capable of standardization against maximal and minimal valves,[1] it has been possible to fill this gap in the physiology of the circulation. The operative technic was so adapted that (1) normal intrathoracic pressure relations during inspiration and expiration were obtained when the records were taken, (2) artificial pressure changes in the intrathoracic cannula and manometer tubes were obviated, (3) clot formation was minimized and recognized when present, (4) only a small portion of the pulmonary circuit was occluded, and (5) the systemic and right auricle pressures corresponded to that habitually found in animals.

The results of 13 such experiments showed that, during quiet normal breathing the systolic and diastolic pressures fell during inspiration and rose during expiration. The systolic pressure averaged 43.3 mm. in expiration and 31.7 mm. in inspiration, the diastolic pressure 20 mm. in inspiration and 11.9 mm. in expiration. In experiments where the heart rate ranged from 180 to 25 per minute, it was found that the diastolic pressure *decreases* as the heart rate is reduced. The same holds true for the systolic pressure between heart rates ranging from from 180 to 100 or 80 (the latter figure varying in different animals). When the heart becomes still slower the systolic pressure again increases.

During temporary apnea vagi, the maximal pressure dropped 40 to 32 per cent., the minimal pressure increased 10–25 per cent. over that occurring during natural breathing, showing that respiratory movements determine to a pronounced extent the extreme pressures in the pulmonary artery.

61 (670)

The results of ligation of the pulmonary and cutaneous arteries in the frog.

By **T. S. GITHENS.**

[*From the Department of Physiology and Pharmacology of the Rockefeller Institute for Medical Research.*]

The frog possesses, in the lungs and the skin, two organs for the purpose of respiratory exchange, and it has long been estab-

[1] Wiggers, *Journ. Exp. Med.*, XV, 1912, p. 174.

lished that the skin respiration suffices for his needs at low temperature.

I have attempted to produce asphyxia in frogs by ligating the vessels which carry blood to the lungs and to the skin. It may be well to mention here certain anatomical data. The truncus arteriosus rises from the heart of the frog and divides into a right and left branch which each give off three branches, the carotid, the aorta and the pulmocutaneous. The last divides into two, one of which goes to the lungs and the other, the cutaneous, supplies the skin of the entire trunk. A large branch from the carotid makes a free anastomosis with the cutaneous artery.

At temperatures below 20° C. the frog requires very little gas exchange and I found that ligation of the pulmocutaneous and anastomosis was not sufficient to produce asphyxia, although it deprives the frog of the lungs and most of the skin, leaving only the mucous membrane of the mouth and the skin of the legs for respiratory purposes. If in addition the mouth was excluded, by ligation of the carotid arteries, thus leaving only the skin of the legs, the frogs died in 2–3 days. If the lungs and entire skin were excluded by ligating the pulmocutaneous and the iliac arteries death occurred in about 36 hours in spite of the respiratory exchange through the mucous membrane of the mouth. Frogs in which the respiration of the lungs and mouth was absolutely prevented by keeping them under water, but in which the entire skin was available, lived indefinitely at this temperature.

With an increase of temperature to 28° frogs in which the cutaneous respiration was entirely excluded by ligation of the cutaneous and iliac arteries were still able to live indefinitely. If the lungs and skin of the body were excluded by ligation of the pulmocutaneous and anastomosing arteries, death occurred in about 24 hours, and if the skin of the legs was also excluded by ligation of the iliac arteries, in about 12 hours. If the pulmonary and buccal respiration was prevented by keeping frogs under water, no asphyxia was noted during the five hours of the experiment, but frogs in which the cutaneous arteries were tied and which were kept under water died within 3 hours.

At a temperature of 34°, asphyxia could be caused by excluding the cutaneous respiration. Frogs in which the cutaneous and anastomosing branches were ligated lived only about 8 hours. If the lungs and most of the skin were excluded by tying the pulmocutaneous and anastomosing arteries, the frogs lived about 6 hours and if the mouth also were excluded by sewing this and the nostrils shut and tying the cutaneous arteries, they lived about 4½ hours. Control frogs kept at this temperature, showed no deviation from normal excepting slight over-excitability.

These results show with how little gas exchange frogs can live and also the large factor of safety with which their respiration is normally provided. Auer and Meltzer have recently shown that dogs could live with a supply of oxygen only one tenth of that which they normally consumed.

The results also show the great increase in the requisite gas exchange with rise of temperature and the inability of the skin respiration of the frog to support life at even moderately high temperatures, at which the lungs and mouth alone are still sufficient.

62 (671)

Variations in the response of different arteries to blood serum and plasma.

By **HUGH A. STEWART** and **SAMUEL C. HARVEY.**

Recent work by Brodie, Sollmann, and O'Connor has shown that the blood contains substances acting on the vasomotor apparatus other than suprarenin. Even before the work of these investigators it had been noticed by Stevens and Lee that the use of defibrinated blood for the perfusion of isolated organs was often unsatisfactory because of the gradual diminution in outflow. This was not investigated thoroughly until 1900 by Brodie. He observed that the injection of blood serum into the jugular vein of a cat caused an immediate fall in blood pressure. The cat's own serum was as efficient in this respect as the serum of any other animal. The cat, however, is the only animal which responds in this manner, for Brodie's experiments were negative on the dog and rabbit. The mechanism in this case appears to be a reflex inhibition of the vasomotor center from excitation of the pulmonary branches of the vagus. The importance of Brodie's work lies in the fact that he was the first to show that plasma and