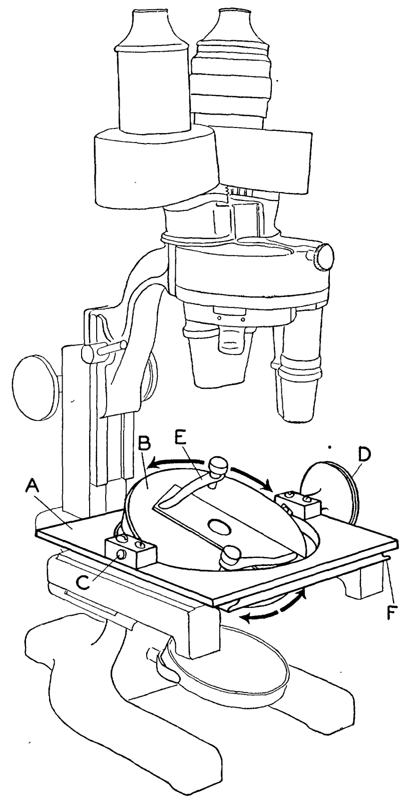
development of various devices and techniques for this purpose. This is especially true in the study of micro-fossils, where the number of specimens handled is often large. The means of obtaining different orientations vary all the way from successively gluing the specimen in different positions on the slide to complicated ball-and-socket devices. The former method often results in broken or lost specimens, while most of the mechanical devices are limited in range of movement or control.

Having these difficulties in mind I designed and built a stage which solves most of the problems encountered in this type of micro-manipulation. This stage rotates, and at the same time the axis of rotation may be tilted at any angle up to 90°, in a plane perpendicular to that of the objectives. This allows the specimen to be viewed from all sides (except that applied to the slide), at any given angle. The effect is to combine universal movement with a high degree of control.

In the accompanying figure the stage is shown in place on a binocular microscope. It consists essentially of a square stage base (A), which replaces the glass stage of the microscope, and a tilting, revolving stage (B), which is supported by the stage base. The stage proper consists of an upper and a lower disk, the upper rotating about an axis fixed in the lower. The lower disk is attached to the stage base by means of the offset shaft (C). This shaft is rotated by the wheel (D), so that the stage as a whole revolves about an axis which passes just above the surface of the slide and lies in the plane of the objectives. The slide is held in place by clips (E).

The whole mechanism is easily attached to the microscope by means of flanges (F), which slide into the grooves provided for the regular glass stage. The front and rear of the stage are interchangeable, so that the wheel (D) may be placed on either the right or the left side. In either position the axis of rotation passes through the center of the field when the back of the stage base rests against the vertical supporting pillar of the microscope.

This stage is most useful in studying or drawing small opaque objects. By changing the orientation and angle of illumination it is often possible to bring out quite sharply suture lines or surface ornamentation which otherwise would have been obscure or invisible. Then, too, the specimen can be quickly and easily turned to any desired position for drawing or



measuring. This is especially convenient when making drawings of Foraminifera, where three views at right angles are usually desired. In fact, we have found the stage most useful wherever rapid controlled orientation has been an important factor.

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SPECIAL ARTICLES

MAMMALIAN LIFE WITHOUT RED BLOOD CORPUSCLES

IN certain invertebrate animals hemoglobin occurs in solution in the circulating blood, where it functions not only to transport the oxygen but to maintain a colloidal osmotic pressure. In all vertebrates hemoglobin normally occurs only within red blood corpuscles, and other proteins have been developed in the plasma to furnish the necessary colloidal components. It has been widely assumed that, in the vertebrates, hemoglobin is incapable of performing its respiratory function when outside of the red blood corpuscles.

We have recently found this assumption to be incorrect, at least in so far as the chemical behavior of the hemoglobin itself is concerned. A "hemoglobin-Ringer" may be prepared, in which hemolyzed mammalian red blood cells have been added to ordinary

Ringer-Locke solution, giving a concentration of dissolved hemoglobin approximating that of the normal plasma proteins (5 to 7 per cent.). The red cells are taken from beef, cat, dog or human blood, twice washed with Ringer-Locke solution, and, after the last centrifugalization, hemolyzed by the addition of distilled water or by ether. For best results absolutely fresh blood must be used. Beef cells are best adapted for the work; they readily hemolyze when added to distilled water, and their potassium content approximates that of normal blood plasma. The final solution is made isotonic with normal blood. The stromata are removed by the centrifuge. The oxygen capacity of the solution when finally prepared is about half that of normal cat or dog blood.

This solution may be introduced into the bodies of cats or dogs through a cannula placed in the jugular vein, and the blood simultaneously removed through a carotid cannula. In this manner, by continuous bleeding, all but the last traces of the normal blood may be swept out of the body, and the concentration of the red blood corpuscles may be reduced to the vanishing point. By this method we have observed:

(1) After complete removal of the normal blood from cats or dogs under veronal anesthesia and replacement by hemoglobin-Ringer the hemoglobin in solution appears to be able to carry oxygen, and furnish base for the transport of carbon dioxide much as when enclosed within the red blood cells. The respiratory movements continue, usually increasing in rate as the experiment progresses. The heart beat remains strong. Reactions to such drugs as adrenalin occur as in the normal animal. Circulatory and respiratory reflexes persist Other reflex actions are present; the pupil of the eye, for instance, constricts upon illumination. The oxygen consumption continues with little or no change during and for up to two hours after the removal of the normal blood. A similar constancy in oxygen consumption has been observed in heart-lung preparations of the dog.

(2) The hemoglobin in solution exerts a colloidal osmotic pressure, which prevents the edema which follows perfusion with ordinary Ringer-Locke.

(3) The completeness of the removal of the red cells has been checked by histological examination. All but the last traces of cells are removed from the various tissues when hemoglobin-Ringer amounting to eight times the normal blood volume has been passed through the body. The bone marrow is readily swept clear. The spleen alone holds some red cells for a longer time.

(4) Blood volume may be directly determined by collection and measurement of all red cells removed from the body. The most dependable values are secured from previously splenectomized animals.

(5) After the removal of the normal blood under ether anesthesia the animals may regain consciousness and exhibit an essentially normal behavior for several hours. Our best experiments of this type have been with cats. They are able to walk, run, see and hear. They are able to jump to the floor from a considerable height, judge distances correctly and make their way about in a normal manner. All postural and equilibratory reflexes appear to be normal. When dropped upside down they land on their feet. Respiratory rates are, however, higher in these animals than normal. They show a marked tendency to sleep, but are easily aroused and may become quite active, for a brief period, only to lapse into sleep again rather suddenly.

(6) Such animals finally die, after five or six hours, not because the hemoglobin is unable to carry on its respiratory function, but because it leaves the blood stream with much greater ease than do the normal plasma proteins. It appears in urine and feces, and is in part removed by cells of the reticulo-endothelial system. Its concentration within the blood-vessels falls considerably, the blood volume appears to diminish and the animal dies from oxygen lack and respiratory failure.

We conclude from these experiments that the chief function of the vertebrate red blood corpuscles is to hold hemoglobin within membranes impermeable to it, so that it can not leave the blood stream. In other respects hemoglobin appears to be able to carry out its respiratory rôle in solution much as it does within the red cells, sustaining every vital function, even the more complicated activities of conscious life.

A full account of these experiments will appear shortly in the *Journal of Cellular and Comparative Physiology*.

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THE BEHAVIOR OF FROG EGGS IN AN ELECTRICAL FIELD

NUMEROUS investigations have been made of the cataphoretic properties of living cells, but until recently the most reliable data have concerned bacteria and blood corpuscles. The electrokinetic potential of these small cells has been found to be negative. The studies of Mr. Katsuma Dan, of this laboratory, have demonstrated that sea-urchin eggs also bear a negative charge.[1]

[1] K. Dan, *Anat. Rec.*, 51: 28, 1931. Extensive paper to appear shortly.