just as awkward a while ago. (Again, "down" turned out to be a relative direction instead of an absolute one.)

Experiments have proved the time dilatation, but only in the case where two frames of reference pass one another in unaccelerated flight. No experiments have been possible for the case of returning objects, but they may be possible in future years. Artificial satellites still have velocities much lower than that of light, thus their time dilatation is extremely small. But with the best atomic clocks we could build, it would become just possible to measure the difference. The only problem is how to build such a clock small enough, and capable of working for many years without any maintenance.

S. von Hoerner

Astronomisches Rechen-Institut, Heidelberg, Germany

Flow through a Permeable Membrane

Leslie F. Nims concludes in a recent article [*Science* **137**, 130 (1962)] that "the rate of flow of a tagged species of a material substance through a permeable membrane is proportional to the rate of flow of the substance itself when, and only when, the species mole fraction of the substance is the same on both sides of the barrier." This conclusion is disturbing in view of the common assumption in kinetic experiments "that the flow of tagged material *is* proportional to the flow of normal material" [L. F. Nims, *Yale J. Biol. Med.* **31**, 373 (1959)] (italics mine). Is not the difficulty resolved by precise specification of the meaning of the word *flow* in a given situation?

Thus, Nims's Eq. 1, from Harned and Owen,

$$-\dot{n}_s = \sum_k M_{sk} \frac{d\mu_k}{dx}$$

relates to *net* flow of species *s*. Even when derived directly from Newton's laws of motion, *net* flows rather than *unidirectional* flows are involved, since, as Nims has pointed out [*Am. J. Physiol.* **201**, 987 (1961)], it is the "drift velocities of a species" which are being treated rather than "thermal velocities of the individual molecules." Similarly, his Eq. 12

$$(-\dot{n}_{s'} = -N_1\dot{n}_s + M_{\text{ex}}\,RT\,\frac{d\ln N_1}{dx})$$

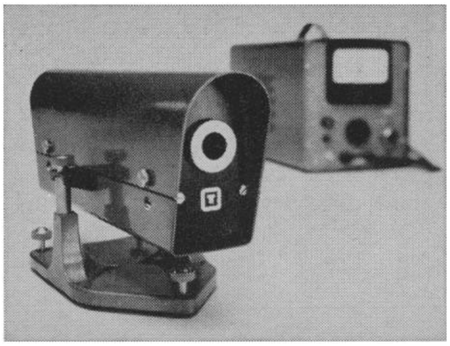
depends also on the application of the Onsager relation, valid only when fluxes are related to conjugate forces derived from an appropriate dissipation function, which again would involve *net* fluxes.

Accordingly, while Eq. 12 indicates the need for considering the gradient of the mole fraction of a tracer in relating *net* flows of tagged and untagged species, it does not seem to invalidate the common use of tracer isotope to evaluate *unidirectional* flow of untagged substance across a membrane. When tracer is added only to the source side, assumption of equivalent kinetic characteristics of tagged and untagged species implies that every molecule, whether tagged or not, has equal probability of moving completely across the barrier, hence that unidirectional flow of tracer must be proportional to unidirectional flow of untagged substance from source to sink.

Alvin Essig

Massachusetts General Hospital, Boston

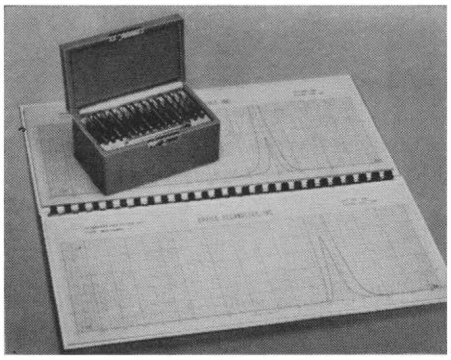
One may assume that material transfer through the membrane of the unit transfer system phase α, membrane, phase β is accomplished by a two-path-



LABORATORY LASER/$995

Now: A low-priced precision source of coherent pulsed light, complete with power supply, designed to accommodate a wide range of accessories for advanced research. The elliptical optical cavity gives high pumping efficiency, and is demountable for easy access to the Xenon lamp and LASER crystal holder. Standard accessories—a cryogenic cooling dewar, Fabry-Perot interferometer, optical bench mount, rubies with highly efficient multi-layer end reflectors—greatly extend experimental research capabilities.

INTERFERENCE FILTERS



WAVELENGTH REJECTION FROM
X-BAND TO X-RAY

VISIBLE SPECTRUM SET 10A—Ten MONOPASS filters to isolate principal lines as K, Ca, Hg, etc. Four neutral density filters and a linear spectral "wedge" filter. Price, $325.00.

VISIBLE SPECTRUM SET 12A—Ten MONOPASS filters uniformly spaced from 400 millimicrons to 700 millimicrons. Price, $325.00.

INFRARED SET 15A—Ten MONOPASS filters spaced at every 0.1 micron between 0.8 micron and 1.75 microns. Price, $450.00.

INFRARED SET 20A—Ten interference filters spaced at every 0.1 micron between 1.75 microns and 2.75 microns. Price, $450.00.

RUBY LASER SET 50A—Seven all dielectric mirrors and beam-splitters at several values of attenuation, designed to withstand high LASER powers without deterioration, plus MONOPASS Filter at 695 millimicron ruby wavelength. Price, $350.00. For additional information, please write or call

OPTICS TECHNOLOGY, INC
248 Harbor Boulevard
Belmont, California
LYtell 1-0358 (Area Code 415)

ordered mechanism. In this case the observable variables of interest pertaining to the phases are related to the material currents in the paths as follows:

$$\frac{dn_1^\alpha}{dt} = \dot{n}_1^{m1} - \dot{n}_1^{m2}$$

and (1)

$$\frac{dn_2^\alpha}{dt} = \dot{n}_2^{m1} - \dot{n}_2^{m2}$$

where the dn/dt's are the rates of change of the number of moles in the phases and $\dot{n}$ indicates the material currents in the membrane. Furthermore, the basic assumption requires that the composition of a particular segment of the current remains constant as it traverses the path, and that it has the same composition as the phase of origin, or

$$\dot{n}_1^{m2} = N_1^\alpha \dot{n}_k^{m2},\ \dot{n}_1^{m1} = N_1^\beta \dot{n}_k^{m1}, \ldots \quad (2)$$

where N_1^α is the mole fraction of the subspecies of k within phase α, and so on. These equations imply that the flow of the subspecies is not due to their concentration gradients but is due to the action of a "pump." Equation 1 may now be written

$$\frac{dn_1^\alpha}{dt} = N_1^\beta \dot{n}_k^{m1} - N_1^\alpha \dot{n}_k^{m2}$$

and (3)

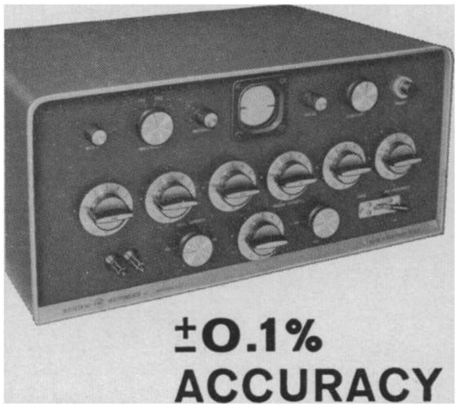
$$\frac{dn_2^\alpha}{dt} = N_2^\beta \dot{n}_k^{m1} - N_2^\alpha \dot{n}_k^{m2}$$

To account for the selectivity exhibited by all membranes, one must further assume that a separate "pump" and pair of paths exist for every kinetic species. In addition, since the experimental evidence indicates that the flow of one species can depend upon the simultaneously occurring flows of other species, one must also assume that the pumps are coupled together in some fashion as yet undefined in physical terms.

Alternately, one may assume that the material currents in the membrane are representative of spontaneous irreversible phenomena associated with differences in the temperatures, pressures, or compositions of the phases. The membrane merely acts as a resistance to material flow. Such a mechanism may be called single-path-random mechanism. Our observational quantities are now related to the physically definite "net" flows, the material currents in the membrane, when the kinetic substance k does not participate in any

new

ELECTROLYTIC CONDUCTIVITY BRIDGE



The Model RC-18 Conductivity Bridge is a further refinement of the familiar Industrial Instruments' Model RC-16 Conductivity Bridge, an industry standard for more than two decades. Combining an accuracy of ±0.1% and a sensitivity of better than ±0.01%, the model RC-18 meets the demand for higher precision conductivity measurements.

FEATURES:

- ★ Range 0-100,000 ohms.
- ★ Cathode Ray Oscilloscope Null Detector permits separate resistive and reactive balance.
- ★ Oscillator provides both 1000 cps and 3000 cps bridge current.
- ★ Resistance and capacitance decades with inline readout.
- ★ Self-contained cabinet or rack and panel mounting.

Write for complete information on the Model RC-18 and accessory conductivity cells and constant temperature baths.

ELECTROLYTIC CONDUCTIVITY IS OUR BUSINESS!

We invite your inquiry.

Industrial Instruments ®
89 Commerce Road, Cedar Grove, Essex County, New Jersey

chemical reactions which may be occurring in the phases, or

$$\frac{dn_1^\alpha}{dt} = \dot{n}_1^m$$

and (4)

$$\frac{dn_2^\alpha}{dt} = \dot{n}_2^m$$

No physically definite material currents as defined by Eq. 2 now exist, since each segment of the material current as it crosses the barrier suffers a change in composition. Equations 1 and 2, if now used, merely estimate the magnitude of hypothetical currents which correspond to rates of transfer obtained by an equivalent two-path-ordered mechanism. In contrast to the implications of Eq. 2, the material currents defined by Eq. 4 may be said to be actual currents, and they do depend upon the concentration gradients.

Therefore, the comments made by Essig and by others, including C. W. Sheppard in his excellent book *Basic Principles of the Tracer Method* [(Wiley, New York, 1962), p. 165], are largely concerned with semantics. The physical meanings of *"net" flow, inflow, outflow, material current,* and so on, are to be found in the assumptions, implicit or otherwise, made in the attempt to answer the question, "Why do material currents appear within the membrane of a unit transfer system?" In the quantitative description of any system, the smaller the number of unverifiable assumptions required to give physical meaning to the terms appearing in the mathematical relations representing the behavior of the system, the better the description.

LESLIE F. NIMS
Department of Biology,
Brookhaven National Laboratory,
Upton, New York

"Grantitis"

I am prompted by the excellent editorial "The need for skepticism" [*Science* **138**, 75 (1962)] to mention some thoughts which have long been on my mind.

Over the past several years a disease has spread rampant throughout science, until today it shows promise of becoming pandemic. The proper name for this affliction is "grantitis," and it exists in all phases of scientific endeavor. From my own very small

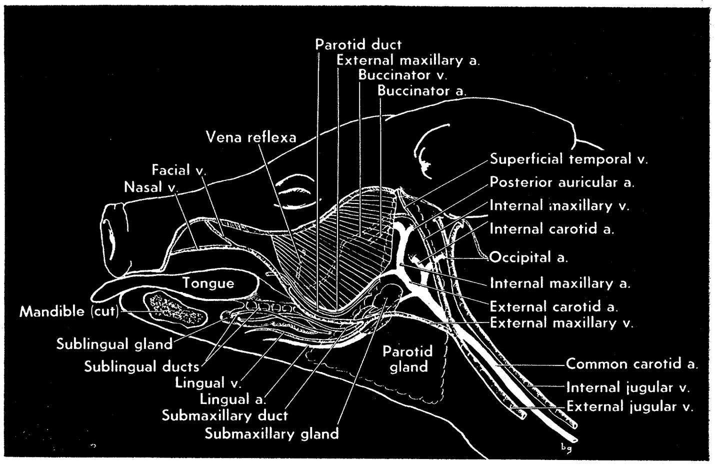


Fig. 47—Dissection of salivary glands and blood vessels of head and neck of fetal pig from Hickman-Hickman, LABORATORY STUDIES IN INTEGRATED ZOOLOGY. This figure appears approximately 55% larger in the manual.

Stimulating new teaching manuals from MOSBY . . .

to make student laboratory work more meaningful

Ready in January! New 2nd Edition Hickman-Hickman

LABORATORY STUDIES IN INTEGRATED ZOOLOGY

This new revised edition provides a flexible, universal workbook which can be used with any text in the field. In this 2nd edition, additional emphasis has been placed upon the vertebrates, particularly the mammal. New units of study have been added throughout, the most extensive being on the perch and fetal pig. Additional invertebrate forms have also been included so the instructor can select those forms best suited to his needs and supplies. An outstanding feature is a large, wall-size chart presenting excellent detailed outlines of taxonomy and the major organ systems.

By CLEVELAND P. HICKMAN, Ph.D., Professor and Head of the Department of Zoology, DePauw University, Greencastle, Ind., and FRANCES M. HICKMAN, A.B., Assistant in Zoology, DePauw University, Greencastle, Ind. To be published January, 1963. 2nd edition, approx. 350 pages, 7¼" x 10½", illus. About 4.00.

Ready in February! Tuttle-Schottelius

PHYSIOLOGY LABORATORY MANUAL

Written by two widely known and recognized authorities, this new laboratory manual provides a stimulating guide to experiments for undergraduate students in both basic and advanced courses in physiology. The distribution of experiments is as follows: 20% involve inanimate material; 40% require, small animals; and 40% are based on human subjects. Furthermore, this manual offers more detailed instructions in laboratory procedures. The appendices include lists of specialized equipment, sources of such equipment and special instruction in laboratory procedures.

By W. W. TUTTLE, Ph.D., Sc.D., Professor Emeritus of Physiology, College of Medicine, State University of Iowa, Iowa City, Iowa, and BYRON A. SCHOTTELIUS, Ph.D., Associate Professor of Physiology, College of Medicine, State University of Iowa, Iowa City, Iowa. To be published in February, 1963. 175 pages, 5½" x 8½", 34 illustrations. About $3.75.

While attending the 129th
AAAS Meeting in
Philadelphia, learn more about
these and other Mosby texts
from our representative in Booth 24

THE C. V. MOSBY COMPANY
3207 Washington Boulevard
MOSBY
Publishers
St. Louis 3, Mo.