The micrographs of 'polysheath', however, suggest that the sub-units of the tailsheath are of the self-assembling type. Leo Sachs (Weizmann Institute) considered problems of cell differentiation and the immune mechanism. Lymphoid cell precursors, in tissue culture, can form essentially pure cultures of either mast cells or antibody-producing cells, provided a suitable layer of other cell types is present in the medium. Lymphoid precursors from lymph nodes of a rat, exposed to mouse cells, differentiate to give cells releasing antibodies, which destroy the mouse cells, that is, this is a heterograft reaction *in vitro*. Both Sachs, and independently Dulbecco, have examined the transformation of normal into tumour cells by the polyoma virus; the virus acts directly on the cells to induce the change. Michael Feldman (Weizmann Institute) considered the role of the thymus in promoting antibody formation in the adult organism, making use of the histocompatibility antigens which are determined by the Y-chromosome of male animals. Transfer of such antigens from a male to a female of the same species, in a tissue graft, leads to rejection of the graft by the female, due to an anti-Y immune response. Some tumours induced in males cannot grow when transplanted into females, because they evoke a similar response. However, animals previously irradiated with X-rays fail to develop the immune response until after several weeks, and the tumour in the female continues to grow. If the animal has been thymectomized, the immune mechanism does not recover at all after X-radiation; grafting a thymus back into such animals, however, does lead to recovery of the immune response. This recovery is an inductive effect of the thymus; it is not due to production of immunologically competent cells by the thymus itself.

H. H. Weber (Heidelberg) discussed the role of ATP in the active transport of ions, with especial reference to the work of W. Hasselbach in his institute on the vesicles of the sarcoplasmic reticulum, which accumulate calcium ions. There is a very close correlation between the Ca^{++} ions transported and the ATP hydrolysed (2 Ca^{++} per ATP). He concludes that the ATP donates an energy-rich bond to phosphorylate a carrier in the membrane, and that the phosphorylated carrier has an affinity for Ca^{++} several hundred times as great as the unphosphorylated carrier. David Nachmansohn (Columbia University) considered chemical control of movements of ions across conducting membranes, with special reference to nerve and electric organs. Hugo Theorell (Stockholm) set forth, with beautiful clarity, his recent work on complexes of liver alcohol dehydrogenase with coenzymes and inhibitors or substrates.

The last session was devoted to immunochemistry. Michael Heidelberger (Rutgers University) described his recent work on the immunological properties of the capsular material of pneumococci of various types. The structure of the carbohydrates in these capsules is now becoming known in far more detail than ever before—in type SV, for example, recent work of Barker in Birmingham, on material supplied by Heidelberger, has identified N-acetyl-L-fucosamine and N-acetyl-6-deoxytalosamine, among other constituents. These two sugars were never before known in natural products. The chemical identification of antigens by immunochemical techniques is now being refined, and in many cases furnishes a short cut to determination of the structure of the antigen. Michael Sela (Weizmann Institute) described his research work on the development of polyamino-acids and their derivatives as synthetic antigens. One good antigen can be made from polylysine, by first growing alanyl chains on the amino groups of the lysyl side-chains, and then attaching tyrosyl chains to the alanyl chains. If the attachments are made in reverse order—first tyrosine, then alanine—the resulting product is not antigenic. The tyrosyl groups must be on the outside to make a good antigen. The optical specificity of the amino-acids is important—compounds made from combinations of D-amino-acids are generally non-antigenic, even when the corresponding L-compounds are strongly antigenic, as recent work of Gill and Doty has shown (*Nature*, **197**, 746; 1963). Dr. Sela's recent work has shown that electric charge is not necessary for antigenicity; they have recently synthesized a water-soluble uncharged polymer that is strongly antigenic (Sela, M., and Fuchs, S., *Biochim. Biophys. Acta*, **74**, 797; 1963). When galactose is attached to a synthetic polymer, the galactose grouping becomes a powerful antigenic determinant. Immunological tolerance may be established to synthetic antigens, as shown by experiments on new-born rabbits. The aim of all this research work is to throw light on the nature of the immune mechanisms found in living organisms; the synthetic chemicals are merely a means to this end.

J. C. Kendrew concluded the final session with brief, graceful and humorous comments on some of the major points of the symposium.

One non-scientific interlude deserves mention. Midway in the week we left Rehovoth for a two-day trip along the coast, to Caesarea, Haifa and Acre, then to the Galilee mountains and the Lake of Galilee. We stopped overnight at a kibbutz which, in addition to the usual farming and other community activities, ran a small and very pleasant hotel for visitors. That evening all of us had the opportunity to talk with members of the kibbutz and learn directly about their way of life, its values and its problems. We returned with renewed zest to the scientific conference after this fascinating interlude. In addition to this thoughtfully arranged pause in the symposium, all of us will remember the warm and generous hospitality of our Israeli hosts, during and after the conference, which combined with the high level of the scientific discourse at the meetings to make this a most memorable occasion.

RADIO OBSERVATIONS OF OH IN THE INTERSTELLAR MEDIUM

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In this article we wish to report the detection of 18-cm absorption lines of the hydroxyl (OH) radical in the radio absorption spectrum of Cassiopeia A, thereby providing positive evidence for the existence of OH in the interstellar medium. The microwave transitions of OH in the ground-state, ${}^2\pi_{3/2}$, $J = 3/2$, arise from two Λ-type doublet-levels, each of which is split by hyperfine interactions with the hydrogen nucleus, so that four transitions result. The two strongest lines have been previously measured in the laboratory at 1,667·34 ± 0·03 Mc/s ($F = 2 \rightarrow 2$) and 1,665·46 ± 0·10 Mc/s ($F = 1 \rightarrow 1$) with relative intensities of 9 and 5, respectively[1]; these results are in agreement with theory. The suggestion that these lines might be detected in the radio spectrum of the interstellar medium has been made by Shklovsky[2] and Townes[3]. A previous search by Barrett and Lilley[4], in 1956, was unsuccessful, primarily because the laboratory measurements of the frequencies had not been made. A recent search for OH emission also yielded negative results[5].

Our observations were conducted on 10 days between October 15 and October 29, 1963, using the 84-ft. parabolic antenna of the Millstone Hill Observatory of Lincoln Laboratory, Massachusetts Institute of Technology, and the spectral-line autocorrelation radiometer designed by Weinreb[6]. The receiver uses digital techniques to determine the autocorrelation function of the received signal. The resulting autocorrelation function is then coupled directly into a digital computer that performs a Fourier transformation and displays the resulting spectrum on a cathode-ray tube or a precision *x*-*y* plotter. During one integration time-interval of 2,000 sec, a 100-kc/s portion of the spectrum is determined with a frequency resolution of 7·5 kc/s. The ability to see immediately a calibrated visual display of the measured spectrum and average this result with others greatly facilitated the conduct of the experiment and eliminated almost all post-observation data handling. The system noise temperature was 420° K, of which 110° K was due to Cassiopeia *A*. System tests were performed by observing the hydrogen line.

The results obtained during the first evening of our observations showed strong evidence of the 1,667 Mc/s line in Cassiopeia *A*; the signal is visible after 2,000 sec of integration. We decided that positive identification of OH absorption lines of Cassiopeia *A* would be secured before proceeding to observations of other regions. Our results indicate that two of the three clouds showing strong H absorption[7], namely, those at radial velocities of −0·8 km/sec and −48·2 km/sec, also give rise to OH absorption lines that we have detected at both 1,667 Mc/s and 1,665 Mc/s. The strong H absorption line at − 38·1 km/sec appears to be composed of two lines at − 37·4 km/sec and − 42·1 km/sec when observed at the OH frequency. It is to be expected that a one-to-one correspondence between OH absorption and H absorption will not be observed because of: (*a*) greater thermal broadening of H lines; (*b*) larger optical depth of the H lines; (*c*) possible OH/H abundance variations from cloud to cloud. A typical rocord showing the 1,667-Mc/s line in the − 0·8 km/sec cloud is shown in Fig. 1. A summary of all of our observations is presented in Table 1.

Table 1. SUMMARY OF OH LINE ABSORPTION MEASUREMENTS IN THE CASSIOPEIA *A* RADIO SOURCE

Radial velocity (km/sec)	1,420·405 Mc/s H-line optical depth (ref. 7)	1,667·357 Mc/s OH-line optical depth	Observed line width (kc/s)	Number of OH radicals per cm^2	Abundance ratio relative to H
−0·8	1·85	0·016 ± 0·005*	13	$\sim 2 \times 10^{14}$	$\sim 1{\cdot}5 \times 10^{-7}$
−37·2	—	0·010 ± 0·005	13	$\sim 1{\cdot}5 \times 10^{14}$	—
−42·1	—	0·012 ± 0·005	20	$\sim 3 \times 10^{14}$	—
−48·2	4·0	0·016 ± 0·008	25	$\sim 5 \times 10^{14}$	$\sim 1 \times 10^{-7}$

* An optical depth of 0·010 ± 0·003 with line width of 16 kc/s was observed for the 1,665·402 Mc/s line.

The evidenco that we are indeed detecting interstellar OH in these observations may be summarized as follows:

(1) Lines at both 1,667 Mc/s and 1,665 Mc/s have been detected with frequencies and intensity ratios that are in good agreement with the expected values.

(2) The OH absorption spectra at both frequencies show general agreement with the H absorption spectra.

(3) The absorption lines disappear when the antenna is positioned off Cassiopeia *A* by one degree in both azimuth and elevation.

(4) The lines shifted 20 kc/s between October 17 and October 29; this is the shift expected from the orbital velocity of the Earth during this time-interval.

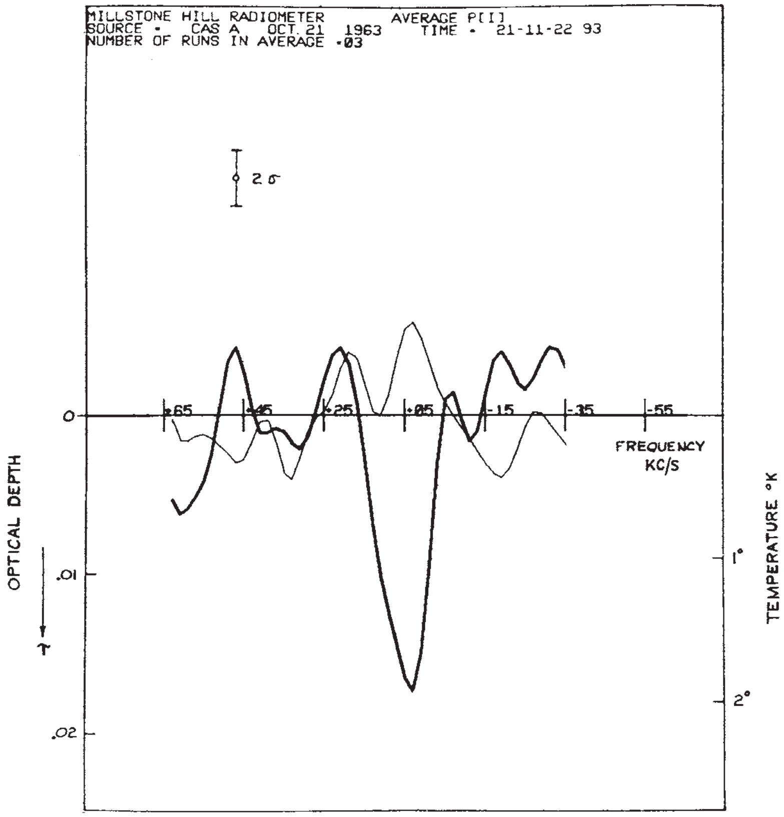

Fig. 1. Observed 1,667 Mc/s OH absorption spectrum in Cassiopeia *A*. The heavy line shows 8,000 sec of data taken with the antenna beam directed at Cassiopeia *A*, and the light line shows 6,000 sec of data taken with the beam displaced slightly from Cassiopeia *A*. The frequency scale is specified in kc/s with respect to the local standard of rest assuming the line rest frequency to be 1,667,357 kc/s

A quantity of immediate astrophysical interest which follows from our observations is the abundance ratio of OH to H. This can be obtained in the following way: the spectral change in antenna temperature ΔT_{OH} owing to the OH absorption is given by:

$$\Delta T_{\mathrm{OH}} = \tau_{\mathrm{OH}} T_{\mathrm{AC}}$$

where τ_{OH} is the OH optical depth in the direction of Cassiopeia *A* and T_{AC} is the antenna temperature attributable only to Cassiopeia *A*. The maximum optical depth is given by:

$$\tau_{\mathrm{OH}} = \frac{hc^2 A N_{\mathrm{OH}}}{8\pi k T_s \nu_0 \Delta\nu} \frac{g_i}{\Sigma g_i}$$

where A is the spontaneous transition probability, T_s is the excitation temperature analogous to the H spin temperature, ν_0 is the line frequency, $\Delta\nu$ is the line width, g_i is the statistical weight of level i, and N_{OH} is the total number of OH radicals per unit cross-section. The statistical weight g_1 of the upper level of the 1,667-Mc/s transition is 5, and for the 1,665-Mc/s transition it is 3; the sum of the statistical weights for all levels is 16. The spontaneous transition probability A must be evaluated by using the matrix element derived from a quantum-mechanical treatment of Λ-type doubling[8], and has the value $2{\cdot}86 \times 10^{-11}$ sec^{-1} for the 1,667-Mc/s transition. The OH dipole moment used in these calculations[9] is $(1{\cdot}60 \pm 0{\cdot}12) \times 10^{-18}$ E.S.U.

The excitation temperature T_s is the subject of considerable uncertainty because it cannot be assumed that it will be the same as that for H. The excitation temperature is defined by the relation:

$$\frac{n_i}{n_0} = \frac{g_i}{g_0} e^{(-h\nu)/(kT_s)}$$

where n_i and n_0 are the densities of radicals in the upper and lower states of the transition, respectively. For H it has been shown that T_s equals the kinetic temperature in a typical galactic gas cloud[10] because radiative transitions are relatively rare as compared with collisional transitions. For OH, however, the spontaneous transition probability is 10^4 times larger than for H, so radiative transitions play a more dominant part in establishing the equilibrium population distribution. A detailed evaluation of the processes that will be important in determining the OH excitation temperature has not been made, but a preliminary investigation shows that slow-moving positive ions may be very effective in inducing transitions between the two states, in spite of their low abundance in a H cloud[11]. This situation arises because the OH transition is of an electric dipole type, and therefore can be induced by the Coulomb field of electrons and ions which leads to large interaction radii. A similar result has been obtained by Purcell when considering the population of the fine-structure states of the $n = 2$ level of H in the solar atmosphere[12]. An upper limit on T_s can be set by our observations off Cassiopeia *A* from which one would expect to detect OH emission. From the preliminary observations we conclude that any OH emission adjacent to Cassiopeia *A* is less than 1° K; this result implies a T_s less than 50° K for an optical depth of 0·02. For purposes of computing the total number of OH radicals from the foregoing equations we have assumed a T_s of 10° K. More extensive observations for OH emission will enable a better estimate of this quantity to be made.

The values of the number of OH radicals per cm^2 in the direction of Cassiopeia *A* are shown in Table 1. The OH/H abundance ratio can be calculated from the results of the H absorption on Cassiopeia *A*[7], and gives typical ratios of 1×10^{-7} (see Table 1). This ratio can be compared with estimates of the CH/H abundance ratio 10^{-6} by Stromgren[13] and 2×10^{-8} by Bates and Spitzer[14].

Our observations have enabled a more accurate determination of the frequencies of the two strongest Λ-type doublet lines of OH. The laboratory and astronomical values are shown in Table 2. It is possible that these values will be of interest to the molecular spectroscopist for a more accurate evaluation of the hyperfine coupling constants.

Table 2. REST FREQUENCY OF OBSERVED LINES

Transition	Laboratory measurement	Astronomical measurement
$F = 2 \rightarrow 2$	1,667,340 ± 30 kc/s	1,667,357 ± 7 kc/s
$F = 1 \rightarrow 1$	1,665,460 ± 100 kc/s	1,665,402 ± 7 kc/s

We thank many people for their co-operation in this experiment. We also thank R. E. Gay, P. J. Conrad, C. Blake, R. H. Erickson, J. F. MacLeod, and the entire personnel of the Millstone Hill Observatory for their assistance.

The work of one of us (A. H. B.) was supported in part by the U.S. Army, the Air Force Office of Scientific Research, and the Office of Naval Research, and in part by the National Aeronautics and Space Administration (Grant *NsG*–419). Lincoln Laboratory is a centre for research and development operated by Massachusetts Institute of Technology with the support of the U.S. Air Force.

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OBITUARIES

Dr. A. A. Griffith, C.B.E., F.R.S.

ALTHOUGH the name of Dr. A. A. Griffith, who died on October 11, was not well known by the general public, he was a creative and original thinker who had considerable influence on the development of jet propulsion systems. A champion of the high-efficiency axial compressor while Whittle was experimenting with the more robust centrifugal engines, Dr. Griffith continued to be ahead of his time in urging, in turn, the by-pass system, small engines for jet lift, the use of hydrogen as a fuel, and had still other novel projects under consideration at the time of his death.

Dr. Griffith was born on June 13, 1893, and attended secondary school at Douglas in the Isle of Man. A Tate technical science scholarship took him to the University of Liverpool in 1911, where he obtained successively a B.Eng. (first-class honours in mechanical engineering), M.Eng. (1917) and D.Eng. (1921).

His first interest was in mechanics, and his joint paper with G. I. Taylor on the use of soap films in solving torsion problems gained the Hawksley Gold Medal from the Institution of Mechanical Engineers in 1917. His famous paper on "Theory of Rupture", in which he used surface energy considerations to determine the stress conditions under which a crack will propagate and lead to failure of a material, was published in 1920, and the concept of the 'Griffith Crack' was discussed at the first International Congress on Applied Mechanics at Delft in 1924.

He had no regular apprenticeship, but received general workshop training between July 1915 and November 1916 at the Royal Aircraft Factory. Following this training, he was successively draughtsman, technical assistant and senior technical assistant in the Physics and Instrument Department at the Royal Aircraft Establishment. During April 1920–April 1928 he was a senior scientific officer in the Physics and Instrument Department, Royal Aircraft Establishment, and then principal scientific officer in charge of the Air Ministry Laboratory, South Kensington, until April 1931, dealing chiefly with engine and instrument work.

During this period he became a firm advocate of the gas turbine for aircraft propulsion, and in 1926 wrote a Royal Aircraft Establishment report entitled "An Aerodynamic Theory of Turbine Design", in which he formulated a number of new ideas. Under his supervision, work on a turbo-compressor test rig was started at the Establishment in 1927.

In 1931, Dr. Griffith was made principal scientific officer in charge of engine research, Engine Department, Royal Aircraft Establishment; in November 1938, the