cates that it is most unlikely that these particles have penetrated into the stratosphere from the troposphere by vertical mixing.

2) Collections of these particles by aircraft at about 20 km over a wide range of latitudes between about 40°S and 70°N over a period of more than half a year show that the particle concentration is remarkably uniform with time and latitude. The combination of these aircraft data with the vertical profiles obtained in middle north latitudes suggests that the aerosol layer is a world-wide, persistent phenomenon.

3) The size distribution, dn/dr, of the particles between 0.1 and 2 μ in radius is of the form

$$dn/dr = kr^{-a}$$

with a being approximately 3; k is a constant. The particles are water soluble, have a tendency to evaporate to a spotty residue in the electron microscope, and show a structure and shape very much resembling those of spray aerosols produced from solutions of ammonium sulfate and some other soluble salts.

4) Analyses of the heavy deposits from long balloon and aircraft flights were performed with electron microprobe techniques and indicated sulfur to be the predominant element in the range of atomic numbers from magnesium (12) through zinc (30). The sulfur is deposited roughly in proportion to the visual density of the collection and has been present in every sample analyzed to date. Occasional samples contained aluminum, silicon, and iron. Some traces of chlorine, potassium, and calcium were found. Table 1 contains a summary of the average composition for both balloon and aircraft samples. We think that these particles consist mainly of ammonium sulfate and adduce, in addition to Table 1, the hygroscopicity of the collected particles and the electron diffraction pattern obtained by Friend (*2*), both of which indicate this compound. The few samples which have contained a significant amount of either silicon or iron, distributed throughout the collection, can be tentatively explained by a temporary fluctuation in micrometeorite influx. In no case was the concentration of either of these elements more than one-third that of sulfur on the same sample, which is in agreement with our identification of the persistent aerosol layer with a soluble sulfate. Since the vertical profile makes a direct tropospheric origin unlikely, and the composition makes an extraterrestrial origin unlikely, it appears that this aerosol must form within the stratosphere itself. The most plausible explanation at the present time is that these particles are formed by the oxidation of H_2S or SO_2 by ultraviolet radiation or ozone at the level where they are found. These gases, known to be present in the troposphere in sufficient quantity, can enter the stratosphere by mixing, without being removed very efficiently by washout in the upper troposphere.

Table 1. Chemical analysis of stratospheric particles from balloon and aircraft samples.

Balloon (0.1μ < particle radius < 1.5μ)		Aircraft (0.02μ < particle radius < 3.0μ)	
Element	Relative concn.*	Element	Relative concn.*
S	0.85	S	0.85
Si†	.08	Al†	.05
Fe†	.04	Si,Ca,K, Fe †	.01
Al‡	<.04		
Cl, K, Ca, Cr, Co, Ni, Cu, Zn ‡	<.01	Mg, P, Cl, Cr, V, Mn, Co, Ni, Cu, Zn ‡	<.01

* No allowance has been included in these figures for combined forms of elements of atomic number less than 12. † The concentration of these elements fluctuates from sample to sample. ‡ These elements were not generally present in detectable amounts.

This world-wide aerosol layer is most likely the one long sought for to explain the Purple Light (*3*). The conspicuous disk of red light above the point of sunset or sunrise has been observed for over a hundred years as a very regular phenomenon. The geometry of its appearance points to a thick aerosol layer in the stratosphere as the origin of the scattered light, although more precise calculations of the height of this layer, to be compared with our profiles, are still missing.

Thus far, our data have provided no support for the theory that rainfall is stimulated on a world-wide basis by the influx of extraterrestrial dust through the stratosphere into the troposphere. The particles of the stratospheric aerosol layer do not have the characteristics required by this theory. In addition, the presence of this aerosol layer seriously prejudices the identification of extraterrestrial dust collected at this altitude. We estimate that, in the size range below 2 μ in radius, the sulfate aerosol is about a factor of 1000 higher in number concentration than the cosmic dust, using Opik's estimate (*4*) for the latter and assuming sedimentation equilibrium in the atmosphere. It is very difficult, therefore, to detect the particles of extraterrestrial origin among the many indigenous ones. On the other hand, the concentration of particles of cosmic dust larger than 2 μ in radius is already so low that optimal sampling conditions provide an expected population of only 1 or 2 per square centimeter on the collection substrate, so that identification against background becomes a problem. If positive fluctuations of meteoritic influx in this size range exist, our data indicate that they must be rare, and it appears that a systematic aircraft collection program is the most promising method for the sampling of such swarms. Such a program is currently in operation through cooperation with the Defense Atomic Support Agency (*5*).

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Queen Honey Bee Attractiveness as Related to Mandibular Gland Secretion

Abstract. The termination of mandibular gland secretion by gland removal in living mated queen honey bees (*Apis mellifera* L.) caused approximately 85 percent loss of queen attractiveness to worker bees. The secretion of attractants in virgin queens increased with age. Old virgins were as attractive as mated queens. A rapid assay for queen attractiveness is described.

The queen bee is attractive to worker bees in the honey bee (*Apis mellifera* L.) colony. Worker bees constantly surround the queen, licking the abdomen, touching various body parts with their antennae, and offering food. Since dead queens or lipid extracts of queens are attractive to worker bees (*1*), chemical mediation of attractiveness is indicated rather than auditory, visual, or other communicative media.

It was observed in this laboratory that the contents of mandibular glands (*2*) removed from the heads of living queens were attractive to worker bees. These observations suggested that the mandibular gland secretion in living queens might be primarily responsible for queen attractiveness.

An experiment was conducted to assess quantitatively the contribution of the mandibular glands to the attractiveness of five classes of living queens (Table 1). Classes I and II were randomly chosen from normal colonies.

Table 1. Attraction of worker bees to queen bees as a function of mandibular gland secretion.

Class of queens	Queens in class (No.)	Mean ranges of attracted workers*	Mean attraction of workers*
I. Laying queens with glands	5	36–75	48.5 ± 8.4†
II. Laying queens without glands	5	2–15	7.4 ± 2.7†
III. Aged virgins with glands	5	21–69	45.7 ± 8.7†
IV. Aged virgins without glands	4	10–23	16.4 ± 3.3†
V. Newly emerged virgins with glands	5	0–14	3.8 ± 4.1†

* Means result from four replicates, with same queens for each test (only three replicates for class V queens). † 95 percent confidence intervals.

Mandibular glands were removed (*3*) from class II one day before assay. Classes III and IV were sister queens. Class III queens were confined in cages within normal colonies from emergence until the attractiveness test 28 days later. Class IV queens were treated identically, except that the mandibular glands were extirpated within 24 hours after emergence. Class V queens were taken directly from an incubator within a few hours after emergence. All queens were tested for attractiveness simultaneously.

Queen attractiveness was assayed by confining the queens singly in new, 30- by 80- by 15-mm wooden cages (queen mailing cages) having approximately 10^3 mm^2 of wire screen (1.9-mm apertures) exposure on one side. The cages were randomized and distributed immediately on their sides over the top bars of an exposed colony, so that bees had easy access to the screened area of each cage. Then the hive was closed, the cover being supported well above the cages by an empty hive body. Thus the cages were enclosed in a dark chamber free of extraneous air currents. After an exposure period of 10 minutes, all cages with adhering workers were confined in separate cardboard containers. Bees in each container were anesthetized with carbon dioxide and counted.

Striking differences were found between the attractiveness of queens with and without mandibular glands (Table 1). Mated laying queens lost a mean of 85 percent of their attractiveness because of the loss of mandibular gland secretion. The results on attraction of aged virgin queens without glands are biased since 50 percent of the population from which these queens were selected died during the 28 days preceding the attractiveness test. The survival of these confined virgin queens depended upon their capacity to attract nurse bees to feed them. Hence the survivors which were assayed probably represent the most attractive half of that population.

No significant difference (Table 1) was found between the attractiveness of aged virgin queens and mated laying queens. It is therefore concluded that the secretion of attractive materials by the mandibular gland in the queen is a function of maturation rather than mating or egg laying, or both. This is an important consideration in biochemical studies of queen attractants since virgin queens, as opposed to mated queens, can be reared and aged conveniently in quantity.

The mechanism of attraction of workers to their queen serves an important function in the social organization of the colony. Recent research (*4*) has demonstrated that bioactive chemicals are produced by the queen and disseminated to worker bees. These chemicals, known as pheromones (*5*), are potent chemical messengers which mediate behavioral and physiological responses in the workers. One orally acting queen pheromone (9-oxodec-2-enoic acid) has been identified and synthesized (*6*). One or more olfactorily acting queen pheromones from the mandibular gland secretion therefore attract worker bees to the source of orally acting pheromones which are then passed from worker to worker through food-sharing activities (*4*, *7*). The combined effects of the queen pheromone complex ultimately contribute to the integration of thousands of bees into an organized insect social community (*8*).

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Provisional Audiogram for the Shark, Carcharhinus leucas

Abstract. In an operant-conditioning study, a bull shark responded to signals at frequencies between 100 and 1500 cy/sec. In its band of greatest sensitivity (400 to 600 cy/sec), it discriminated, from high-level ambient noise, signals of amplitudes which the apparatus could not measure.

In an operant-conditioning study, which was prematurely terminated because of circumstances beyond our control, we obtained a provisional audiogram for the bull shark. To our knowledge, three precedents for the conditioning of sharks have been established. Vilstrup (*1*) conditioned spiny dogfish to a motor horn. Moulton (*2*) demonstrated the ability of the smooth dogfish, *Mustelus canis,* to associate an oscillator signal with an electric shock. Clark (*3*) showed that an instrumental (= operant) response could be elicited from large lemon sharks (*Negaprion brevirostris*).

Lowenstein and Roberts (*4*) reported an electrophysiological study of elasmobranch hearing, but expressed the belief that the frequency range derived therefrom had dubious physiological significance.

The subjects of the present experiments were a healthy male *Carcharhinus leucas* which had been captured in the spring of 1959, and a female which was introduced into the pens in the early spring of 1960. All experiments reported here were conducted in one of the 12- by 24-m shark pens at the Lerner Marine Laboratory, Bimini, Bahamas, described by Gilbert and Kritzler (*5*).

Originally, our subjects were trained to manipulate a bar near the surface of the water as the conditioned response to a motor horn signal (peak intensity at 610 cy/sec). In the course of these training exercises, and after the female of the pair had achieved a high level of performance, we became aware of the fortuitous appearance of an operant response in which both sharks demonstrated perception of the sound stimulus by abruptly terminating their normal random movements and swimming, with accelerated velocity, directly to the location of the sound source, about 6 m from the reinforcement area. Subsequent experiments, in which the sound source was moved at random with respect to the reinforcement area, confirmed that the location of the former, rather than of the latter, governed the orientation of the subjects.

The data reported here were secured by exploiting the turning and acceleration components of this orientation response; only the male was used. Attempts to capture a replacement for