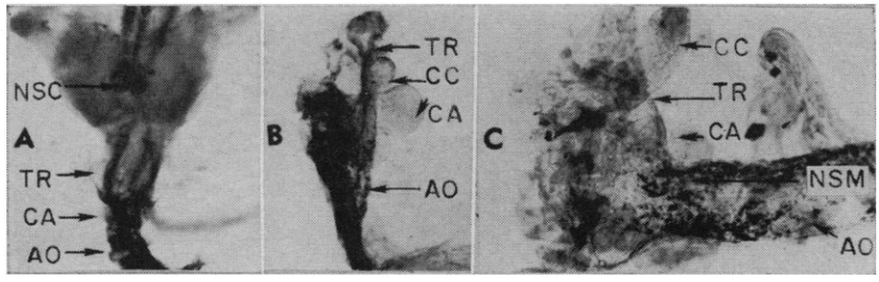

Fig. 1. *A*, Brain, retrocerebral complex, and aorta of *Iphita*; whole mount, Formol-saline, performic acid–Victoria Blue (× 25). Abbreviations as in Fig. 2. *B*, Retrocerebral complex and aorta of *Iphita*; whole mount, Formol-saline, performic acid–Victoria Blue (× 25). *C*, Retrocerebral complex of *Iphita*; whole mount, Formol-saline, performic acid–Victoria Blue (× 90).

method for staining neurosecretory materials in whole mounts (*4*), we traced axons from neurosecretory cells in the pars intercerebralis; they traverse each side of the corpus cardiacum and appear to terminate on the wall of the aorta, where the neurosecretory colloids accumulate in a typical neurohemal structure (Figs. 1 and 2). When eggs are developing in copulating females, there are large accumulations of stainable neurosecretory materials in this tract and the aortic wall. In ovipositing females, however, these neurosecretory colloids are clearly depleted, depletion suggesting a release of stored neurosecretory products. Notably, moreover, this technique reveals no stainable colloid in the allatal nerve or in the corpus allatum at any stage of egg development or oviposition.

Our technique, a modification of the method of Adams and Sloper (*5*), reveals sites of resulting cysteic acid. Thus one may presume that the neurosecretory material that finds its way to the wall of the aorta in *Iphita* contains cystine or cysteine, as does the neurosecretory material of vertebrates. The neurosecretory supply to the corpus allatum (*2*) must involve a different neurosecretory material, because no cysteic acid could be demonstrated. Thus we tentatively suggest that there are at least two neurosecretory components involved in the reproductive cycle in *Iphita*: One, not demonstrable by Humberstone's technique but discernible by the usual staining methods, goes to the corpus allatum and is a possible allatotropin; the other, containing cystine or cysteine, is released from a neurohemal structure in the wall of the aorta and is a probable myotropin. Both types of neurosecretion are stainable by the usual techniques.

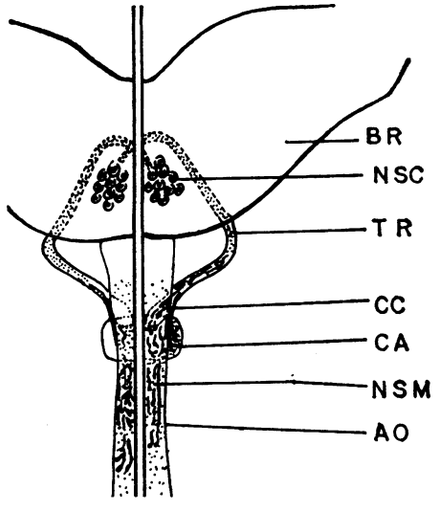

Fig. 2. Composite diagram representing preparation stained with Gomori's chrome-hematoxylin-phloxin on the right side and with performic acid–Victoria Blue preparation on the left. On the left appear the median neurosecretory cells (*NSC*), and the neurosecretory tract (*TR*) leading directly to the aorta (*AO*) forming the neurohemal organ. Corpus cardiacum (*CC*) and corpus allatum (*CA*) are not stained. On the right is seen the tract leading to the heart (as on the left), but neurosecretory material (*NSM*) is also shown in the corpus cardiacum and corpus allatum. *BR*, brain.

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References and Notes

1. K. K. Nayar, *Biol. Bull.* **108**, 296 (1955); *Proc. Indian Acad. Sci.* **B42**, 27 (1955); *Proc. Nat. Acad. Sci. India* **22B**, 171 (1956); *Z. Zellforsch. Mikroscop. Anat. Abt. Histochem.* **51**, 320 (1960).
2. ———, *Z. Zellforsch. Mikroscop. Anat. Abt. Histochem.* **44**, 697 (1956).
3. ———, *Proc. Indian Acad. Sci.* **B47**, 233 (1958).
4. G. S. Dogra and B. K. Tandon, *Quart. J. Microscop. Sci.* **105**, 455 (1964).
5. C. W. N. Adams and J. C. Sloper, *J. Endocrinol.* **13**, 221 (1956).
6. We thank K. K. Nayar, the Ford Foundation for financial support (of P. I. I.), the Government of India for a research training scholarship (to K.R.S.), and B. K. Tandon for demonstrating Humberstone's technique.

21 February 1966

Multicapillary Mixer of Solutions

Abstract. *A mixer made from a bundle of glass tubules can mix two solutions within 30 microseconds, with a total-solution flow rate of 1.33 milliliters per second. One solution passes through the interstices of the bundle; the other moves through the lumens of the tubes.*

Studies of the time course of a reaction following mixture of the components require complete mixing within a period short in relation to the duration of the reaction. We now describe a device that produces a paraxial array of alternating jets of reactants that appear to mix the streams intimately within a short distance in a plane normal to the flow axis. Kletenik's (*1*) similar approach used alternating thin sheets of reactants.

The mixer is made by fusing a bundle of thin-wall glass tubules, each about 2 mm in outside diameter, into a tube of about 10-mm outside diameter that serves as a jacket; the bundle is then pulled to a tip about 2 mm in diameter within a distance of about 1 cm (Fig. 1). When cut, the narrow section presents a smooth fracture plane through all the glass tubes. A side tube to the jacket permits fluid to be pumped around the tubules to reach the tip through the interstices; the spaces between the tubules are sealed by fusion upstream of the side tube, which separates the two fluid paths. Fluid entering this end reaches the tip by flowing inside the tubes; fluid entering the side tube reaches the tip by flowing through the interstices. After a little practice, the assembly can be made in about 20 minutes exclusive of time for annealing.

The size of capillaries obtained depends primarily on the amount of heat applied before the tubes are drawn out. When these units are properly made, the drawn end will have the same proportions as the original dimensions. The ratio of wall thickness to intra- and extra-capillary space remains the same, but on a reduced scale. Diameters of individual capillaries have varied from 25 to 250 μ, depending on the construction of the mixer. The ratio of the cross sections of the two channels can be altered by changing: (i) the thickness of the capillary wall (increase in wall thickness also increases dead space); (ii) the shape of the capillary; or (iii) the number and size of the capillaries within the outer glass jacket.

The flow velocities obtained with one such mixer were measured by orienting the axis of flow almost vertically and measuring the maximum height attained by the fluid under a stated driving pressure. The vertical exit velocity (V) was calculated at $V = (2gh)^{\frac{1}{2}}$, where g is gravity and h is maximum altitude. The velocity estimates are probably low because no corrections were made for air-friction effects or nozzle coefficient. Flow rates were measured by collecting the fluid passed by the mixers within a measured period.

Measurements on one model showed that, with a driving pressure of 6.8×10^4 newton/m^2 (gauge; 0.7 atm), the intracapillary flow velocity was 4.2 m/sec; the extracapillary, 2.55 m/sec. With the driving pressure increased to 13.6×10^4 newton/m^2, the velocities increased to 7.7 and 4.7 m/sec.

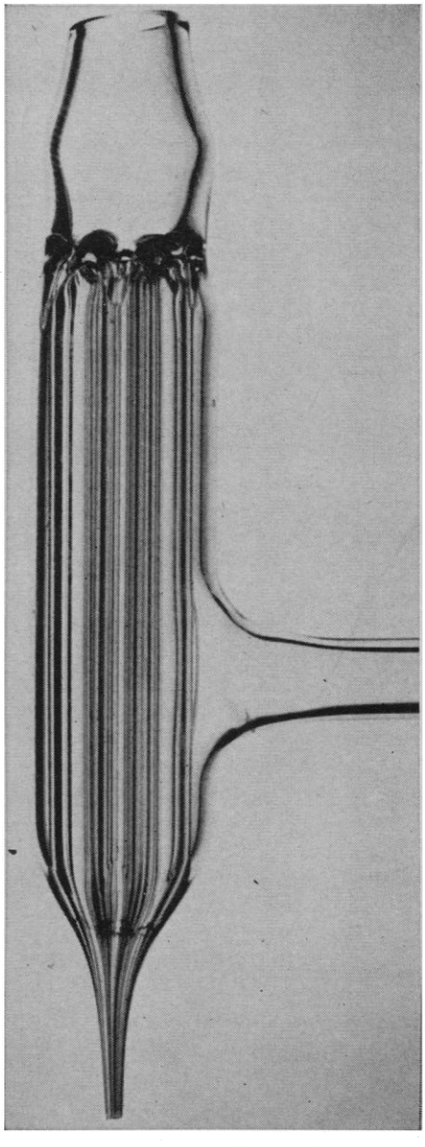

Fig. 1. Multicapillary mixer.

We have used two techniques to observe and analyze the mixing capabilities of the microcapillary system:

1) The production of a fluorescent compound by mixing two nonfluorescent solutions—quinine becomes fluorescent in an acid solution. A relatively nonfluorescent solution of quinine hydrochloride was passed through the intracapillary space, and acetic acid was forced through the extracapillary spaces, the mixture being a fluorescent acid solution.

2) The intracapillary solution was an alkaline 100-mg/liter solution of luminol (5-amino-2,3-dihydro-1,4-phthalazinedione). The other solution contained potassium ferricyanide (1 g/liter), with methylene blue or hemoglobin at several milligrams per liter. Production of visible light by combination of the two reactants was the indication of mixing.

The characteristics of the capillary mixer were determined by observation through a microscope or by scanning the mixing area with a photomultiplier using a 0.4-mm slit to define the measured region. At flow velocities of less than 0.5 m/sec the individual solutions remain unmixed for about 5 cm beyond the jet orifices, but, as the flow velocities increase, the pattern changes and the region of mixing moves closer to the orifices of the jets. While the fluid flow remains laminar, mixing at the boundaries results from diffusion of the reactants across the boundary; this mixing is ineffective, but, with increasing flow velocities, the point of turbulence approaches closer to the jet orifices and a sharply defined area of complete mixing is observed. With driving pressures of 3.4, 6.8, 10.2, and 13.6 newton/m^2 on the reservoirs of quinine and acid, one mixer gave flows of 0.51, 0.85, 1.10, and 1.33 ml/sec and velocities of 2.7, 4.2, 5.8, and 7.2 m/sec, respectively; under these conditions the point of maximum fluorescence was 2, 1, 0.25, and 0.20 mm away from the tip, which means that the mixing times were 0.74, 0.24, 0.044, 0.028 msec, respectively. The photomultiplier showed no observable change in light output beyond 0.75 mm away from the jet orifices when the driving pressure was 6.8×10^4 newton/m^2 or more. In order to ensure mixing in a sharp plane adjacent to the orifices without increasing the flow velocities, an electron-microscope grid (*2*) was placed within 0.1 mm of the orifice; although the grid added resistance to the flow, the light output indicated that solutions were completely mixed on emergence from the grid.

This system permits the simultaneous mixture of three or more reactants by addition of another set of capillaries. Use by the unit of very small quantities of reactant solutions makes it useful for studying biologic reactions for which materials are limited.

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References and Notes

1. Yu. B. Kletenik, "A mixer for investigating the kinetics of rapid reactions in solutions by the flow method," *J. Phys. Chem. U.S.S.R.* 37 (5) (May 1963).
2. Athene type-New 200 specimen grids; Smethurst High-Light, Ltd., Bolton, Lancashire, England.

29 March 1966

Action of Anionic and Cationic Nerve-Blocking Agents: Experiment and Interpretation

Abstract. *Barbiturates and anesthetics similar to procaine bind to phospholipids in vitro. The former increase the binding of calcium to the phospholipids; the latter decrease it. The data can be correlated with the effects of these drugs on peripheral nerve. The nonpolar portion of the narcotic agents may lie between the lipid chains of the membrane, with the charged region in close approximation to the polar heads of the phospholipids.*

Most current views on the mechanism of anesthesia appear to fall into three categories: (i) biochemical theories which relate to oxygen consumption and oxidative metabolism (*1*); (ii) theories pertaining to the formation of hydrates (*2*); and (iii) theories relating directly to cell membrane phenomena, that is, lipid solubility and "surface effects." Limitations of the first two theories, which are concerned primarily with the central nervous system and mechanisms of general anesthesia, have been noted (*1, 3*). Evidence for the third category, which includes much of the data on the mechanism of local anesthetic action, includes correlations between anesthetic potency and solubility in media with low dielectric constants, polarizability, and penetration of lipid monolayers (*4*). Despite the wealth of chemical data, there has been little correlation of it with recent physiolog-