SPECIAL ARTICLES

VISUAL PURPLE IN SNAKES

IN the extensive literature of the visual cells of vertebrates the reptiles appear to have had less consideration than other groups. Few species have been investigated, and these few have apparently been chosen because they were easy to secure and handle rather than because they were taxonomically representative. The forms which have been studied are chiefly members of the large families, and are too closely related and too similar in habits to form a basis for sweeping generalizations concerning the retinae of reptiles as a group.

Nevertheless, such generalizations have been made and the classic pieces of comparative ophthalmological literature concur unanimously in a summary to the following effect:

Crocodiles and their relatives possess both rods and cones; geckoes have only rods, "true" lizards and chameleons only cones. All snakes (except possibly *Boa constrictor*) and all turtles have pure-cone retinae. The situation in *Sphenodon* is in dispute.

Students of the retina seem satisfied to let these statements stand in spite of the fact that rods are necessary for scotopic vision and large numbers of reptiles (most of which are snakes) have vertically elliptical pupils—a feature which herpetologists have long considered a certain indication of nocturnal habit. The writer has felt that the entire reptilian group should be resurveyed with the application of modern criteria for the distinguishing of rod from cone, and has undertaken the histological study of the light- and dark-adapted retinae of a hundred or more species of reptiles chosen with proper regard to their light-habits and to their phylogenetic relationships.

While this histological program will of course form the bulk of the writer's work upon this group, rods and cones are not always easily distinguishable in sections. Since the most essential difference between them is the presence of the sensitizer, "visual purple" in rods and its absence in cones, an investigation of the distribution of this substance in reptiles was made as a highly desirable preliminary to the histological studies.

Briefly, the presence of visual purple in a dark-adapted retina is certain proof that functional rods are present, no matter what their form as seen in sections. Although this criterion was established fifty years ago through the great work of Kühne, no one has applied it widely to reptiles in which, considering their light-habits, one would be led to expect visual purple—and hence, rods.

Visual purple has been found in nocturnal geckoes and crocodiles, but only diurnal lizards and turtles have been examined for it, with negative results, and so far as the writer knows it has not even been looked for in any snake.

The writer has employed the following technique on a number of ophidian species: the animal is left overnight or longer in absolute darkness; by ruby light the snake is etherized or decapitated and an eye is removed. The excised retina is transferred to a depression slide in normal saline and covered. This slide, in a light-tight box with a white bottom, is then brought out into diffuse daylight where, after light-adaptation of the experimenter, it is opened in the presence of one or more additional witnesses. Visual purple, if present, is seen as a distinct pink, red or lavender coloration of the preparation which bleaches in a few seconds when taken near a window.

With this method visual purple was found in the following forms: Boidae, *Python molurus* and *Boa constrictor;* Colubridae, *Tarbophis fallax* and *Dasypeltis scaber;* Viperidae, *Agkistrodon mokasen, Sistrurus miliarius* and *Crotalus horridus.* All these forms have vertical pupils, and all except *Tarbophis* represent subfamilies all members of which have vertical pupils.

In four vertical-pupilled forms no visual purple was seen; in *Trimorphodon vandenburghi* (Colubridae), *Vipera berus* and *V. ammodytes* (Viperidae) the pigment epithelium refused to separate from the bacillary layer and as a consequence the retina was black macroscopically. In *Bitis arietans* (Viperidae) this trouble was not encountered, but visual purple was not surely seen, perhaps having been bleached by the ruby light during the excessively long time required for complete anesthesia in this case. The fresh *Bitis* retina, under the microscope, showed numerous slender cells with cylindrical outer segments (assuredly rods) surrounding large, plump cells (typical ophidian cones) whose outer segments had disintegrated in the saline.

No visual purple was found in round-pupilled forms, most of which are considered strictly diurnal by herpetologists. Some round-pupilled species are secretive and crepuscular and a few are called "nocturnal" in herpetological literature; examples are *Coronella girondica* and *C. austriaca, Micrurus fulvius, Lampropeltis t. triangulum* and *Drymarchon corais couperi* (all Colubridae). All these were examined with negative results; these and other forms may prowl at night, but the duplicity theory would lead us to pronounce them incapable of vision at night. They must hunt by other senses, perhaps olfaction, which is known to be acute in snakes.

From the above, together with the facts of distribution and significance of vertical pupils in reptiles, the writer does not hesitate to make the following statement: rods are to be expected, either to the exclusion of cones or in combination with them, in all Boidae, in all Viperidae[1] and in such Colubridae as have vertical pupils. Rods should be present in the Amblycephalidae and in *Xenopeltis,* but will probably not be found in any round-pupilled Colubrid.[2]

Most ophidian *species* are diurnal Colubrids, but most ophidian *families* are, bodily, nocturnal and have vertical pupils. Thus, in spite of the generalization seen in the literature, it is probable that rods are very wide-spread in snakes and that, from the phylogenetic standpoint, it is the pure-cone retina which represents the major departure from the beaten path.

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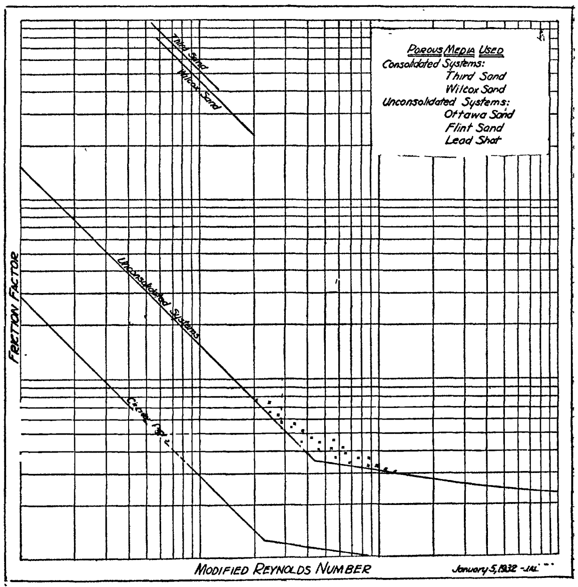
A NOTE ON THE FLOW OF FLUIDS THROUGH POROUS MEDIA

THE flow of fluids through porous media is being studied intensively in the Petroleum Research Laboratory of the Mineral Industries Experiment Station at The Pennsylvania State College.

Over 200 tests of the flow of water, air and crude petroleum through Ottawa sand, graded flint sand and six sizes of lead shot have been made as well as a few of the flow of water through consolidated sandstones. Of the latter, samples from cores of the Wilcox sand of Oklahoma and the Third sand of Venango County, Pennsylvania, were used.

The data have been correlated with the flow of fluids in circular pipes[1] by plotting a modified Reynolds number against a friction factor. Points so plotted for all systems of unconsolidated material define within the region of viscous flow a straight line parallel to that for circular pipes. Chilton and Colburn[2] recently found this to be true for columns packed with broken solids many times greater in mean diameter than the sand systems used in this work. A break in this line, or rather a region of change, is found with sand systems for large Reynolds numbers exactly as is the case for circular pipes corresponding to the change from viscous to turbulent flow.

It is remarkable that the flow of water through the consolidated sands studied so far, defines a straight line on this chart for each sand parallel to the lines for circular pipe and unconsolidated systems. The displacement evidently must be due to differences in composition and degree of consolidation of the sands. The illustration shows the type and relative displacement of the curves.



These experiments indicate that it may be possible to calculate energy relationships, permeability of oilsands to fluids and similar factors germane to the production of petroleum from the properties of the fluid and the reservoir rock.

The investigation of the flow of fluids through consolidated porous systems is being studied in greater detail in this laboratory.

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1 Except possibly the primitive genus *Causus,* which some writers state to have a round pupil and to be partially diurnal.

2 Certain of the round-pupilled Elapines, such as *Naja* sp., may prove to have rods. The Cobras and their allies are in a state of confusion as regards their light-habits, as described by various authors. Even the matter of pupil-shapes in many Elapines is unsatisfactory, for authors who have observed living specimens disagree as to whether the pupil is round or a vertical slit!

1 Walker, Lewis and McAdams, "Principles of Chemical Engineering," 2nd ed., p. 87, McGraw-Hill Book Co., Inc., 1927.

2 Chilton and Colburn, *Ind. Eng. Chem.*, 23, 913–19, 1930.

BOOKS RECEIVED

APPLETON, E. V. *Thermionic Vacuum Tubes.* Pp. 113. 68 figures. Dutton. $1.25.

DALAKER, HANS H. and HENRY E. HARTIG. *The Calculus.* Second edition. Pp. viii + 276. 107 figures. McGraw-Hill. $2.25.

JOHNSTONE, JAMES. *The Essentials of Biology.* Pp. xv + 328. 44 figures. Longmans, Green.

LANDMAN, J. H. *Human Sterilization.* Pp. xviii + 341. Macmillan. $4.00.

RICHARDSON, LEON B. and ANDREW J. SCARLETT, JR. *A Laboratory Manual of General Chemistry.* Revised. Pp. viii + 143. 23 figures. Holt. $1.50.