

AEROALLERGEN STUDIES WITH THE MOLECULAR FILTER MEMBRANE

CLIFFORD W. GURNEY, M.D., AND SYDENHAM CRYST, M.D.,* ANN ARBOR, MICH.

INTRODUCTION

AEROALLERGEN studies were performed in Ann Arbor, Michigan, during the summer of 1954. The specific goal was to examine the patterns of fluctuation of ragweed pollen concentration through twenty-four-hour cycles. Since this information was being obtained, it was thought to be of some interest to see to what degree fluctuations of patients' symptoms might be related to change in ragweed pollen concentration.

A massive volume of literature pertaining to atmospheric sampling of ragweed pollen has been recorded in the last twenty-five years, culminating recently in a detailed account of regional distribution of aeroallergens.¹ Most of the data accumulated have been concerned with samples obtained in consecutive twenty-four-hour periods; there have been occasional investigations of diurnal ragweed pollen variation. In 1929, Durham² stated, "An hourly study, made during the height of the season, shows that most of the day's yield of pollen was thrown into the air early in the morning at the usual time of ripening of the male flowers. By midnight, the bulk of this load had been precipitated." This conclusion is based on data obtained over a single twenty-four-hour period. Excellent studies pertaining to the diurnal variation in incidence of grass pollen have been performed in Great Britain by Hyde and Williams³ employing a modification of the gravity sampling technique. Since dissemination of ragweed pollen is not a problem in Great Britain, these investigators did not include results pertaining to this aeroallergen. More recently, Smith and Rooks,⁴ employing an impingement type of volumetric sampler, concluded: "Only 10 per cent of the pollen collected for the twenty-four-hour periods was collected from 6:00 P.M. to 6:00 A.M. during the months of August and September." This is consistent with the results of Jones,⁵ who used a gravity type sampler. However, Wilmer and Cobe,⁶ employing a modification of the gravity sampler, obtained counts every two hours at nine different levels, and it is interesting to note the high values obtained at 5:30 A.M.

It has long been recognized that the ideal method of obtaining estimates of aeroallergens would be the actual filtration of a known volume of air. Precise quantitative pollen counts could then be made, and they would have volumetric significance. Previous methods of aeroallergen study have been ingenious compromises with this ideal technique and the reality that no filter was available to perform this service. The variety of techniques employed

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*From the Department of Internal Medicine, University of Michigan Medical School.

(hair dryers,⁷ air centrifuges,⁸ a vacuum cleaner,⁹ shielded slides and slides exposed to the wind,¹⁰ cascade impactors, etc.) testify only to the generally unsatisfactory nature of available techniques. Nor did erudite discussions of Stokes's law and Scheppegrell's modification¹¹ serve to place gravity sampling on any firmer foundation. Perhaps the objections to the gravity sampling technique have been expressed most succinctly by Hewson¹² when he stated: "The number of particles which are impacted per unit time on the slide must be a complex function of their size and of the contemporary atmospheric turbulence; the impaction rate will vary with the fluctuating wind speed and

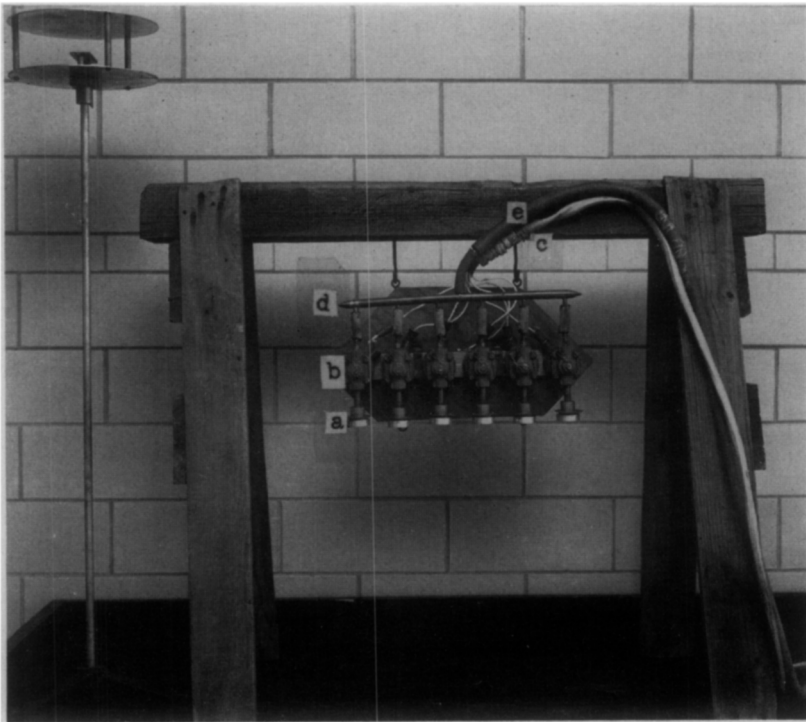


Fig. 1.—The portion of the apparatus containing the molecular membrane filters, and a conventional gravity sampler.

This portion of the apparatus was photographed in the laboratory. During the course of the experiment, it was located on an unobstructed roof six floors above the ground.

A molecular filter membrane is present in each of the metal heads (*a*). Electrical valves (*b*) are connected to control apparatus by way of wires coming through conduit (*c*). When each valve in its turn is open, air passes through the filter into the metal tube (*d*) and into the tube (*e*) which is attached to a vacuum pump.

angle of attack on the coated slide. A more accurate conversion factor which is a function of gustiness might be specified, but the gustiness itself would then have to be measured, which introduces a complication. A direct, simple, and accurate measuring technique is greatly to be preferred," and by Fletcher and Veltz,¹³ who stated that "probably because of high degree of turbulence associated with variation in air movement, pollen grains actually land on an exposed slide more in accordance with the laws of chance than with laws of

gravity." Throughout all these early studies, the allergist readily called upon his colleagues in physics, botany, and engineering for help in solving the problem. The technique which we adapted does likewise.

The method to be described herein is complex and the apparatus is costly. It is not intended to replace the conventional method of pollen counting at the present time, but we believe that it has value as a research tool.

THE METHOD

In recent years a synthetic filter, known as the molecular filter membrane,¹⁴ became available. The filter, 1 inch in diameter, is paper-thin and contains $5 \text{ by } 10^7$ pores per square centimeter. Particles as small as 0.2 micron are quantitatively removed from an air stream passing through the filter. A simple compact pump is available for obtaining single samples of any desired volume of air but, since we wished to obtain frequent determinations

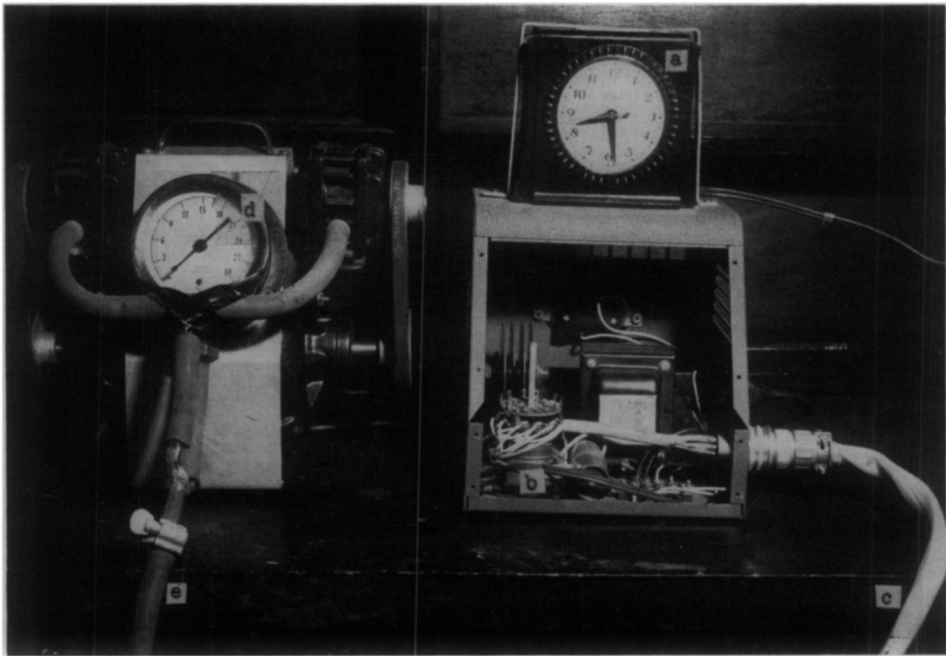


Fig. 2.—Apparatus which controls periodic sampling.

Telechron clock (a) activates solenoid (b), permitting current to flow to a different valve every four hours through conduit (c). Vacuum pump (d) is in operation while each valve is open, and is connected with the heads containing the molecular filter by the tubing (e).

during each twenty-four-hour period, a more complex apparatus was necessary. Ours consisted of a battery of six such filters connected to an air pump and controlled by electrically operated valves (Figs. 1 and 2). A timing device was added so that serial samples could be obtained throughout the day. We obtained thirty-minute samples every four hours, giving six samples in each twenty-four-hour period. The filters were removed and mounted on slides, and total ragweed counts were made each day. Each used filter, con-

taining all aeroallergens of particle sizes greater than 0.2 micron obtained from a volume of 270 liters of air, was counted in its entirety. Pollen and fungi could be identified as readily on these filters as on conventional gravity slides. A separate report describes in detail the specifications and operation of our apparatus.¹⁵

Preliminary studies indicated that if the battery of filters pointed into the wind there was a significant increase of pollen when compared with simultaneous determinations taken down wind. In order to nullify the effect of wind, the filters were directed downward when further studies indicated that there was no significant loss of pollen. The apparatus was placed on an unobstructed roof six floors above the ground.

DATE: SUN., MON., TUES., WED., THURS., FRI., SAT.,	Aug. SEPT.					
	2:00 AM- 6:00 AM	6:00 AM- 10:00 AM	10:00 AM- 2:00 PM	2:00 PM- 6:00 PM	6:00 PM- 10:00 PM	10:00 PM- 2:00 AM
STUFFINESS.						
WATERING OF NOSE.						
SNEEZING.						
ITCHING: NOSE OR EYES.						
WHEEZING						
ANTIHISTA- MINES.						
OTHER MEDICATIONS.						

REMARKS:

CODE # _____

O = NO SYMPTOMS
 + = MILD TO MODERATE
 ++ = SEVERE SYMPTOMS
 ✓ = OUT OF TOWN
 S = SLEEPING

Fig. 3.—A sample postcard. Each patient was supplied with one such postcard for each day of the 1954 ragweed season.

Seventeen patients with ragweed sensitivity, living in or near Ann Arbor, were supplied with postcards (Fig. 3) on which they recorded severity of symptoms according to a code at the bottom right-hand corner. An arbitrary index of symptom severity was calculated by adding the numbers of plusses in each time period for all the patients and dividing this sum by the number of patients reporting for each period. On those days when any patient was away from the Ann Arbor vicinity, his reports were excluded from calculation of that day's index of symptoms. Thus, if all seventeen patients experienced the maximum symptoms from 6:00 A.M. to 10:00 A.M. on a given day (recording ++ for each of the five symptoms—stiffness, rhinorrhea, sneezing, itching of nose, and wheezing) totaling ten +'s per patient, the total would be 170 for the four-hour period. If this figure is divided by seventeen (the number of patients reporting), the index of symptoms would be 10. The index is thus corrected for absence of patients, failure to reply, incorrect dating of postcard, or masking of allergic symptoms by other illness.

RESULTS

The fluctuation of pollen concentration is shown in Figs. 4 and 5; each block represents one day, and the date is shown on the abscissa. The initial value each day is the 8:00 A.M. determination, and the following values rep-

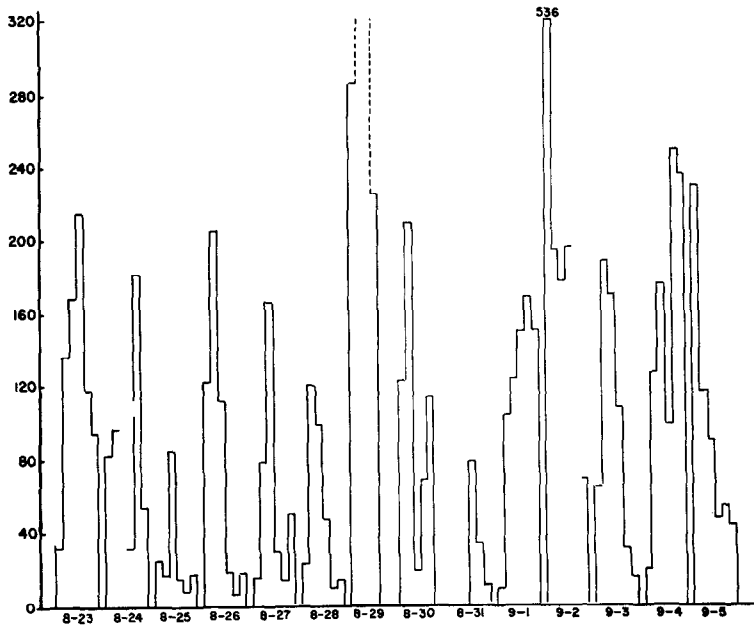


Fig. 4.—Fluctuation of ragweed pollen concentration. Dates are recorded along abscissa. Values along ordinate represent ragweed pollen grains per 270 liters.

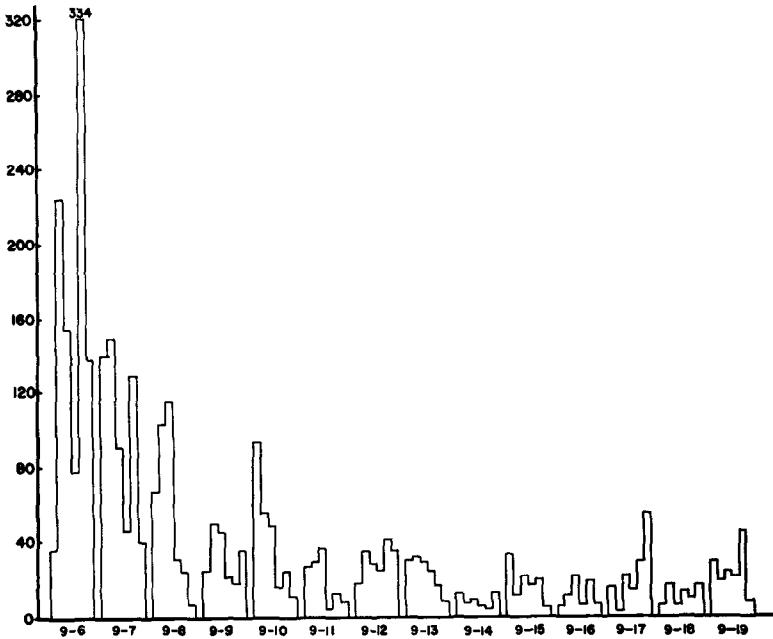


Fig. 5.—For explanation, see Fig. 4.

resent the determinations every four hours thereafter; the last value in each day's bar represents the 4:00 A.M. value for the following day. The method of graphing was chosen, as it seemed likely that the ragweed pollen in the atmosphere at midnight and 4:00 A.M. largely represented carry-over from the pollen liberated in the previous twenty-four-hour period. The height of each individual bar represents the number of ragweed pollen grains on the corresponding filter. The pollen was obtained from the 270 liters of air which passed through the filter during the half-hour that its specific valve was open.

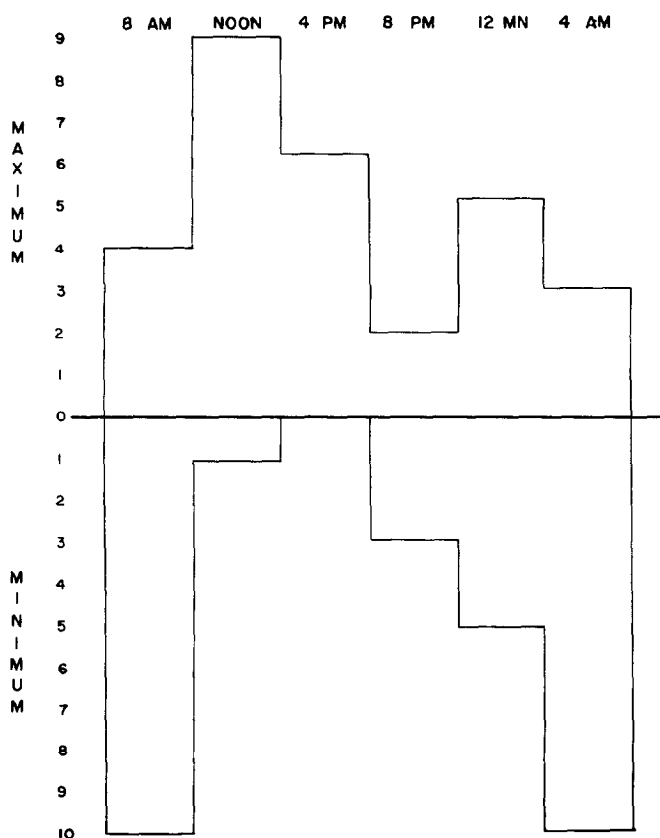


Fig. 6.—Frequency of the daily maximum and minimum pollen concentrations at each of the sampling periods.

The ordinate, then, shows the amount of pollen contained in approximately 10 cubic feet of air (270 liters = 9.5 cubic feet) during each of the time periods shown on the abscissa. On two occasions the results were too high to be charted using the coordinate values employed; these results are indicated in the appropriate space.

Several conclusions are apparent from Figs. 4 and 5. First, the usual pattern of fluctuation of ragweed pollen concentration is for higher values during the midday and lower values in early morning and late at night, as would be anticipated. Second, although pollen is liberated in the late morning,⁵

these studies show that high concentrations of ragweed pollen were present at midnight and 4:00 A.M. on several occasions. For example, on August 30, September 4, and September 6, late peaks occurred, on the latter two occasions with the daily maximum concentrations occurring at midnight.

Fig. 6 represents the incidence of maximum and minimum concentrations in each four-hour period. Of the twenty-nine complete daily cycles shown, twenty-three were taken from Figs. 4 and 5 (in each of the instances where complete data were available for the twenty-four-hour period). The data for the other six days were obtained prior to Aug. 23, 1954, at a time when the orientation of the filters was upward rather than downward, and we have not included them in Fig. 4, as they are not comparable. The difference, however, does not affect the time of maximum pollen concentrations. On the basis of the information in Fig. 6, one can again appreciate the fact that, although a pattern appears to emerge with higher concentrations occurring at noon and 4:00 P.M. and lower concentrations occurring from midnight through 8:00 A.M., the maximum and minimum concentrations can occur at any time with the exception of 4:00 P.M., when no minima are recorded. We should like to emphasize that these generalizations stem from a limited amount of data; many future determinations are necessary if they are to be verified. The patterns described apply to a sixth-floor level and, since simultaneous ground-level determinations were not obtained, we do not know whether the same fluctuations occur at zero elevation.

Figs. 7 and 8 record the fluctuations of patients' symptoms. Each fragment of the broken line represents one day, extending consecutively from Aug. 23, 1954. Only 6:00 A.M. to 10:00 P.M. periods are recorded; the 10:00 P.M. to 2:00 A.M. and 2:00 A.M. to 6:00 A.M. indices were omitted because it was found that most patients were sleeping during these periods and, therefore, did not record symptoms. Calculating the index of symptoms at times when the patients with severe allergies were awake because of allergic difficulty, excluding those patients whose disease was of less severity but whose symptoms entered into the calculations during the day, would give falsely high values for indices during the night.

The preceding data suggest that fluctuations of symptoms of patients in and around Ann Arbor fail to show any close correlation with ragweed concentration as determined at the sixth floor. Possibly the concentrations of ragweed at the sixth floor may be different from those on the ground, and the variations of ragweed concentration in different locations probably are quite marked. Further, the concentration of dust, fungus, and other aeroallergens, to which some of the patients were also sensitive, would not necessarily parallel ragweed. Perhaps of greater importance is the pattern of fluctuation. It will be seen that, with one exception (September 18), symptoms were always higher in the morning, falling to a lower value at noon. Frequently there was a secondary rise in symptoms in the evening; this value sometimes exceeded the 8:00 A.M. determination. With one exception, there is a consistent pattern of more difficulty in the morning and improvement at

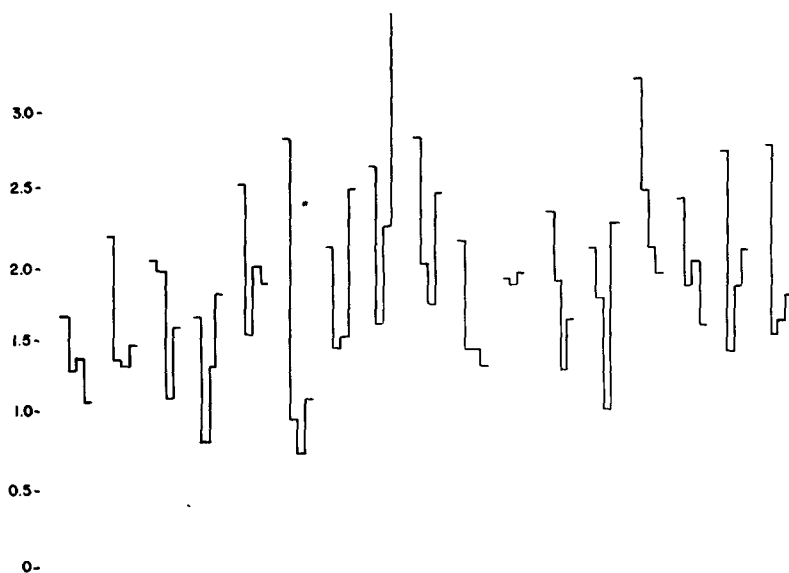


Fig. 7.—Index of symptoms. Each day is represented by one portion of the broken line, beginning on Aug. 23, 1954 (left), and extending through Sept. 8, 1954 (right).

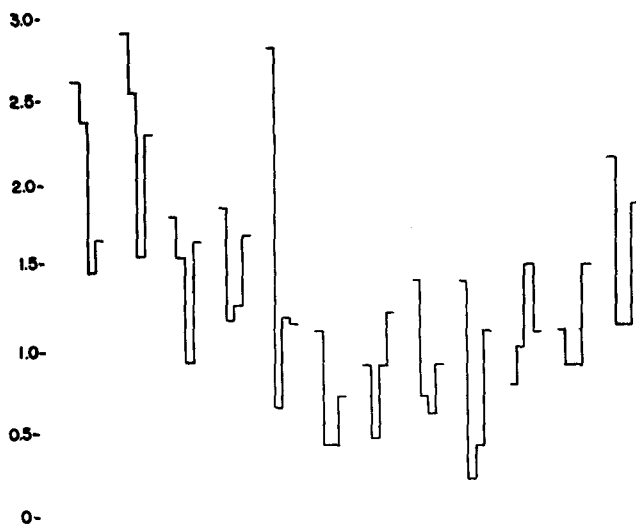


Fig. 8.—For explanation, see Fig. 7. Sept. 9, 1954, through Sept. 20, 1954.

noon, frequently in spite of a marked rise of ragweed concentration during this interval. This pattern of symptoms would seem to be worthy of further investigation.

CONCLUSIONS

1. A new method of aeroallergen determinations is discussed.
2. Fluctuations in ragweed pollen concentration throughout twenty-four-hour cycles are recorded. A pattern of higher ragweed concentrations at mid-day and lower concentrations in the late evening and early morning hours is suggested, although there are exceptions to this tendency.
3. The symptoms of the patients studied do not correlate readily with ragweed concentration, but suggest an interesting independent pattern. Manifestations of allergic disease were more prominent in the morning and decreased at midday, often despite a marked increase in ragweed levels.
4. In view of the lack of correlation between fluctuations of aeroallergen concentrations and severity of patients' symptoms, there does not appear to be sufficient reason at this time to recommend the replacement of the simple method of aeroallergen sampling presently used by a precise, though more complicated, volumetric method of sampling.

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