the semiconductor detector extremely attractive for use in an x-ray emission spectrograph.

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23 May 1966

Divers' Communications Improved

Underwater communication by voice between divers and between diver and surface, whether transmitted by cable or through the water, has been inadequate because of the respiratory noises and distortions of speech associated with the use of air-conduction transducers in face masks. When a mouthpiece is used for breathing, speech is even less intelligible. The use of standard air-conduction techniques with earphones is unsatisfactory because covering the ears with earphones interferes with the equalization of pressures on opposite sides of the eardrum and with detection of sounds from the environment. Voice communication between diver and surface is made effective by the use of a system in which bone-conduction transducers are utilized.

In quiet environments one transducer attached at either the forehead, top of the head, or back of the head (these sites are in order of decreasing effectiveness) is adequate for both talking and listening. For environments in which there are high levels of noise (100 db or higher), two transducers, one located on the upper lip for talking and the other located on the mastoid for listening, provide adequate transmission and reception.

The transducers, used with a full-face mask and a cable system, work well at 12-m depths in water and in simulations of 90-m depths in a compression chamber. Since in the water other divers within about 30 cm of the diver wearing the transducer also can hear the transmission from the surface, it seems probable that hearing is accomplished through both bone- and ear-conduction.

While it achieves adequate speech intelligibility, use of the bone-conduction transducers also allows the diver to hear sounds from his surroundings. Moreover, voice communication is possible while one uses mouthpiece-breathing equipment; speech is relatively unintelligible but, with adequate training in speaking and the use of a a "restricted" vocabulary, low-fidelity communication can be effected; and with the diver "on transmit" his breathing is audible and can be monitored at the surface.

This development was based on data obtained during investigation in my laboratory of the bone-conduction of sound and on the results of tests carried out jointly with the Personnel Research Unit of the Royal Canadian Navy at the Institute of Aviation Medicine, Toronto. I understand that the Royal Navy uses an underwater communication system for divers that employs a similar technique. This is Defence Research Medical Laboratories technical note 633.

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