a component of this thrusting there was a vertical uplift of the plateau, due mainly to shearing in the mechanical zone.

The island of Cyprus, in the eastern Mediterranean, Willis found to be of especial interest to him who seeks horizontal forces. Three main structural elements are found in the island; in the north an east-west range of mountains; in the south a higher and broader range, and between them a central plain or lowland. The northern range includes Cretaceous Oligocene sediments, folded and faulted. The central lowland is of tilted and beveled Miocene shales and limestones, overlain unconformably by the horizontal Pliocene. In the Miocene sediments at the foot of the northern range, there is a marvelous exhibition of crushing. The southern massif is the famous Mt. Troodos, the old Olympus of Greek mythology. It is a mass of hornblendic igneous rock, an old plutonic mass, now gneissic.

There has been a thrusting from the north, so that the northern mass has been moved southward. There are no faults in the Miocene central plain except normal faults due to tension. The Miocene dips northward off the northern flank of Mt. Troodos at about 15 degrees, and the rocks have been stretched. The upland of Mt. Troodos is a smoothly rolling mature-land, and on it the ancient Miocene shoreland is approximately indicated by a longitudinal valley, high up on the flank of the mountain, where, banked in by the former cuesta front of the Miocene, a subsequent river has cut a trench into the crystallines of the Troodos massif.

This old shore-line indicates that there was a vertical movement of Mt. Troodos, probably as much as four thousand feet, while twenty miles to the north there is a great overthrust. Here, therefore, is another example of vertical movement in connection with great horizontal compression. The great movement came from the north and was deep-seated (the overthrusting of the northern range is only a shallow expression of it) and as a result of the development of gneissic structure in the Troodos mass in response to the horizontal compression, the southern part of the island was considerably uplifted.

In response to questions on the Cyprus mass, Willis said that he thought that the movements were still going on in Cyprus, of which the recent destructive earthquake of Salamis is testimony. This raised the question of the cause of destructive earthquakes. Willis stated that in his opinion such earthquakes are not the result of slight movements on normal faults, but rather the elastic spring of rocks, from the energy stored up in them through years of compression.

Willis stated that he thought the thrusting upward of a piston of crystalline rock, like that at Mt. Troodos, with a drag along the side of the piston, and consequent removal of material from beneath the contingent areas of the lee side, away from the side of active horizontal pressure, is the cause of subsidence, and the formation of geosynclines.

A lively discussion by Professors Lane, Daly, Terzaghi, Collet, Morris and Dr. Boydell followed Professor Willis's address.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE USE OF THE X-RAY IN BIOLOGICAL INVESTIGATIONS

Though X-ray pictures have been generally adopted by the medical sciences, they have been little used in the descriptive natural sciences where I believe they would greatly facilitate studies. A picture may save months of painstaking technical work. For students it would save the laborious work of microtomy and the subsequent reconstruction of organs from sections.

By using this method many a valuable organism can be kept intact that otherwise would have to be sacrificed for the purpose of study.

As far as I know, X-ray pictures have been used in zoology and botany only by a few workers and by them in only a small way. Probably the first to use them was Dr. David Starr Jordan, who reproduced X-ray photographs of fishes, but confined himself in the main to showing the pictures without giving a detailed description of the objects represented.

One of the main reasons why this method has been so little employed by biologists is the fact that its use necessitates expensive apparatus and that the pictures have to be made by carefully trained experts, who are thoroughly familiar with all the details of the process. In addition to that, the pictures themselves are quite expensive, and as a consequence only institutions with large available funds are able to undertake the work.

Because of the splendid cooperation between the Queen's Hospital and Bernice P. Bishop Museum of Honolulu, I have been able to realize my ambition to study by means of X-rays the majority of the representatives of the ichthyological fauna of a relatively large area and also to make observations and experiments regarding the adaptability of this method to biological studies as a whole.

An undeniable advantage of the Roentgen method, as compared with all others, is that every bone, even the finest, may be seen in its natural position. Even the intermuscular ossifications not connected with the skeleton can be clearly observed; whereas by any other known method their accurate position in relation to the rest of the body can be determined only with the greatest difficulty. Even while dissecting in the most careful and exact manner, one can not avoid cutting off some very fine points of the ribs or projections from some other bones. An X-ray picture makes this unnecessary.

The X-ray picture would be especially valuable for studying fossils; above all for the study of fossil fishes. An X-ray picture resembles such a fossil much more than a skeleton without any of the soft parts could possibly do. While these parts are rather dim on the negative, they are sharply circumscribed and remind one of the shape of the fossilized animal, whose outlines and soft parts of the body can only be distinguished by a discoloration of the stone.

In differentiating a number of closely related species of the same genus, whose only differences consist in colors and small dissimilarities of the body, the paleontologist is faced with an extremely difficult problem. It might be said that, in the meaning applied to living species, such a procedure is futile. By means of X-ray pictures *real* species distinguish themselves through constant differences between each other (small differences of the skeleton, in the air-bladder, etc.). These differences, however, in many species are so inconsiderable that we can hardly use them as a basis for distinguishing paleontological species, if we consider that the fossil print incorporates a number of changes and disturbances of the several parts of a body.

In studying the skeleton, the possibilities of biological investigation are by no means exhausted. Even the usual X-ray picture shows that the soft parts of the body appear on the negative in varying degrees of intensity. On fishes, for instance, the air-bladder will appear very clear and sharply outlined, especially if the picture has been taken immediately after the death of the animal. A procedure, so generally adopted in medical practice, to inject certain solutions or emulsions into cavities on account of their relative impermeability to X-rays in order to make them visible on the negative, points a way to a method which has been hardly used at all.

I injected barium sulfate solutions into the heart and the larger vessels of fishes and obtained pictures which are clear to the most minute detail; many show even the last capillary vessels absolutely plain. That in such pictures each vessel will be shown in its true position and relation to the rest of the body goes without saying. Here again the advantage of saving a great amount of time and work is apparent. Biologists are well aware that investigations involving the smaller vessels demand preparations which involve months of painstaking technical work.

I know of a distinguished scientist whose studies of the position and relations of the smaller vessels of the human heart demanded years of his time. An X-ray picture of a properly injected organ might have shortened that time to a few hours. It is possible to make just as easily studies of the vessels of invertebrate animals. As a matter of fact, these promise even more success, because there are no skeletons to disturb the picture. The practice of using certain selective staining methods for representing certain elements of the body—for instance, the nervous system—seems to me to be altogether within the limits of adaptation.

In the same manner as vessels, other cavities can be shown by means of injections. Here is the main field for roentgenographical work in botany. Also the entomologist, who studies plants that have been attacked by insects, will surely find in X-ray pictures a valuable help.

Naturally each field of investigation and its peculiar technic must be studied in all its particulars. The representation of the blood vessels, too, necessitates certain preliminary conditions and a certain practice which can be acquired only through experience.

In a forthcoming paper I am discussing the methods and advantages of X-ray pictures as applied to zoological and botanical materials. The use of this method is fully demonstrated in a monograph on Hawaiian fishes, now in preparation.

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A CONVENIENT METHOD OF DETERMINING THE RATE OF CLEAVAGE

FOR the study of factors influencing the rate of cleavage of developing eggs, it is essential to determine that rate for a large number of eggs. Since the individual differences in the time of cleavage usually extend over a period of only a few minutes, the counting has to be done quickly. The inexperienced worker will have to spend some time in acquiring the necessary skill for obtaining reliable data.

The following convenient and accurate method is suggested. The camera lucida is used. Note the time of the appearance of the first cleavage of the eggs in the microscopical field, and from now on mark on the drawing paper, with the aid of the camera lucida, all those eggs that divide within the first two minutes with No. 1 written across the image of the egg. Eggs dividing within the next two-minute period, mark with No. 2, and so on until the whole field has divided. A record is left on the paper. Now count from this record the number of eggs marked with 1, 2, 3, etc. You thus obtain the data for a regular distribution