ing out more than speculative analysis, but certainly, as suggested by Lars Onsager, there must be a momentum deficiency in the microdomain of the pore in the solution side of the barrier. That is, in a solid region of the barrier, the time average transfer of momentum is that prescribed by the hydrostatic pressure of the phase, but in the opening of the pore there is a deficiency since the momentum arising from the macromolecule is not transferred to the solvent species in the pore, being cut off by the finite size of the pore. Thus, within the pore and only within the pore, a gradient of pressure arises and quasi-laminar flow ensues from the solvent side to the solution.

Although the experimental observations in the osmometer experiment do not demonstrate the diffusion component of flux explicitly, it is reasonable to assume that this component is present:

$$\left(\frac{dn}{dt}\right)_{diff.} = \frac{-DA}{RT} C \frac{\Delta u}{\Delta X} \cdot$$

$$= \frac{DA}{RT} \frac{C}{\Delta X} [\bar{V}\Delta P + \Delta RT \ln N]$$

$$= \frac{DA}{RT} \frac{C\bar{V}}{\Delta X} [\Delta P + \frac{RT}{\bar{V}} \ln (1 - N_{H_2O})]$$

$$= \frac{DA}{RT} \frac{1}{\Delta X} [\Delta P - \pi]$$

Thus, the total flux is

$$\frac{dn}{dt} = \left[\frac{DA}{RT\Delta X} + K f(A)\right] [\Delta P - \pi]$$

The diffusion component would be all-important in a barrier whose "pores" have a cross-sectional area of the order of the solvent molecules such that only a molecular-molecular drift of the solvent could occur.

In conclusion, the point to be emphasized for workers in the field of membrane permeability is the fact that in osmotic transfer the chemical potential difference of the solvent can give rise to both a quasi-laminar flux and to a diffusion flux, the relative importance of the two components being dependent on the nature of the barrier. For most barriers, the predominant component is the quasi-laminar flux.

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References and Notes

1. F. P. Chinard, *Am. J. Physiol.* 171, 578 (1952).
2. V. Koefoed-Johnson and H. H. Ussing, *Acta Physiol. Scand.* 28, 60 (1953); E. Zeuthen and D. M. Prescott, *ibid.* 28, 77 (1953); R. P. Durbin, H. Frank, A. K. Solomon, *J. Gen. Physiol.* 39, 535 (1956).
3. I am deeply indebted to my colleagues H. Morowitz, J. H. Wang, D. Hitchcock, G. Meschia, and Lars Onsager for their kind help with theoretical discussions and experimental details.
4. G. S. Hartley, *Phil. Mag.* 12, 473 (1931).

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Aggressive Behavior in Castrated Starlings

Androgens have long been known to affect the aggressive behavior of birds and mammals. Experiments conducted during the last two decades have shown that animals of various species ceased aggressive behavior when they were castrated, or rose in social rank when they were given injections of testosterone. This paper (*1*) reports the maintenance of aggressive behavior in castrated starlings and the failure of testosterone to affect their social rank.

The methods consisted of observing castrated starlings (*Sturnus vulgaris*) that were living in a large room (14 by 16 feet). Eleven birds were bilaterally castrated on 20 Dec. 1956, when the testes were still in the regressed winter condition but were starting to increase. The birds were painted on the tail with bright colors for individual identification. These birds maintained fighting and singing behavior for a month. A conventional diagram describing the social rank was prepared. In most cases the relative position was clear, but in some cases the birds may have been tied for position, and in other cases no contests were observed.

On 15 Jan. a series of injections of graded doses of testosterone was begun, to determine the effect of testosterone on the seminal vesicle (*2*). The dosage was not known to the observer. The rank of the individuals did not change during a period of 10 days. The birds that were injected with control material remained in their rank. The birds that received the highest amounts of testosterone were sixth and ninth in rank even at the end of the 10-day period. It was suspected that three of the birds might have some testicular tissue because their bills remained yellow. These birds ranked first, third, and eighth and, on autopsy, were found to have some tissue.

Because these results were the gleanings from another experiment, a program was specifically planned. Five birds were castrated 2 Feb. and were observed until 11 Mar. A rank was obvious, and song continued vigorously. Injections of testosterone (begun 11 Mar.) at various dosages had no effect on rank. On autopsy, on 21 Mar., one bird (second in rank) had 25 mg of testicular issue, but the top-ranking bird had none.

These results demonstrate that castrated male starlings maintain a rank, as do normal birds. Since the aggressiveness of these adults might be the result of learning, experiments with young birds are planned. However, the aggressiveness might result from androgen from another source. But the threshold of response would have to be below the level that controls bill color and growth of seminal vesicles because castrated birds have black bills and minute seminal vesicles. Furthermore, the fact that injections of large amounts of testosterone did not alter rank indicates that androgens are not involved. The aggressiveness might be responsive to another hormone, such as a hypophyseal hormone, since Witschi (*2*) concluded that, in some birds, plumage changes are controlled by gonadotropins. This possibility is being explored.

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References and Notes

1. This work was conducted under a grant from the National Institute of Mental Health.
2. A description of this work is in preparation.
3. E. Witschi, *Mem. Soc. Endocrinol.* 49, 149 (1955).

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Nature of Fluorophore Localizing in Tetracycline-Treated Mouse Tumor

It has been previously observed that certain chemical agents such as fluorescein (*1*) and hematoporphyrin (*2*), when administered parenterally to tumor-bearing animals, tend to localize in the tumor tissue. This phenomenon finds limited clinical applications in the localization and diagnosis of neoplastic diseases (*3*). The fluorophore in the tumor tissue was usually assumed to be the unchanged compound administered, without, however, inquiry being made into its exact chemical nature.

Recently, Rall *et al.* (*4*) reported that, in animals bearing transplantable tumors, localized fluorescence was noted in the bones and the tumor tissue after treatment with any of the tetracyclines. The discovery aroused considerable interest in that a variety of animal tumors as well as a few human neoplasms exhibited this behavior. In addition, the localized fluorescence persisted as long as the animals survived (*5*).

In view of the sustained interest in the problem and the obvious chemotherapeutic possibilities implied, an effort has been made in our laboratory to study the chemistry of the fluorophore in the tetracycline-treated mouse tumor. In this report, evidence is presented to show that the localized fluorescence is attributable to unchanged tetracycline which, however, probably does not exist as such in the tumor tissue, but rather as a loose complex bound with a peptide which is one of the normal constituents of mouse sarcoma tissue.

CAF_1 mice weighing 20 to 24 g with 6-day-old sarcoma S-37 were injected in-