

refers to the Republic florule as Oligocene. The present evidence would suggest that the Republic florule is Eocene in age.

In terms of age, the Princeton and Tranquille floras are synchronous with that from the Green River formation of Wyoming and Colorado. However, there appears to be a fairly large discrepancy in the floral composition between the two. This is not surprising, inasmuch as there are some 4½° of latitude between the two, together with unknown ecological and physiographical differences. The discrepancies in floras point out the continuing need for fundamental research on the extent of the effect which latitude, altitude, mountain barriers, climate, and other factors had on synchronous but geographically isolated floras of the Tertiary.

It is intended that the present program of potassium-argon dating should provide the basis for relating future paleontological and stratigraphical investigations. With several critical horizons now well established, it will be much easier to relegate more accurately many other sedimentary and volcanic series to the stratigraphic column. This, in turn, will greatly enhance our knowledge of the history of the Tertiary period in western North America (8).

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Effect of Electroconvulsive Shock on an Extinguished "Fear" Response

Abstract. To test Gellhorn's hypothesis that electroconvulsive shock reinstates extinguished responses, a conditioned "anxiety" response was established and then extinguished in rats. A series of treatments did not restore the extinguished "anxiety" response; in fact, control animals showed appreciable spontaneous recovery of the "anxiety" response while treated animals did not.

Studies reported by Gellhorn (1), and a later investigation by Hamilton and Patton (2), have shown that convulsions produced variously by Metrazol, insulin, or electroshock would reinstate previously inhibited (extinguished) conditioned responses. In these studies animals were trained to avoid shock by jumping from one compartment to another of a double grill box upon presentation of an auditory stimulus. The avoidance response, which was extinguished by means of a series of non-shock trials, reappeared after convulsive therapy.

Griffiths (3) later replicated this finding by using treadmill running to induce convulsive seizures. On the assumptions that the avoidance behavior in these studies was motivated by "fear" and that the effect of withholding the shock following acquisition was to extinguish a conditioned "fear" response, Griffiths inferred from his results that convulsions tend to reinstate the extinguished "fear."

The present study was intended as a test of this inference by a technique which was first described by Estes and Skinner (4). In this situation thirsty animals are trained to press a lever for a water reward; the fear response is then superimposed on the lever-pressing responding by pairing an auditory stimulus with a shock during the lever-pressing session. The "fear" response appears as a perturbation in the lever-pressing curve, accompanied by crouching, immobility, and usually defecation.

Twelve male albino rats, 60 days old at the start of the experiment, served as subjects. All animals were deprived of water for 48 hours. They were then placed in modified Skinner boxes in which they learned to press a lever, first for regular, and then for aperiodic, water reward. All sessions were of 8-hour duration and were run on alternate days. Animals received no water except that obtained in the experimental boxes.

The "fear" response or conditioned emotional response was superimposed on the lever-pressing habit as follows. While the animals were lever-pressing, a clicking stimulus was presented for

3 minutes and terminated contiguously with the delivery of a painful electric shock (1.5 ma) to the animals' feet. All animals received such conditioning trials every 20 minutes through the 8-hour session. Not all of these trials, however, were shock-reinforced during the 8-hour session. Only 50 percent of the conditioned stimuli were paired with the shock, in a mixed order.

The conditioned emotional or "fear" response, characterized by suppression of lever-pressing, piloerection, urination, and defecation was quantified in the following manner. A record was kept of the number of lever responses made by the animal in the 3-minute clicker period and the 3-minute period preceding the clicker. The magnitude of the "anxiety" response was measured in terms of a suppression ratio which was computed by dividing the number of responses made during the 3-minute clicker period by the number of responses made during the 3-minute period just preceding the clicker onset. Complete cessation of lever responding during the 3-minute clicker period yields a ratio of 0 and is taken to indicate a well-developed "fear" response. Unchanged output during the clicker yields a ratio of 1.00 and increased output a value greater than 1.00. Mean suppression ratio values were calculated for each 8-hour session for each animal. Animals received such conditioning trials for 23 successive days at which time all showed marked suppression of lever responding during the stimulus period.

The extinction procedure was the same as that during conditioning except that the shock was omitted. This procedure was maintained for seven successive days until the suppression ratio values for all animals approximated a value above .90.

Animals were then divided into experimental (six animals) and control (six animals) groups. The experimental animals were given 21 electroconvulsive shock treatments administered three per

Table 1. Suppression ratio values for the last conditioning session (I), the last extinction session (II), and the first trial of the recovery test after electroconvulsive shock (III).

Rat No.	I	II	III
<i>Treated group</i>			
AD 1	0.37	0.98	0.49
AD 5	.08	.84	1.00
AD 6	.16	.92	0.82
AD 10	.06	.91	.80
Mean	.17	.91	.78
<i>Control group</i>			
AD 4	0.15	0.72	0.06
AD 7	.37	.87	.00
AD 8	.12	.97	.00
AD 9	.06	.99	.02
AD 11	.05	.93	.04
Mean	.15	.90	.02

day for 7 days; the control animals were left undisturbed in their home cages. All animals were given free access to food and water during the treatment period.

After treatment all animals (5) were deprived of water for 48 hours and then tested. The test procedure consisted of an 8-hour run with nonshock-reinforced presentations of the clicker every 20 minutes during the session.

As is shown in Table 1, all animals had low suppression ratio values on the last set of conditioning trials, indicating a high degree of acquisition of the "fear" response. On the last extinction session, suppression ratio values for all animals approached 1.00, indicating recovery of lever-pressing during presentations of the clicker stimulus. After the electroconvulsive shock period, however, clear differences are evident between the treated and the control animals on the first trial of the test session (6). Lever responding by all of the control animals was almost completely suppressed in the presence of the auditory stimulus, which was indicated by suppression ratio values ranging from .02 to .06. All treated animals, on the other hand, continued to press the lever during the stimulus presentation, as is reflected in the suppression ratio values which range from .49 to 1.00.

These results are in accord with previous findings (7, 8) which demonstrated that electroconvulsive shock would virtually eliminate a "fear" response of the type described in the present experiment. In fact, to the extent that the "fear" response is spontaneously recovered during the time interval of the treatment period (and the present findings indicate that this is considerable), this study is essentially similar to the studies of Brady *et al.* (7) which did not involve an extinction phase prior to administrations of electroconvulsive shock.

The present findings that electroconvulsive shock treatments do not reinstate extinguished "fear" responses appear to be in direct conflict with the findings of Gellhorn. This apparent conflict may result from the possibility that electroconvulsive shock treatments have at least two effects. One effect is to attenuate "emotional" responding. The second effect, suggested by observation of behavior following electroconvulsive shock, is to produce hyperirritability, which is manifested primarily in easily elicited and high-amplitude startle reactions. That this effect of electroconvulsive shock will facilitate avoidance responding of the kind studied by Gellhorn seems to be indicated by the results of a study by Gellhorn and Minatoya (9). These investigators reported: "A partial conditioning leading to an

average of only 20% positive responses in the control group causes 82% conditioned responses in the experimental group subjected to two hypoglycemia during the training period."

In the light of this evidence, and in view of the present findings, it would seem that convulsions do not reinstate extinguished responses in any general sense.

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Possible Effect of Lethal Visible Light on Year-Class Fluctuations of Aquatic Animals

Abstract. Visible light killed the eggs and developing embryos of brook and rainbow trout. It is hypothesized that light could kill the eggs and embryos of all aquatic vertebrates and invertebrates. Adaptations minimize but do not completely block this lethal effect. Under some circumstances, visible light could cause heavy mortality in a new year-class of an aquatic animal.

Eggs of the brook trout, *Salvelinus fontinalis*, stripped from fish at the New York State hatchery at Cold Spring Harbor in November 1959 and retained in the hatchery troughs, suffered an unusually heavy initial mortality, estimated at over 90 percent, in contrast with a usual mortality for such an operation of about 10 percent. Experiments proved that the visible light from 40-watt cool-white fluorescent bulbs was responsible.

Similar results were reported by Handorf (1) with another species of salmonid, the rainbow trout, *Salmo irideus*. Handorf also found that the various components of white light showed a differential lethal effect on the fertilized eggs and embryos. The violet

and blue bands were highly lethal, while the green, yellow, and orange bands were progressively less lethal and of a much lower level of lethality. A greater resistance to the lethal effect of all bands of visible light was exhibited by the more intensely colored yellow eggs than by the paler eggs.

In nature, salmonid eggs are shielded from the light by the loose gravel of the stream bottom on which they are laid and with which they become covered during the spawning process. Also in nature, salmonid eggs are normally of a more pronounced yellow color than is usual with the eggs of hatchery fish. In the hatchery, it has been proved that direct sunlight kills salmon and trout eggs in a few minutes, while indirect daylight increases the mortality of eggs and embryos of the sockeye salmon (2). Although the lethal effect of direct sunlight might have been due to ultraviolet rays, the subdued indirect light entering a hatchery would be devoid of ultraviolet rays, and the increased mortality of the eggs and embryos must be attributed to natural visible light.

On the basis of these findings, it is hypothesized that visible light is potentially lethal to the fertilized egg and developing embryo of all fishes, other aquatic fishlike vertebrates, and aquatic invertebrates. However, through adaptive changes in the structure of the body and behavior of the adults and in the structure of the fertilized egg and embryo, the lethal effect of visible light has been minimized, at least under normal conditions. Obviously in ovoviviparous forms, the abdominal wall and the often heavily pigmented, coelomic lining shield the fertilized egg and embryo from the deleterious effects of light.

In oviparous forms, the spawning habits of the adults help to protect the eggs and embryos from the lethal effects of light. A large number of fishes and aquatic invertebrates spawn during periods of the year when cloudy, windy, and rainy weather predominates. Such weather conditions, by increasing the turbulence and turbidity of the water, reduce the penetration of light. Also, most fishes and aquatic invertebrates spawn in the littoral and sublittoral zones. Here, submerged and floating algae in salt water, and vascular plants and algae in fresh water, together with suspended matter including phytoplankton, filter out the more lethal violet and blue components of light and permit the greatest penetration of the less lethal green light (3). In the shallower waters of the littoral zone and in some lakes and streams, plankton and organic stains color the water to such an extent that only orange or red light, of low lethality, penetrates.

In addition to this general adaptive