interest as a simple laboratory technique for the production of tracer C^{13}. The possible application of the high-cut method to the enrichment of other isotopes is being considered.

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References and Notes

1. C. R. McKinney *et al.*, *Rev. Sci. Instr.* 21, 724 (1950).
2. M. Dole, *Chem. Revs.* 51, 266 (1952).
3. For background on the influence of isotope effects on tracer studies, see J. Bigeleisen, *Science* 110, 14 (1949).
4. This research received financial support from the U.S. Atomic Energy Commission and the Michigan-Memorial Phoenix Project. I am indebted to the Alfred P. Sloan Foundation for a fellowship which made this work possible.
5. R. B. Bernstein, J. Phys. Chem. 56, 893 (1952).
6. ———, in *Proceedings of the International Symposium on Isotope Separation* (North-Holland, Amsterdam, Netherlands, in press).
7. G. A. Ropp, A. J. Weinberger, O. K. Neville, *J. Am. Chem. Soc.* 73, 5573 (1951).
8. P. E. Yankwich and R. Haschemeyer, in preparation.
9. I appreciate the help of D. E. Marsh and C. D. Miller with the mass spectrometer.

19 April 1957

Lung Volume of Amphibian Tadpoles

In 1949 Witschi (*1*) described, in tadpoles of the genus *Rana,* a pair of fibrous strands which connect the round windows of the otic capsules with the bronchi. In the following year (*2*) he noted that larvae of *Xenopus* possess small diverticula of the bronchi which also come into contact with the round windows of the ears. Witschi called these structures bronchial columellae and bronchial diverticula, respectively.

It occurred to Witschi (*1, 3*) that these connections of the gas-filled lungs with the ears might serve for the transmission of pressure changes, particularly sound vibrations. In order to make quantitative statements about sound and pressure reception by the lung, the lung volume is an important quantity to be known.

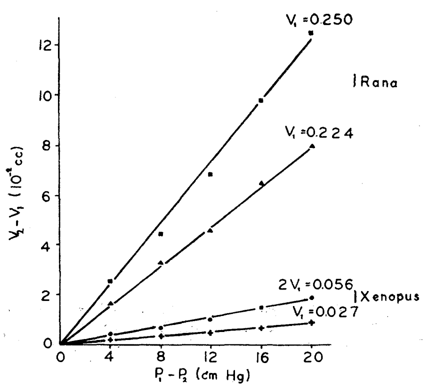

Fig. 1. Relation of applied pressure difference (P_1-P_2) to lung volume increase (V_2-V_1) in larvae of *Rana* and *Xenopus.* The calculated original lung volume is indicated in cubic centimeters at each graph. Note that one curve for *Xenopus* represents two animals ($2V_1 = 0.056$ cm^3).

Since dissection of the lungs and subsequent determination of their volume introduces uncontrollable errors because of manipulation, it was decided to devise a technique for measurement in the living animal.

Let a specimen of *Rana* species be swimming free in a vessel under atmospheric pressure P_1. The volume of the animal's lung may be denoted by V_1. Then, if the vessel is partially evacuated to pressure P_2, the volume of the lung (assuming passive behavior of this organ) will increase to V_2, such that

$$V_1P_1 = V_2P_2$$

(temperature T constant). By suitable manipulation, this expression may be restated

$$V_1 = \left(\frac{P_1}{P_1 - P_2} - 1\right)(V_2 - V_1)$$

Since P_1 and P_2 are known, it is necessary to know only ($V_2 - V_1$), or the increase in volume. To measure this quantity, one or more animals were enclosed in a small vessel completely filled with water. Through the stopper of this vessel, a calibrated capillary protruded, which was approximately half filled with water. Thus, the only free air present in the system is the air in the lungs of the animals. This small vessel was put in a larger vessel, in which a volume of water served as a temperature buffer, so that no changes in temperature would occur during an experiment; a thermometer was added to check this. The large vessel was then evacuated to a preset pressure in the range of 56 to 76 cm-Hg, and the rise in level of the fluid in the capillary was measured. Since the capillary was calibrated, the rise in level could be read directly as 10^{-2} ml increase in volume.

It was assumed that the lung expanded passively; if this assumption is correct, the same value for V_1 must obtain from any set of P_1 and P_2, or in a graphical representation, the relation ($P_1 - P_2$) versus ($V_2 - V_1$) should be a straight line. For each animal or set of animals, such a straight line was obtained. Figure 1 shows four cases, two of *Rana catesbeiana* and two of *Xenopus laevis.* It is apparent that the slope of a particular relation is determined by the initial volume, V_1, which is indicated in the graph. In a series of measurements on single *Rana catesbeiana larvae* of stages 28 to 29 (Witschi, *4*) values of V_1 ranged from 0.14 to 0.42 cm^3, with the mean at 0.28 cm^3. *Xenopus laevis* larvae of similar age were measured in groups of three, four, and ten individuals, and the total lung volume was divided by the number of animals. Thus, values of V_1 ranged from 0.020 to 0.034 cm^3 with the mean at 0.026 cm^3. Since *Rana* larvae are heavier than water and tend to sink to the bottom, while *Xenopus* larvae are lighter and have to make continuous effort to keep from floating up (*5*), one is led to infer that *Xenopus* larvae carry relatively more air than *Rana* tadpoles. It is then meaningful to express the lung volume as percentage of body volume. Therefore, the body volume of the animals was measured before each pressure experiment by dropping them in an appropriate graduated cylinder and noting the rise of the meniscus. Thus it appears that *Rana* larvae have an average lung volume amounting to 2.3 percent of body volume; *Xenopus* larvae, on the other hand, maintain an average of 3.7 percent air.

From these results, it is possible to obtain an upper and lower bound of the specific gravity of the tadpole as a whole. Assuming a floating condition (specific gravity, 1.0000), where the air just cancels the weight of the tissue in excess of the weight of an equal volume of water, one may calculate from the quoted percentages that the specific gravity lies between 1.020 and 1.034.

A measurement was carried out to determine the specific gravity of *Xenopus* larvae in the following manner. A small number of larvae were homogenized in a known volume of water. The total volume was determined after homogenization, which thus yielded the volume of tadpole tissue. From this 1-cm^3 samples were weighed; after correction for the added water, these weighings averaged at 1.025 for the specific gravity of *Xenopus* larval tissue (*6*).

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References and Notes

1. E. Witschi, *Z. Naturforsch.* 46, 230, (1949).
2. ———, *Anat. Record* 108, 590 (1950).
3. ———, *J. Morphol.* 96, 497 (1955).
4. ———, *Development of Vertebrates* (Saunders, Philadelphia, Pa., 1956).
5. W. A. van Bergeijk, *Anat. Record* 120, 754 (1955).
6. This work was aided by a contract between the State University of Iowa and the Office of Naval Research, Department of the Navy (NR 163-145).
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15 April 1957

Leaching of Carbohydrates from Plant Foliage as Related to Light Intensity

Modern use of radioactive isotopes has effectively demonstrated the loss of mineral nutrients from plant foliage by leaching with aqueous solutions (*1, 2*). In addition, large amounts of organic materials, principally carbohydrates, can