is obscured behind a cloud of opaque matter. It may be suggested that this center radiates a small but substantial amount of heat, sufficient to raise the temperature of the earth a few degrees. If this is the case, during the periods when the earth does not lie behind the obscuring cloud, it will be a few degrees warmer, and when the cloud passes in front, the temperature will drop a corresponding small amount. Such a small difference in temperature may well make the difference between a stretch of time when glacial periods are frequent and wide-spread, and one when they are rare and mainly limited to mountain areas.

As the obscuring cloud is nearer to the center of the Milky Way than ourselves, the obvious assumption is that it is revolving about the center more rapidly than ourselves (obviously in the same direction). We can calculate what its period would have to be, to occult the center every 210 million years, and it works out at 110 million years. Assuming that most of the mass of the Milky Way is concentrated at its center (Plaskett suggests 80 per cent.), this would make the radius of its orbit of the order of 5,000 light-years.

If this is the case we have gone about the center of the Milky Way some eight times, and the obscuring mass about 17 times, since the oldest visible rocks were laid down, some 1,850 million years ago.

This scheme is presented as a suggestive hypothesis, rather than a full-fledged theory. Its chief weaknesses are two: one due to the uncertain dating of the geological deposits, especially as glacial deposits and datable radioactive ones (igneous) are rarely found in close association; the other, which Dr. Boothroyd would emphasize, that the amount of radiation possible from the center of the galaxy would not be able to raise the temperature of the solar system even the few degrees necessary. A systematic error in the radioactive datings might change the figures involved somewhat, but could hardly be large enough to interfere seriously.

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EGGS OF FRESH-WATER FISHES SUITABLE FOR PHYSIOLOGICAL RESEARCH[1]

Fundulus heteroclitus, a marine Poeciliidae commonly called the killifish, or marine minnow, has been used for many years as the standard fish for various types of physiological research. Their eggs are especially well adapted for experimental studies due to the fact that they can be easily fertilized in the laboratory and their embryos can be observed during development through the transparent shell membrane.

It is not always possible or desirable, however, for the investigator to conduct his research at a marine biological station but since several of the fresh-water laboratories are now equipped for fundamental physiological research as well as for ecology, life-history and taxonomic studies, it may be of interest to call attention to a few species of fresh-water fishes, the eggs of which have been found to be very satisfactory for research on the beat of the embryonic heart. By the use of these eggs it is often possible for the inland investigator to conduct his research in or near his own laboratory.

The log-perch (*Percina caprodes*)[2] is one of the larger and more abundant of the darters belonging to the family Percidae. It occurs in all the Great Lakes, in Lake Champlain, in the St. Lawrence and the various tributaries of this system and ranges south to Virginia, Alabama and throughout the Ohio basin, westward to Kansas, and southwestward to Texas. An excellent colored plate and description of this species is contained in Forbes and Richardson's "Fishes of Illinois." The plate is opposite page 282.

The adults are found in schools of several hundred at spawning time. The spawning beds are found along the shallow windswept shores of lakes, usually where sand is abundant. When the water is quiet the schools move to the very edge of the lake and spawn in a few inches of water. Spawning takes place during the day time on quiet days. The males remain in a group while the females rest on the sand at the edge of the spawning area. At intervals the individual females move toward the group of males, one of which starts spawning with her, during the progress of which the eggs and sperm are emitted while the tails vibrate in such a way as to dig a pit in the sand and cover many of the eggs. Reighard[3] has described the spawning and method of sex recognition of this species in excellent detail. Spawning takes place from as early as June 15th and may continue as late as July 20th at the University of Michigan Biological Station on Douglas Lake in Northern Michigan.

During the spawning season log-perch are easily collected with a twenty-five or thirty foot minnow net. The fish can be stripped immediately and the eggs fertilized in finger bowls or syracuse watch-glasses or fishes may be kept in an aquarium with the water at a cool temperature and stripped when desired. A 70 to 80 per cent. fertilization is usually secured if the eggs are fertilized by the dry method. The eggs are collected in the dry watch-glasses and

[1] Contributions from the University of Michigan Biological Station, North Dakota State College, and The College of the City of Detroit.

[2] For a discussion of the taxonomy of this species see Hubbs and Brown, *Trans.* Roy. Can. Inst., 17: 1–56, 1929.

[3] Reighard, Papers of Mich. Acad. Sci., p. 104–105, 1913.

the concentrated sperm poured over the eggs and a minute or two allowed to elapse before the addition of water. The watch-glasses are then kept in a covered crystallization dish filled with water to a depth just greater than the height of the syracuse watch-glasses which contain the eggs. Water changes can be made in the main dish leaving the eggs undisturbed. When examination is necessary the watch-glasses may be lifted out of the water and placed on the stand of the microscope.

The eggs are about a millimeter and a half in diameter and are perfectly clear and transparent. Cleavage and development is rapid. The first cleavage furrow appears in about an hour at the temperature of the water during spawning. The pulsating heart can be observed on the second day and the circulation is very distinct on the third day. At a general temperature of about 22° C. the eggs hatch on the seventh day. For two or three days after hatching the larvae remain inactive and lie on their sides on the bottom of the dish. In this position the heart action and the course of circulation can be easily studied. Pigment cells are practically wanting at this stage and the blood corpuscles can be seen passing through the finest of the capillaries.

The abundant straw-colored minnow (*Notropis deliciosus*) is found from Michigan, Ohio, Ontario, and New York to Tennessee, westward to the Dakotas, and southwestward to Kansas and Texas. An excellent colored plate of this species is contained in Forbes and Richardson's "Fishes of Illinois," opposite page 137. For a key for the identification of the Great Lakes minnows and a discussion of nomenclature see Hubbs' "List of the Fishes of the Great Lakes, etc."[4]

The straw-colored minnows are found in spawning condition along sandy shores and are usually taken best at night. Little is known of their natural spawning. Working with a seine at night they can be taken in numbers sufficient for experimentation. The fishes can be stripped and the eggs fertilized in the same manner as *Percina*. The spawning season extends a little later than *Percina*, lasting until August 1st at Douglas Lake. The eggs are about a millimeter in diameter and are transparent. Development is very rapid. The first cleavage furrow appears within an hour after fertilization, followed by the second about fifteen minutes later. The eggs hatch about 72 hours after fertilization at temperature 22°–24° C.

The eggs of the common shiner, *Notropis cornutus*, are also excellent material for research. The development is not so rapid, however, as in the straw-colored minnow. They are best taken at night with seine or fine-meshed fyke.

Eggs of the common yellow perch (*Perca flavescens*) are quite satisfactory but the females can not be stripped with any degree of success and the eggs must be secured after they have been naturally spawned and hence the exact time of fertilization can not readily be ascertained. These eggs can frequently be secured from fish hatcheries in April and May in Michigan, and thus are available at an early date.

Reighard[5] worked with a related species wall-eyed pike (*S. vitreum*) which should be satisfactory for physiological purposes.

This list is very incomplete, and no doubt more study will add other species producing suitable eggs for work throughout the spring and summer months.

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[4] Hubbs, Univ. of Mich. Museum, Miscellaneous Publications No. 15, 1926.

[5] Reighard, "Development of the Wall-eyed Pike (*S. vitreum*)," Mich. Fish Comm. *Bull.*, 1: 66, pl. 1–10, 1890, Lansing, Mich.

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