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 curve from which you read off the average time at which cleavage of a large number of eggs occurred.

The advantages of this method are: a permanent record is left on paper; the counting is done with ease after the process has passed; each egg is counted only once, the mark across the image of the egg on the paper indicating the eggs already counted in the preceding period.

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SPECIAL ARTICLES

THE EFFECT OF A SECONDARY SOUND UPON HEARING

THE problem of hearing in the presence of a secondary sound has of late received considerable attention from correspondents of this journal. The ancient belief that certain persons suffering from paracusia, in the form of a partial deafness of the conduction-type, are able to hear more acutely in noisy surroundings than under conditions of quiet has been brought to question and debated on various sides.[1]

The matter seems at last to be decided by the excellent experiments of Knudsen and Jones, reported recently.[2] The threshold of hearing was ascertained for speech-sounds and for a faint tone both in silence and with a constant noise, and it was shown that for all subjects, normals and defectives alike, acuity is reduced in the presence of a noise. This finding is not incompatible, it must be noted, with the well-attested fact that under particular conditions the paracusic can carry on conversation more easily in the presence of a secondary sound. The phenomenon is a consequence not of an increased sensitivity of the acoustic mechanism, but rather of a relative advantage which the situation affords the paracusic over his normal companion.

The explanation is plain. The commonest auditory defects involve a considerably greater reduction of low tones than of high tones, and since most extraneous noises are made up predominantly of low-pitched tones, it follows that the person of impaired hearing is deaf to the secondary sound relatively more than he is to the essential tones of speech (which are of higher pitch) and thus in conversation is disturbed by the sound relatively less than is a person of normal hearing. Now since the loudness of one's voice is adjusted by reference to the background as he hears it, the normal person, being greatly disturbed by a sound, speaks much louder than usual, but the defective, selectively deaf to the sound, raises his voice but little. The net result of the background, in this situation, is a favoring of the person of impaired hearing, though actually the acuity of both persons is reduced as compared with silence. This explanation is supported by the fact that the illusion of improved hearing in the presence of a noise occurs only in conversation between a normal and a defective, and never between two normals or two defectives.[3]

All this seems clean-cut enough. The writer has merely to add some remarks upon an experiment which in a measure confirms, and further extends, the findings of Knudsen and Jones and which brings forth an additional problem for settlement. The experiment, conducted at the University of California last year in collaboration with Mr. Stanley R. Truman, was concerned with the effect of a background of tone upon the acuity of the normal ear.[4] Various frequencies and intensities of tone were used for the background and for the testing-tone, and we found, as Knudsen and Jones did, that at the introduction of a tonal background hearing is always reduced.

However, we came upon the further discovery that the threshold does not remain constant under such conditions. At the entrance of the secondary tone the acuity is considerably diminished, but recovery of sensitivity begins immediately and proceeds at a rapid rate until, under a given set of conditions, it may become three or four times as great as it was at first. Sensitivity does not, however, reach the level shown under conditions of silence; after about two minutes it has attained its highest extent and from then on we found no indication of further significant change.

Just what is the cause of this change in threshold-sensitivity we are thus far unable to state with conviction, but experiments are in progress which it is hoped will afford a clue. It would be interesting as well as significant in this relation to know whether paracusics would show the same type of curve of threshold-recovery as do normal persons under the conditions stated, and whether with prolonged stimulation by a secondary tone the relative advantage which, as has been pointed out, circumstances may afford the paracusic would continue to be maintained. Unfortunately, Knudsen and Jones do not tell us the temporal conditions of their tests, and the presumption is that they took no pains to control them—though it is plain on the basis of our results that the temporal factor is of first importance. It is to be hoped that some investigator with the necessary clinical facilities will extend the work of Knudsen and

[1] See, *e.g.*, 60 (1924), 360; 61 (1925), 260 ff.; 62 (1925), 109–111 and 182; and esp. Kranz, 60 (1924), 549.

[2] V. O. Knudsen and I. H. Jones, *Laryngoscope*, 36 (1926), 623–663.

[3] See Knudsen and Jones, *ibid.*, and *cf.* H. Fletcher, *Volta Rev.*, 26 (1924), 443 f., 447 f.

[4] See *J. Exper. Psychol.*, 11, 1928, 98–112.