It is slightly lighter than paraffin at the latter's melting-point and when the specimen sinks, as described earlier, it remains floating on the paraffin. Xylene, on the other hand, is heavier than melted paraffin and sinks with and surrounds the specimen. There is an additional advantage in the use of butyl alcohol as slight traces of it in the paraffin blocks do not render them crumbly as does a like amount of xylene.

Butyl alcohol does not harden wood, and its use makes the higher concentrations of ethyl alcohol unnecessary. Any wood that can be sectioned green may be sectioned in paraffin if dehydrated, cleared and embedded as described above. Thus it is possible to get thin, smooth sections of the soft cambium and phloem even if hard xylem elements occur in the slices. Woods as hard as hickory (*Carya ovata*) and locust (*Robinia Pseudo-Acacia*) have been sectioned satisfactorily. The fine cytological details which can be investigated by this technique are destroyed by the prolonged hydrofluoric acid treatment, a necessary concomitant of the colloidin technique. However, butyl alcohol does not soften wood which has once been hardened by fixation, by drying, or by a too rapid dehydration, and all such material should be prepared for sectioning in other ways.

The simplicity of the butyl alcohol method, as pointed out by Larbaud, makes it preferable for other plant organs: buds, leaves, root-tips, etc. It is much quicker than the ethyl alcohol-xylene technique.

CONWAY ZIRKLE
ARNOLD ARBORETUM AND BUSSEY INSTITUTION
HARVARD UNIVERSITY

SPECIAL ARTICLES

GEOLOGICAL EVENTS IN THE HISTORY OF THE INDIO HILLS AND THE SALTON BASIN, SOUTHERN CALIFORNIA

THE landward extension of the long depression occupied by the Gulf of California has experienced a very eventful history during Tertiary time. In the course of an investigation of the Indio Hills, now in progress, several facts of geologic significance have been discovered.

The trough, extending northwestward for nearly three hundred miles from the head of the gulf, was formerly known as the Colorado Desert. Its topographic subdivisions, in order from the gulf northwestward to its head at San Gorgonio Pass which leads into the coastal portion of Southern California, are the Colorado River delta or alluvial cone, Imperial Valley, Salton Sink or Salton Sea, and Coachella Valley. It is flanked on the west throughout much of its length by high mountains, rising to a maximum height of about 10,000 feet; it sinks to about 275 feet below sea-level beneath the recently formed freshwater Salton Sea. Tertiary marine and continental sedimentary formations outcrop at various places along the margins and bottom of the trough and yield clues to its origin and geological history.

The area of these deposits which we are studying, known as the Indio Hills, lies north of Indio, in central Riverside County. A similar neighboring area to the southeast, known as the Mecca Hills, is being investigated by Mr. Hampton Smith.

The Indio and Mecca Hills trend northwest-southeast, and lie end to end. Each of the two areas measures about twenty miles long by two to six miles wide, and together they extend most of the distance from the Salton Sea to the northwest end of the Coachella Valley. They occupy a position parallel to and only slightly northeast of the median line of the broad depression. The hills rise about 1,000 feet above the plain and in the very arid climate exhibit a magnificent badland topography.

Our investigation is part of a broad program of Tertiary history studies initiated by Dr. John C. Merriam and sponsored by the Carnegie Institution of Washington.

1. We find that the upper part of the Indio Hills block is constituted of two formations. One of these is marine and is doubtless the correlative of the Carrizo formation, named by W. S. W. Kew[1] with type locality on Carrizo Creek, southwest of Salton Sea. It outcrops in the Indio Hills as small areas at several localities both east and west of the mouth of Thousand Palms Canyon and in the northern part of the hills. It consists of yellow clays with some sandstone and conglomerate. Its age was determined as upper Miocene by Ralph Arnold[2] and as lower Pliocene or younger by T. Wayland Vaughan.[3] The formation, containing a fauna related to that living in the Gulf of California and very distinct from the west coast invertebrate assemblages of California, records an invasion of the Gulf of California over the Indio Hills block. This incursion has been determined by other workers to have extended almost to San Gorgonio Pass.

The second formation is several thousand feet thick and consists entirely of arid-climate, terrestrial de-

1 "Tertiary Echinoids of the Carrizo Creek Region in the Colorado Desert," Univ. Calif. Publs., *Bull. Dept. Geol.*, 8: 2, 1914.
2 U. S. Geol. Surv. Bull. 396, p. 44, 1909.
3 U. S. Geol. Surv. Prof. Pap. 98, p. 369, 1917.

posits. Clays, probably playa deposits, arkosic sandstones and fanglomerates with considerably worn fragments form in sub-equal thicknesses nearly the entire exposed section in the hills. For this areally and stratigraphically important set of rocks the name Indio formation is proposed, its type section being taken along a northeast-southwest line through the Indio Hills about two miles northwest of Thousand Palm Canyon.

The Indio formation is part of the comprehensive Mud Hill Series of Free,[4] which includes all the Cenozoic strata of the region, both marine and continental. The marine portion was, as indicated, separated in 1914 as the Carrizo formation by Kew.

2. At all localities the Indio formation overlies the Carrizo formation. Considering both the striking difference in the nature of the sediments and in their mode of deposition the Indio is probably unconformable on the Carrizo.

3. We have secured no fossil material in the Indio formation, but its stratigraphic relations to the Carrizo formation on the one hand and the well-indurated character of the Indio formation on the other indicate a probable age not greater than middle Miocene and not less than lower Pliocene; in short, approximately middle Neocene.

4. The San Andreas fault, heretofore thought to skirt the northeast margin of the hills, has recently been located quite independently by Dr. Levi F. Noble in the course of his elaborate study of that important structural feature, and by us. It crosses the northwest end of the hills obliquely and then follows the southwest base.

5. Structurally the hills are strongly folded, and our mapping of axes indicates that the folds are not parallel to the margins or trend of the hills but strike somewhat more westerly so that they are cut off obliquely on the west by the bordering San Andreas fault. An interesting but as yet somewhat speculative inference from the trend of the folds is that while the initial and earlier movements on the San Andreas fault in this region may have been due to forces acting roughly parallel to it, the folding and more recent movement on the fault—northwestward shifting of the southwestern block relative to the northeastern—have probably been caused by forces acting from the south and at a considerable angle to the fault. It is quite possible that the eastward swing of the San Andreas fault in the Indio Hills region is related to the shortening across the Indio Hills block indicated by the folding. The above explanation for the folding of course relates the folding and the San Andreas faulting as to date; this is plausible, for while the folding occurred some considerable time ago, as indicated by the deep erosion of the hills, the San Andreas fault, though now active, is also known to have suffered movement intermittently far back in Tertiary time.

6. In a number of references, including a recent text-book, the Salton Basin is asserted to have been occupied so recently by the Gulf of California that it was separated from it by the building of the Colorado delta or alluvial cone. It appears to us much more probable, however, that the depression below sea-level of the present Salton Basin has occurred during or since the building of the delta or cone, not before, and long after the last invasion by the sea.

The possibility of concurrent depression and delta building, as contrasted with pre-delta depression, was first pointed out and discussed by Free[5] but not urged, probably because at that time less information was available regarding the age and structural relations of the formations.

The belief that the depression of the basin and the delta or cone building were contemporaneous and that the delta did not cut off an arm of the sea is based upon the following considerations.

(*a*) The delta or cone of the Colorado River is relatively young geologically, probably Quaternary in age, since it was superposed as a feature upon a landscape which already resembled the existing one, although not identical with it. The lowest line across the cone along which the sea might enter the Salton Basin, along the intersection of the west slope of the cone and the west wall of the basin, rises to only about thirty feet above sea-level. Hence, under the old view, the basin would have been connected with the gulf until the last or upper thirty feet of the cone was added. This fact coupled with the youthfulness of the cone would make the latest presence of marine or brackish waters an event of Recent or Quaternary time. But while deposits of a relatively recent fresh-water lake fed by the Colorado are excellently exposed in the basin, no marine beds of sufficiently late age or bearing expectable relations to the topography and to the sea-level contour have been anywhere encountered by the writers in journeys about the basin nor are such reported in the literature.

(*b*) While terraces referable to the recent fresh-water lake are conspicuous, no marine terrace or strand has anywhere been noted by the writers nor have such features been recorded by others.

(*c*) The marine strata in the basin—the Carrizo formation of Miocene or lower Pliocene age—are much older than the Colorado cone.

(*d*) The position of the marine strata hundreds of feet above sea-level and the fact that they are strongly

[4] Carnegie Institution of Washington, Publication 193, p. 23, 1914.

[5] Carnegie Institution of Washington, Publication 193, pp. 25–29, 1914.

folded and beveled by erosion indicate that they were not deposited during an occupation of the present basin by the sea but in an earlier depression of considerably different form, and long before the present basin was formed.

(*e*) The strongly folded and erosionally beveled Indio formation records a long interval of continental deposition, deformation and degradation between the deposition of the underlying marine Carrizo and the development of the landscape which truncates the Indio and on which the Colorado cone—heretofore regarded as the dam which cut off the sea—was built.

(*f*) The very late date for the depression of the Salton Basin below sea-level is made the more probable by abundant evidence of recent movement in the form of very young fault scarps cutting alluvial fans and occasional earthquakes.

It might at first sight appear somewhat improbable that, in a sinking trough, the Colorado should maintain a cone now only about thirty feet above sea-level at its lowest point and yet high enough continuously to exclude the gulf out of the area sinking below sea-level to the northwest. But only two alternatives were possible if the floor of the trough sank from above to below sea-level: either the river was or was not able to upbuild its cone as rapidly as the floor subsided tectonically and to maintain it as a dam. The size of the stream, its unusually heavy burden of sediment and the 125-mile extension of the cone which it has built southward to the head of the gulf give ample ground for believing that the river would be able to cope with the sinking of the trough and maintain the dam. If any part of the cone sank, through tectonic movements, somewhat below the normal grade line of the river, which was necessarily always above sea-level, that portion would soon be built up again during one of the frequent swings of the river down the different radii of its cone.

That the salt in the bottom of Salton Basin was in all probability derived from the evaporation of Colorado River water and not from a cut-off arm of the sea has been shown by W. H. Ross.[6]

In the light of our observations and present recorded knowledge we consider it highly probable that, instead of being a cut-off and desiccated arm of the Gulf of California, the present Salton Basin sank below sea-level while the Colorado River excluded the gulf by maintaining a dam in the form of a huge alluvial cone across the southern portion of the basin.

JOHN P. BUWALDA
W. LAYTON STANTON

BALCH GRADUATE SCHOOL OF
THE GEOLOGICAL SCIENCES,
CALIFORNIA INSTITUTE OF TECHNOLOGY

[6] Carnegie Institution of Washington, Publication 193, pp. 45–46, 1914.

SEX GLANDS AND ADAPTIVE ABILITY[1]

THE purpose of our investigation[2] was to determine the relation between sex glands and adaptive ability. As the first of a series of experimental reports, the present paper deals with the effect of castration upon problem box and maze performances by the white rat. The term castration is used here in its narrow sense, meaning extirpation of the testicles of male animals. It does not include ovariectomy of the female, which will form the subject of a separate experiment.

As soon as time permits, we shall attack the same general problem by studying the effects of heat, X-ray, vitamin E deficiency, testicular elevation and the ligation of vas deferens. Some of these experiments are now in progress. Besides these, we plan to study the effect of injection of testicular extracts as well as the effect of feeding interstitial tissue. These two problems will be studied along with implantation and transplantation with reference to such questions as organotherapy and rejuvenation.

The maze and the problem box were used in our experiment because they offer two widely different problematic situations to our animals and at the same time represent the best recognized technique we have in comparative psychology. White rats were chosen as our subjects. In the future, we hope to repeat our experiments on higher animals such as dogs, monkeys, etc.

Twenty-seven male rats were used in our original experiments. They were of approximately the same age and body weight. All of them had learned Maze A in an earlier experiment. Operation was performed at the age of about five months. Twelve rats had both of their testicles removed (total castration), eight had only one testicle removed (semi-castration), while the remaining seven were put through a sham operation without being castrated, that is, an operative control. Preliminary feeding was given once daily for one week, after the operation, at the center of a single-platform problem box. Six of the totally castrated rats and the seven control animals were tested in the morning, while the other six totally castrated and the eight semi-castrated ones were left for the afternoon. Each animal was confronted with the problem box situation once daily for four weeks. Bread and milk were used as the incentive. Time was the only criterion that could be employed. It was taken with a stop-watch. The results for the problem box experiment are presented in Table I.

These data on the problem box experiment justify the following statements.

[1] Read before the Ninth International Congress of Psychology held at New Haven, Connecticut, September, 1929.

[2] The author expresses his sincere gratitude to Professor Harvey A. Carr for kind aid and interest in this research.