prime vectors $\mathbf{e}_1$ $\mathbf{e}_2$ $\mathbf{e}_3$ we take three adjacent non-coplanar atoms. Let unit vector **r** give the direction of the incident ray and unit vector **s** that of the emergent ray. The conditions for the reinforcement of an emergent ray of wave-length λ are

$$s_1 - r_1 = m_1\lambda \quad s_2 - r_2 = m_2\lambda \quad s_3 - r_3 = m_3\lambda \quad (1)$$

where m_1 m_2 m_3 are integers.

We take a vector **m** the components of which in the derived reference frame are the integers m_1 m_2 m_3 so that

$$\mathbf{m} = m_1\mathbf{e}^1 + m_2\mathbf{e}^2 + m_3\mathbf{e}^3$$

Equations (1) are then all included in

$$\mathbf{s} - \mathbf{r} = \lambda\mathbf{m} \quad . \quad . \quad . \quad . \quad (2)$$

From this we have

$$\mathbf{s}.\mathbf{s} = (\mathbf{r} + \lambda\mathbf{m}).(\mathbf{r} + \lambda\mathbf{m})$$

or

$$2\mathbf{r}.\mathbf{m} + \lambda\mathbf{m}.\mathbf{m} = 0 \quad . \quad . \quad . \quad (3)$$

the equation that gives the wave-length.

The directions of the incident and emergent rays make the same angle with the vector **m** and this might be called the incident angle. The glancing angle θ, which it is the custom to measure, is the complement of the incident angle, and is the angle made with the mesh planes perpendicular to **m**. It is given by

$$\cos 2\theta = \mathbf{r}.\mathbf{s}$$

which by the help of equations 2 and 3 becomes

$$\sin\theta = \frac{\lambda}{2} \text{ times the magnitude of vector } \mathbf{m}.$$

When m_1 m_2 m_3 are prime to one another, the distance d between successive mesh planes is the reciprocal of the magnitude of **m**, so that

$$\sin\theta = \frac{\lambda}{2d}$$

The derived reference frame is equally appropriate in three dimensions and in four. D. B. MAIR.

January 11.

Weather Prediction from Observation of Cloudlets.

MR. CAVE writes: "I am not sure that I understand the second of Sir Archdall Reid's definitions of cloudlets—'small diaphanous clouds that can be seen at the same time in every part.'" The preceding definition was "the smallest and thinnest fragment of cloud that can be clearly isolated." I do not know how to express myself more plainly. On the other hand, Mr. Cave and I may not mean the same by "cumulus" and "cirro-cumulus." If there be any difference, then, since I am a mere amateur, I am sure he is right. I can only say that my suggestion as to the utility of observing cloudlets is founded on many years' experience, and, so far as I can judge, on common sense. To me it appears true (1) that rain is preceded by the condensing of clouds, and a return of fine weather by their dissolving; (2) that when clouds wax visibly rain is probable, and fine weather when they wane swiftly; (3) that, in proportion to their sizes and densities, the waxings or wanings of big clouds are difficult to observe; (4) that, in proportion to their smallness, thinness, and isolation, the behaviour of cloudlets is easy to observe; and (5) that the behaviour of cloudlets is usually an index of the behaviour of neighbouring clouds, and therefore of current atmospheric conditions. I find it hard to believe that clouds *commonly* change their behaviours so rapidly "that the method is scarcely of more use than the tossing of a coin."

It may be, as Mr. Cave says, that "Lenticular cirro-cumulus is composed of cloudlets that are born on the windward side and die on the leeward side of the cloud mass"; but, if so, the fact puzzles me. I can understand why a cloud should condense on the windward side of a cold mountain peak and dissolve to the leeward. I can understand that a cloud may grow on its cold shadowed side while dissolving on its sunlit slopes—though, because of the difficulties of observation, I have never seen this phenomenon. But I cannot understand how wind can so affect cirro-cumuli that they grow to windward and dissolve to leeward. Are not these cloudlets *in* the wind (and therefore, in a sense, *out of it*) like plums in a pudding? This phenomenon also I have not seen: or at least have not connected with the wind. However, this is not a matter for the "likes of me" to theorise about. The fact remains that any one, at any time, on any day, when cloudlets can be isolated, may test, in a few seconds, the utility of weather prediction by means of cloudlets. I think, like Dr. J. W. S. Lockyer, he will find it useful. I wonder whether Dr. Lockyer can remember whether the rapid growth of his cloudlets usually presaged rain, and their dissolution fine weather? May I insist once more that I have only sought to indicate what seems to me an easily observed and exceptionally reliable weather sign?

G. ARCHDALL REID.

January 12.

Rate of Growth of Fungus Rings.

MR. O. G. S. CRAWFORD's letter in NATURE of December 26, page 938, concerning the age of fairy rings, seems to warrant a letter for publication in addition to a more detailed private letter.

Fairy rings have been objects of interest from very early times and are the subjects of myths in most civilised countries, and are not beneath the notice of writers from Shakespeare to Kipling. As diverse as the myths are the suggestions regarding their mode of formation, ranging from fairy feet to fiery dragons and from thunder to moles.

It is now common knowledge that the rings are the result of a perennating fungus-mycelium and not of an annual spore discharge and germination. It is sometimes alleged that rings may remain stationary for several years; W. G. Smith stated that he knew a fairy ring of *Clitocybe geotropa* on Dunstable Downs which had remained much the same size for forty or more years. Most observers, however, agree that normally the rings increase in size. The rate at which the mycelium extends outwards varies considerably and is apparently dependent on weather conditions. There have been few actual measurements. Thomas studying rings of *Hydnum suaveolens* over a period of nine years found an average annual increase of 23 cm. Ballion records an increase of 12 cm. in one year for *Marasmius oreades*, but the advance was irregular being apparently more rapid when the ring was young, whereas for *Psalliota arvensis* the average increase was more than 50 cm. Bayliss with *Marasmius oreades* found the minimum annual increase to be 3 inches, the maximum 13½ inches. Shantz and Piemeisel estimated the average yearly advance as 12 cm. for *Agaricus tabularis*, and calculated certain Californian rings to be about 250 years old, and a number of small fragmentary rings which apparently had a common origin as approximately 600 years: the largest ring of *Calvatia cyathiformis*, with an average annual increase of 24 cm., was more than 400 years old.

It is obvious that the rate of advance depends upon the species of fungus concerned, and also upon conditions of environment which necessitates observations over a number of years.