over minutes and perhaps even hours or days (*3, 4, 7*). The discrepancy between our results and those of Chorover and Schiller (*2*) and Quartermain *et al.* (*1*) may be related to different species used (rats versus mice) or to the intensity of the punishing shock. There is a suggestion in the data of Chorover and Schiller (*2*) that a retrograde amnesic effect may have been produced by ECS administered 30 seconds after foot shock when the duration of the punishing shock was diminished to 0.5 second.

Beyond 1 hour the gradient appears to level off and differences between groups that received ECS 1 and 6 hours after the learning trial versus unconvulsed animals may be due to a proactive disinhibitive effect of the ECS on retrieval test performance. The time course of proactive disinhibitive effects of ECS cannot be determined from the present results.

In order to check the possibility suggested by Chorover and Schiller (*5*) that ECS effects obtained after long delays might be due to an action on a generalized CER established in the course of the learning trial, we examined the generalizability of the punishment. A group of animals was trained in the apparatus in the usual way, except that upon stepping into the inner compartment they were immediately removed and put into a small restraining device, an electrode was applied to the base of the tail, and a strong electric shock was administered (800 volts a-c through 40 kohm in series causing approximately 2.5 ma r.m.s. ± 30 percent to flow through the animal for 0.8 second). Under these conditions all animals squeaked and appeared to experience intense pain. It can be seen in Table 2 that group B, which received such a strong punishment outside the box, showed retest latencies that were essentially the same as those of unpunished control animals (group C) and were significantly lower ($p < 0.005$) than those of animals shocked in the box (group A). This indicates that the mice discriminated the stimuli of the avoidance situation and it implies that ECS lowered retest latencies by producing retrograde amnesia to a well-discriminated painful experience.

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22 April 1966

Insulated Gate Field Effect Transistor Amplifier

Rapid progress in semiconductor technology has made available devices that are well suited for use in specialized types of biological instrumentation. Junction gate and insulated gate field effect transistors (FET's) are examples of such devices, and each can be used in simple amplifier and other circuits that feature high input reactance, relatively low noise, and high gain (see *1*).

An inexpensive, miniature d-c electrometer-type amplifier was designed and built with the newest of these commercially available devices, the insulated gate field effect transistor (IGFET). Its characteristics make it especially useful for recording small biopotentials through high-resistance microelectrodes. The IGFET amplifier circuit (Fig. 1), its specifications, and some comparisons with other amplifiers are presented here.

The amplifier is 4 by 4 by 2 cm (another unit is a little larger than a cigarette), costs $36, and took 4 hours to build with standard components. The circuit uses an unbiased IGFET as the input stage which, although simple, still allows linear amplification of large (1 to 2 volts) or small (50 μv) positive or negative signals. This is not possible with other types of transistors.

The overall gain is 15 and it is developed in the first stage for maximum signal-to-noise ratio. Gain can easily be increased to 100 or more with a few simple component changes. Input resistance is 10^{13} ohm, output resistance is 6 kohm, and uncompensated input capacitance is between 1 and 4 picofarads. Input equivalent noise is about 2.5 db at 1 kc/sec with an input resistance between 4 and 10 Mohm. Although this noise figure is slightly higher than that of many IGFET's and "low-noise" conventional transistors, it is unique in that it occurs in the resistance range of microelectrodes that are used in many types of electrophysiological experiments.

The amplifier stages are directly coupled with simple resistor networks, and only two power sources are used. The latter should be mercury batteries for minimal long-term drift. Input

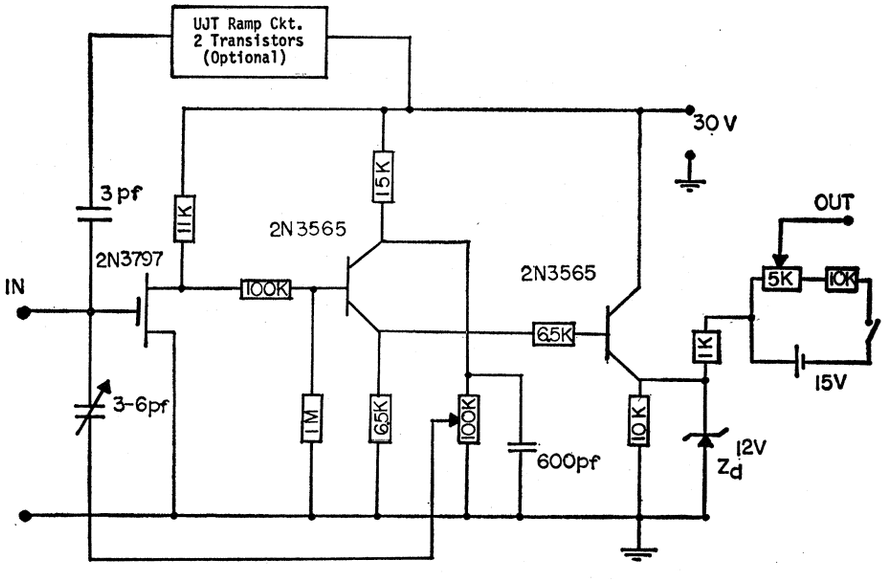

Fig. 1. Schematic diagram of the IGFET amplifier. For resistance values, $K = 1$ kohm. The UJT ramp circuit is used to check electrode resistance *in situ*. The 2N3565 are low-noise transistors operated at unity gain. Negative capacitance compensation is provided by the variable capacitor.

equivalent d-c drift is 5 mv/hr (maximum) and the temperature coefficient of d-c output voltage is 1 mv per degree Celsius. A negative capacitance circuit is provided which improves the overall frequency response of the amplifier but unavoidably adds noise to the input signal if large stray capacitances are compensated. Signals of 40 μv through 7 Mohm (microelectrode in saline) can be faithfully reproduced.

The amplifier has been tested in physiological experiments in which microelectrodes (0.5 to 3 μ) were used to record resting and action potentials (extracellular) from neurons in frog spinal cord, chicken cerebellum, isolated monkey brain (*2*), and nerve fibers in vitro. The IGFET amplifier gave consistently better overall results than a variety of commercial electrometer amplifiers (vacuum tube and transistor types) that were used to make the same measurements.

Many other applications for this device and simple associated circuits have already been found. I believe the unusual features of this amplifier make it suitable for routine use in many types of research; it seems to answer the needs of large laboratory instruction classes where 10 to 20 amplifiers are needed and the cost of commercial devices is prohibitive.

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25 July 1966

"Neutral Hydrogen Survey of Andromeda Galaxy": Addendum

Edward Argyle (*1*) has called our attention to the fact that van de Hulst, Raimond, and van Woerden (*2*) postulated the existence of a neutral hydrogen ring in M31 in their article published in 1957. We regret that we (*3*) did not point this out in our report. Their inference, however, was based on peaks found along only a single axis through the ring. Roberts' survey (*4*) was the first to be made, in a nearly continuous manner over much of the galaxy with sufficiently high resolution, to demonstrate clearly this ring structure and the marked deficiency of neutral hydrogen inside. Our survey (*3*) confirmed this result and was the first to delineate the ring completely around the nucleus.

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22 August 1966

Phyletic Position of Tree Shrews

Although much of the recent evidence on the taxonomic position of the tree shrew argues strongly against including the Tupaioidea in the Lemuriformes, the new findings still fail to establish whether or not the tree shrews are closer phyletically to Primates than to any other extant mammalian group. If the Tupaioidea diverged from the Primates very early in the evolution of the Primates, the tupaiids would show hardly any more affinities to the recent groups in the rest of the Primates than to the extant members of any other mammalian order. The data reviewed by Campbell (*1*) emphasize the distinctiveness of the tupaiids rather than their relatedness to either primate or insectivore types.

Campbell suggests that the extensive visual system in tree shrews and primates may have resulted from convergent evolution. It is of interest that serological studies on primate lens proteins reveal pronounced affinities among lorisoid, tarsier, and higher primate lenses. However, these studies demonstrate divergence of tree shrew lens proteins from those of primates comparable to that between lens proteins of non-primates and primates (*2*).

The serological data on serum proteins, gathered since the Burg Wartenstein conference on Classification and Human Evolution, further emphasize the distinctiveness of the tupaiids. Antiserums produced in rabbits to hedgehog serum and to tree shrew serum, while yielding strong homologous reactions, yield very weak reciprocal cross-reactions and unlike the chicken antiserums fail to detect any special correspondence between tupaiids and erinaceoids. Indeed, the precipitins to albumin in the antiserum to tree shrew serum develop larger cross-reactions with human albumin than with hedgehog albumin and the other nonprimate albumins tested (*3*). Thus the original data (*4*) obtained with chicken and rabbit antiserums to human albumin, and confirmed by Hafleigh and Williams (*5*) suggesting that *Tupaia* has serum albumin more like that of primates than insectivores, is now directly demonstrated.

The data of Dr. B. H. Hoyer, cited by Campbell, on the homologies of polynucleotide sequences as judged by competition of various primate and nonprimate DNA fragments with those of humans are compatible with the possibility that the Tupaioidea branched off from the base of the Primates. If they did, they should not be expected to show much more relatedness to man than would the nonprimate mammals. Thus the value of 28 percent competition for tree shrew DNA compared to 20 percent for nonprimate mammalian DNA's might prove to be highly significant.

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Surveyor I Location

By attempting to correlate the positions of summits of lunar hills, situated beyond the horizon of Surveyor I, with features given on the Aeronautical Chart and Information Center map of the area, Jaffe *et al.* (*1*) derive a loca-

Table 1. Surveyor landing sites.

Derived from	Site	
	South latitude (deg)	West longitude (deg)
Photo correlation	2.57 ± 0.02	43.34 ± 0.02
Tracking data	2.49	43.32