in convenient form by transfer onto a plate of window glass of the record made by withdrawal of successive 5 cc volumes of air from the chamber into an accurate burette. The rulings are scratched on this glass plate with a diamond point and are then filled with colored wax; the transparent rule thus produced can be placed on each tracing and used to read off the oxygen consumption values accurately and quickly. Simultaneous ordinates for the signal magnet time record are transcribed onto the oxygen line of each tracing by manual operation of the drum and writing lever, after the test run.

In practice, then, the fasted rat is placed into the small wire mesh cage referred to above, and this is inserted into the animal chamber of the basal metabolism machine. Oxygen is admitted and allowed to flow out of the open stopcock and to bubble out of the spirometer until all air in the system is replaced by oxygen. Then the chamber is closed and at least 30 minutes are allowed for the animal to fall asleep and for the system to reach equilibrium. A 30-minute tracing is made and the best 5-minute period noted, along with an estimate of activity as determined from the smoothness of the tracing.

When the oxygen line indicates by an absence of any waves that the rat has been sleeping soundly throughout the recording period, all of the 5-minute readings give practically identical rates of oxygen consumption. Any movement which does occur elevates the succeeding readings in direct proportion to the intensity and duration of the activity; even a mere shift in position by a visibly sleeping animal increases the oxygen consumption for at least the next 5-minute period.

The graph of Fig. 2 shows the distribution of values, expressed as cc/kg/hr, according to age, in 172 determinations on 42 adult male rats. Only those observations made on sleeping animals are included, and all rats were housed in a constant temperature room at 26°C. Averages for the individual age groups show, with other observers, a progressive decline with age, reaching what appears to be a plateau at about 6 months. The mean oxygen consumption of the 133 determinations made in the 6-9-month age range is 692 cc/kg/hr $\pm$ 3.0 (P. E.), which may be taken as the basal metabolic rate obtained in "metabolic maturity." This figure is equivalent to 635 Cal/m^2/24 hr, using the formula, S. A. $=$ 9.1 $\times$ W2/3, for calculation of surface area.

Summary. 1. A method is described for determination of oxygen consumption in the rat. Its major advances are: (a) Humidity control, inducing sleep. (b) Sensitive recording method, which shows body movements on the oxygen line and makes feasible readings covering 5-minute periods.

2. Values obtained in 172 determinations on 42 male rats show a decline from 771 cc/kg/hr at age 4 months and 752 cc/kg/hr at 5 months to a plateau at 6 months and maintained to at least 9 months. The average for 133 determinations on rats of 6-9 months is 692 cc/kg/hr $\pm$ 3.0 (P. E.), or 635 Cal/m^2/24 hr.

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The Susceptibility to Furacin of Bacterial Strains Resistant to Sulfonamides or Antibiotics.*

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Furacin or 5-nitro-2-furaldehyde semicarbazone has been found to be both bactericidal and bacteriostatic for a large group of Gram-positive and Gram-negative bac-

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teria.[1] It has found practical application in the local treatment of infected areas when combined with carbowaxes and propylene glycol as a washable base.[2] In connection with its clinical application, it is of interest to determine whether or not organisms resistant to sulfonamides, penicillin or streptomycin are also resistant to furacin. The experiments reported in this paper have shown that pairs of strains respectively resistant and susceptible to sulfonamides, penicillin or streptomycin do not differ in their susceptibility to furacin.

Methods and Materials. Five pairs of coagulase-positive strains of *Staphylococcus aureus* were obtained—one member of each pair resistant and the other susceptible to sulfonamides. The resistant strains had been derived from the parent strain by continuous transfer in increasing sulfonamide concentrations. For streptomycin similar pairs were obtained comprising *Shigella paradysenteriae*, *Escherichia coli*, *Proteus vulgaris*, *Streptococcus viridans*, and *Staphylococcus albus*. The dysentery strains were obtained through the courtesy of Dr. Morton Klein of this laboratory. The resistant strain was obtained by culturing the organism in the presence of increasing concentrations of streptomycin. The others were obtained through the courtesy of Dr. C. W. Buggs of Wayne University School of Medicine. They were isolated from a patient who suffered from an abdominal gun shot wound and was treated with 4 g of streptomycin every 24 hours. The parent strains were isolated before therapy and the resistant ones at various times during therapy. Through the courtesy of Dr. John E. Blair, Hospital for Joint Diseases, New York, 3 pairs of coagulase-positive

TABLE I.

Growth of Organisms Susceptible and Resistant to Various Chemotherapeutic Agents in Dilutions of Furacin.*

Chemotherapeutic agent	Inhibitory concentration	Organisms	Dilutions of Furacin									
			10,000	25,000	50,000	75,000	100,000	250,000	500,000	750,000	1,000,000	Control
Sulfathiazole†	1/10,000	*S. aureus* 5A			—§	—	—	4	4	4	4	4
,,	1/1000	,, ,, 5E			—	—	—	4	4	4	4	4
Streptomycin	<16 γ/ml	*E. coli* 135A	—	—	4	4	4	4	4	4	4	4
,,	>5000 γ/ml	,, ,, 167A	—	—	4	4	4	4	4	4	4	4
,,	<32 γ/ml	*P. vulgaris* 196B	—	4	4	4	4	4	4	4	4	4
,,	>5000 γ/ml	,, ,, 198B	—	4	4	4	4	4	4	4	4	4
,,	200 γ/ml	*S. viridans* 135B	—	1	2	2	2	2	2	2	3	3
,,	>5000 γ/ml	,, ,, 179	—	1	2	2	2	2	2	2	3	3
,,	<1 γ/ml	*S. albus* 146B	—	—	—	—	—	3	3	3	3	3
,,	150 γ/ml	,, ,, 241B	—	—	—	—	—	3	3	3	3	3
,,	25 γ/ml	*S. paradysenteriae* (Flexner II)	—	—	—	—	—	4‖	4‖		4	4
,,	>1000 γ/ml	,, ,,	—	—	—	—	—	4‖	4‖		4	4
Penicillin‡	0.1 unit/ml	*S. aureus* 726	—	—	—	—	—	2	4	4	4	4
,,	>4 units/ml	,, ,, 726R	—	—	—	—	—	4	4	4	4	4

* 48-hour readings are given as representative of the results obtained. † 5 pairs tested. ‡ 4 pairs tested.
§ No visible growth. ‖ Actual dilutions used were 200,000 and 400,000 instead of 20,000 and 500,000.

[1] (a) Dodd, M. C., and Stillman, W. B., *J. Pharm. Exp. Therap.*, 1944, **82**, 11; (b) Dodd, M. C., *J. Pharm. Exp. Therap.*, 1946, **86**, 311; (c) Cramer, D. L., and Dodd, M. C., *J. Bact.*, 1946, **51**, 293.

[2] (a) Snyder, M. L., Kiehn, C. L., and Christopherson, J. W., *The Military Surgeon*, 1945, **97**, 380; (b) Dodd, M. C., Hartmann, F. W., and Ward, W. C., *Surgery, Gynecology, and Obstetrics*, 1946, **83**, 73; (c) Shipley, E. R., and Dodd, M. C., *Surgery, Gynecology, and Obstetrics*, in press; (d) Neter, E., and Lamberti, T. G., *Am. J. Surgery*, 1946, **72**, 246.

penicillin-resistant and susceptible strains of *S. aureus* were obtained. These strains were isolated before and after penicillin therapy.

The following procedure was used in testing the cross resistance of these strains:

All reagents were diluted either in casein hydrolysate or extract broth. The standard test inoculum for all strains was 200,000 bacteria per ml. The strains were checked for their resistance or susceptibility to penicillin, streptomycin or sulfonamides, respectively. All of the strains were tested against various dilutions of furacin to determine whether or not there was any difference in susceptibility to this drug of the resistant and susceptible strains. Daily visual observations of growth were made for 4 days and the results recorded as negative (no visible growth), doubtful, 1+, 2+, 3+ or 4+ growth. Casein hydrolysate medium was used for testing the penicillin and sulfonamide strains, extract broth for testing the streptomycin strains.

Results. In Table I representative results are given for each of the drugs tested. Not all of the results are given. Those omitted were essentially similar in character to those given in Table I. Except for some of the penicillin strains, a fairly high order of resistance to the various drugs tested was obtained. None of the paired organisms resistant to sulfathiazole, streptomycin or penicillin showed any change in resistance to furacin.

In most cases identical results with furacin were obtained with both the resistant and susceptible members of a pair of organisms. In some cases at the end of 48, 72, or 96 hours, differences were observed in the highest dilution inhibiting growth; that is, one member of a pair would show growth only at the next lower dilution. This reaction was just as likely to occur in the resistant as the susceptible strain of a pair of organisms.

Several experiments were tried with pairs of pneumococci[1b] resistant to sulfathiazole, acriflavine, atabrine and optochin. However, these strains grew at the highest possible concentration of furacin (1:5000), both under aerobic and anaerobic conditions, with minute inocula. The relative resistance to furacin, therefore, could not be ascertained.

Summary and Conclusions. Several Gram-negative and Gram-positive organisms resistant to sulfonamides, streptomycin and penicillin and the parent susceptible strains were tested in parallel for their susceptibility to furacin. No differences were observed between the resistant and susceptible strains in regard to their susceptibility to furacin. Resistance to penicillin, streptomycin or sulfathiazole does not result in any change to furacin resistance.

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The Corneal and Lenticular Changes Resulting from Amino Acid Deficiencies in the Rat.

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Corneal vascularization is a tissue change which may result from certain nutritional deficiencies.[1] Totter and Day[2] observed that this change resulted in the rat from deficiencies of tryptophane or lysine. Maun, Cahill and Davis found that corneal vascularization

[1] Dann, W. J., and Darby, W. J., *Physiol. Rev.* 1945, **25**, 326.

[2] Totter, J. R., and Day, P. L., *J. Nutrition*, 1942, **24**, 159.