1: 10,000. Since the rocker tube concentrations in the wound-hormone experiments were all above this range, and showed stimulation of a higher order, the stimulation obtained in these experiments can not be accounted for by the direct effect of heteroauxin on the yeast in the rocker tubes.

It is concluded that the effect of heteroauxin on yeast is consistent with the mode of action suggested by Leonian and Lilly for its effect on plant tissues.

JOHN R. LOOFBOUROW
SISTER CECELIA MARIE DWYER, S.C.
INSTITUTUM DIVI THOMAE
INSTITUTE OF SCIENTIFIC RESEARCH
CINCINNATI, OHIO

CHANGES IN WHEAT METABOLISM CAUSED BY POWDERY MILDEW

INFECTION of wheat with the obligate parasite *Erysiphe graminis tritici* results in a gradual decline in vigor and growth, culminating, in cases of severe infection, in the death of the host. This effect of the mildew is accomplished in spite of the fact that the parasite does not penetrate beyond the epidermal cells, in which large-lobed haustoria are formed. Up to the present time it has not been possible to measure separately the respiration and fermentation of an obligate parasite and that of its host. We have been able to accomplish this, however, in the case of *E. graminis tritici*. By carefully scraping away all the wheat tissue except for the lower epidermis, the latter may be obtained as a strip a single cell thick, with the uninjured mildew attached. Measurements on 5 cm.^{2} of normal epidermis give no respiration within the limits of the apparatus ($\pm$ 0.05 c. mm 0_2/cm^2 surface per hour), while with a similar area of mildewed epidermis the oxygen consumption is 1.3 c. mm per cm^2 surface per hour. On removal of the mildew from the epidermis with a camel's hair brush the oxygen consumption disappears. Thus the oxygen consumption of mildewed epidermis is, within the limits of experimental error, a measure of the mildew respiration. In this way it is possible to distinguish changes which the mildew induces in the host respiration from gross changes in the host-mildew association.

Our experiments were carried out using a Fenn[1] volumetric micro-respirometer, at 22.0° C. Only the first leaf of normal wheat 15 to 25 days old was used. Within these age limits, respiration and fermentation of wheat are fairly constant. Normal wheat was heavily inoculated about 10 days after planting, and the first leaf used for experimental work 7 to 8 days later. The infected wheat was therefore 17 to 18 days old.

Pratt has shown in an article appearing recently[2] that in wheat inoculated with *Erysiphe graminis tritici* there is a rapid rise in the respiration to a value two to three times that of normal wheat of similar age. We have obtained similar results, as may be seen from the data in Table I. In these experiments the respiration of infected wheat was increased 250 per cent. above that of normal wheat. In addition, we have found that if the mildew is removed from the wheat with a camel's hair brush the respiration does not return to the level of uninfected wheat. This conclusion is borne out by measurements of the respiration of mildewed epidermis. One cm.^{2} of infected epidermis consumes only 1.3 c. mm of 0_2 per hour, which is much less than the increase in respiration produced in diseased wheat by the mildew (Table I).

TABLE I

Tissue	c. mm O_2 consumed/cm^2 leaf surface/hour			
	1	2	3	Average
Normal epidermis	±.05	±.05	...	..
Mildewed epidermis	1.17	1.61	1.21	1.3
Infected epidermis Mildew removed	±.05	±.05	...	..
Normal wheat	1.81	1.67	1.68	1.7
Mildewed wheat	6.33	5.22	6.46	6.0
Mildewed wheat	10.7	6.6	...	..
Mildew removed	7.4	5.4	...	..

Further confirmation of this conclusion was obtained by the use of sodium azide as a poison to differentiate between the respiration of mildew and wheat. A 0.001 molar solution of sodium azide has no appreciable effect on the respiration of normal wheat, but nearly eliminates the respiration of the mildew (Table II).

TABLE II

Tissue	c. mm 0_2 consumed/cm^2/hour				Decrease from control value
	1	2	3	Ave.	
Mildew	1.61	1.08	1.21	1.30	
Mildew NaN_3	.18	.13	...	0.15	
Normal wheat	1.81	1.68	1.67	1.72*	
Mildewed wheat	6.33	5.34	6.46	6.04	
Mildewed wheat 10^{-3} M NaN_3	4.45	3.50	...	4.45	1.39

* In this group of experiments no measurements were made of the respiration of normal wheat in azide. In another set, however, the decrease in azide was only 8 per cent.

If the increased respiration due to infection is largely an increase in host respiration, sodium azide should cause a decrease in the oxygen consumption of mildewed wheat which is not greater than that of the mildewed epidermis. As may be seen from Table II, this is actually the case. Although cyanide is just as effective a poison for the respiration of mildew, it is unsatisfactory as a differential poison, since it stimulates wheat respiration.

The fermentation of normal wheat can readily be compared with that of the infected wheat tissue, as

[1] W. O. Fenn, *Amer. Jour. Physiol.*, 84: 110, 1928.
[2] R. Pratt, SCIENCE, 88: 62, 1938.

mildewed epidermis shows no measurable anaerobic CO_2 production. From Table III it is at once apparent that the infection causes an increase of about 50 per cent. in host fermentation.

TABLE III

Tissue	Anaerobic CO_2 in c. mm			$CO_2/cm^2/hr.$
	1	2	3	Ave.
Normal wheat	1.76	1.80	1.76	1.77
Mildewed wheat ...	2.63	2.70	...	2.67
Mildewed epidermis .	±.03	0.00	±.08	...

The pathogenesis of mildew infection of wheat is correlated with an increase in fermentation and a larger increase in respiration of the host tissue. These changes in the host metabolism occur in the green cells of the mesophyll which are not in contact with, nor invaded by, the hyphae of the mildew. Preliminary measurements of the effect of the disease on photosynthesis indicate that the destruction of functional chlorophyll is subsequent to these changes in fermentation and respiration.

PAUL J. ALLEN
DAVID R. GODDARD

DEPARTMENT OF BOTANY,
UNIVERSITY OF ROCHESTER

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A PRACTICAL BELLOWS RECORDER[1]

THE Brodie bellows is regarded as one of the most satisfactory recorders of volume changes that we have. Various modifications have been suggested from time to time, but most of them are time-consuming in preparing them for use or they are too complicated to be easily practical. One of the most popular methods of preparing the Brodie bellows is with cargile membrane. This method presents several difficulties. A set of patterns is necessary to cut the membrane. The gluing constitutes the most troublesome feature of the preparation. It usually requires a skilled technician to prepare one that is effectively air-tight. After one has been used once, it requires continuous attention to insure its being available for a second use, *i.e.*, it must be covered with cotton and soaked in glycerin in order to keep it pliable. A few months' use of this instrument together with frequent failure on the part of technicians to prepare one properly led the author to study the problem with the purpose of devising an instrument that would not lose in accuracy and yet be easy to prepare.

The following device was finally arranged and has been in use for some time by the author and many other workers. It consists essentially of a base plate of brass, to which is attached an arm for mounting to an iron support. At the distal end of the mounting arm is a small removable block which is fastened to the base plate by set screws. Through the middle of the base is drilled a hole, which is countersunk from above. A threaded brass tube with a shoulder at one end passes through this hole, the shoulder fitting accurately into the countersunk depression. The bellows fold is made by using either a rubber condom or, with the smaller models, a thin finger cot. If a condom is used, it may be cut off at about one-half length, and with the removable block raised or removed, the condom is placed on the brass plate until the closed end extends a little beyond the free end of the brass plate. Note the position where the threaded tube which passes through the brass plate lies. Mark the point on the condom and cut a small hole in it at that point. Remove the brass tube and inserting its small end first into the condom, push the small end through the hole previously cut. Place a little colophonium cement in the countersunk depression. Warm it gently and then quickly thrust the tube through the hole and immediately tighten the wing nut screwed on the tube beneath the brass plate. Now place the open end of the condom under the brass block and tighten the set screws. The bottom of this block should be covered with a thin piece of soft leather or blotting paper and a similar piece should be laid on the top of the base plate lying under the block. In our laboratory, we have taken a piece of leather from a lady's kid glove and have split a thin layer from it. The object of the leather is to form a padding to grip the condom tightly when the thumb screws in the block are tightened.

All that is left to do now is to fasten the aluminum plate on the top of the condom. This is done by placing one edge of the aluminum plate in the groove in the brass block. With a spot of colophonium cement on the under side of the plate and with *very gentle* traction on the condom, heat the aluminum plate with a metal rod or small flame and push it down firmly against the rubber, holding it until the cement has set. The object of making slight traction on the condom is to insure the edge of the aluminum plate being drawn back snugly into the groove in the brass block when the condom is released. In this way a perfect hinge is formed and wobbling is prevented. On top of the aluminum plate may be fastened any type of writing point—straw, aluminum or celluloid. The length of the writing point may be suited to the needs of the experiment at hand.

[1] From the Department of Pharmacology, Boston University School of Medicine and the Evans Memorial Hospital.