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THE ATMOSPHERE OF STELLAR SPACE.

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IT was an interesting speculation that Sir R. Ball opened up in this journal, a short time since, with regard to the lunar atmosphere. His argument might easily be carried further, and would take us, as I shall try to show, into the realms of stellar space. It has been objected to his theory that the velocity of the particles of air at ordinary temperatures, though on the average about five hundred yards per second, is not enough to carry a particle so quickly away from the moon that it would not be drawn back again by its gravitation. This objection vanishes if we consider, not the average velocity, but the velocities of individual particles, and the changes those velocities rapidly undergo in consequence of frequent collisions among the particles. It is not easy to grasp the numbers involved in my argument, but I will state them on the authority of Lord Kelvin's popular lecture on the size of atoms. He gives the number of particles in one cubic centimetre, or one-sixteenth of a cubic inch, of atmospheric air at ordinary barometric pressure and at ordinary temperature, as not less than a million million of millions, or 10^{18}. Maxwell, in his article on "Atoms," in the Encyclopædia Britannica, makes the number greater. These particles cannot move far, not more on the average than about one hundredth of a thousandth of a centimetre, without encountering one another, so that each particle collides with one or another of its neighbors no less than five thousand million times in every second. If we suppose the density of the moon's atmosphere to be only a millionth of that of our atmosphere at the earth's surface, there will still be at least a million millions of particles in one cubic centimetre of it, and the frequency of their encounters with each other will still be some thousands per second for each of them. These encounters will cause them to be perpetually changing their velocities, and while some will have, at any given instant, velocities many times greater than the average, others will move at correspondingly slower rates. The directions, also, of their movements will be constantly changing from the same cause. If we suppose two particles, moving with equal velocities in directions at right angles to one another, to come into direct collision, one of them will have its velocity increased in the ratio of the square root of two to one, or rather more than seven to five, while the other will be reduced to momentary rest. If, now, the former come into a similar collision with a third particle, one of these two will acquire a still greater velocity. And considering the prodigious number of the particles and the short distance they can move without encountering others, it is evident that there must be an immense variety of rates of motion amongst them, and many of them must have velocities far exceeding that necessary to carry them clear away from the moon, or the earth, or even from the sun. In fact, amongst so many millions of millions the chance that some one will go on increasing its velocity at every one of a large number of successive encounters is very great indeed, practically a certainty. If this be granted, some, if it be but a small fraction of the whole, will be always escaping from the outer surface of the lunar atmosphere into the planetary space; and the like must go on from the atmospheres of other planets, only the fraction of the whole which get clear away from the bigger planets will be so much less because of the greater attraction of the bigger masses.

One interesting consequence of this escape of only the quicker moving particles, is that the temperature of interplanetary space must be thereby raised above that of the outer regions of a planet's atmosphere. For the temperature is directly proportional to the average square of the velocities of the particles, and as only the quickest fly off for good, the average velocity of the remainder must be less than that of those that break away. The process of dissipating an atmosphere into space might be stopped by its own cooling effect. But it is obvious that there is another cause which prevents anything like this. The planets are continually sweeping through the interplanetary space where the escaped particles are moving about, and even if the density of this interplanetary atmosphere be only a millionth of a millionth of the density of that at the earth's surface, still there will be at least a million particles in each cubic centimetre, and some of them will get swept up by the planets in their course and will not get away again. Hence the process of dissipation will cease when a planet picks up in its course through space just as many as it loses by diffusion in the same time. It follows from this that there must exist in planetary space an atmosphere, greatly reduced in density, it is true, but of the same chemical constitution as the earth's atmosphere. That is to say, the chemical constituents will be the same, though not quite in the same proportions. For the average velocity of the particles of nitrogen is a trifle greater than that of the particles of oxygen, and so the former will escape into space rather more frequently in proportion to their numbers than the latter. Besides, the effect of gravity is to increase very slightly the proportion of oxygen to nitrogen in the lower strata of the atmosphere. Hence, for both reasons, the atmosphere of planetary space will be a trifle richer in nitrogen than the air we breathe. There is so very little free hydrogen in our atmosphere that we cannot detect it, but for all that, it is most probable that there is a very little. And as oxygen particles are sixteen times as heavy as those of hydrogen, the proportion of free hydrogen to the other gases will be proportionally greater in the upper regions of the air than in the lower; and since hydrogen particles move four times as quickly as oxygen particles, it follows that the former will escape from the earth's attraction about four times as fast, and so the proportion of hydrogen in planetary space may be sensibly greater than in air we are able to test. A similar argument will apply to particles of water vapor, which are little more than half as massive as particles of oxygen. If all the planets are thus losing continually some of their atmospheres and picking up an equal amount from the space they move in, it follows that all the planets must have atmospheres of similar constitution to our own. For each planet has for ages been losing some of its own and acquiring some of the air of other planets, and if there had ever been any difference, which is unlikely, considering the general unity of the solar system, it must long ago have disappeared in consequence of this interchange.

The argument is strengthened by what we know of the atmospheres of the planets, especially of our nearest neighbors, Mars and Venus. Not only do these planets give plain indications of their atmospheres, but it is certain that they are very much like our own. That is found out in the following way: Amongst the many dark lines, Fraunhofer lines, as they are called, in the solar spectrum there are certain well marked groups which Sir D. Brewster long ago pointed out to be due to the absorption of rays by our atmosphere, because they are seen to be blacker and more intense when the sun is low than when he is high in the sky. That is because the rays have to pass through a greater thickness of air before they reach us when the sun is nearer the horizon. Now, by carefully observing the light reflected from Venus and Mars, which must have twice passed through so much of their atmospheres as lies above the reflecting surface, it has been found that precisely the same rays which are darker when the sun is low are also darker in the spectra of these planets. Moreover, in these planets there are no new dark lines indicating any absorbent of a different kind. The more distant planets show additional absorption bands, but their atmospheres must, on account of their greater masses, perhaps also from lower temperature, be denser, and besides they appear to be full of clouds which may not be merely water-dust, and may well produce their own absorptive effects.

The argument, however, reaches a good deal farther. Not only are the planets moving through the so-called planetary space, but the sun and all its train are moving through the interstellar space. Astronomers are agreed that we are moving, but the direction of the movement is much better known than the pace. The rate is sometimes set down at about thirty miles a second: certainly not an extravagant estimate. But at any rate we are going, and leaving the interplanetary atmosphere, or some of it, behind. Even if the solar system had no such motion, the process of diffusion must gradually carry the interplanetary atmosphere into regions beyond, and, unless this diffusion were compensated by accession of air from without, the planets must gradually lose their atmospheres until the loss was stopped by the cooling effect before mentioned. After countless ages we have manifestly not reached that stage, so we must conclude that interstellar space is pervaded by an atmosphere, though it be of very great tenuity.

If this atmosphere is not of similar chemical constitution to our own, ours must be changing by slow degrees, and in course of ages the change must tell. There is, however, no reason to think that our atmosphere has for millions of years undergone any change sufficient to affect the constitution of animal life of the higher types, and if that be so the air of stellar space must be much the same as that of interplanetary space and our own. Sterry Hunt, from the preponderance of vegetable growth at certain periods of the earth's history, inferred that at those periods there must have been an excessive quantity of carbonic acid in the atmosphere; and he fancied that this was acquired from the stellar space as the solar system made its way into regions where there was an unusual amount of carbonic acid. Spectrum analysis has not led us to think that the chemical elements of the stars of any region are different from those with which we are acquainted in the earth and in the sun. Stars in the same region are mostly of the same type, and the types are few, and all the common types of spectra of stars give indications of elements which we know, and no certainty of any other elements. Distance makes no difference at all. The few stars with unusual spectra do not so much seem to have peculiar elements as to be in peculiar physical states. The universe seems, so far, of one make, and there are no facts which negative the supposition that the whole vast space through which we see stars is filled with air; air very rare indeed, perhaps not a millionth of a millionth as dense as ours, but still, on the whole, similarly constituted.

FISH ACCLIMATIZATION ON THE PACIFIC COAST.

BY HUGH M. SMITH, M. D., UNITED STATES FISH COMMISSION.

Few experiments in fish culture have been economically more important and successful than those which have been conducted by the United States Fish Commission with reference to the Pacific Coast. Coincident with the propagation of native fishes the introduction of non-indigenous species has been undertaken, with results that have been extremely gratifying to fish culturists, and perhaps more striking than any previously obtained in this or any other country.

Among the fishes inhabiting the rivers and coast waters of the Atlantic slope, none is better known, more important, and more highly esteemed than the shad (*Clupea sapidissima*) and the striped bass or rockfish (*Roccus lineatus*), the former being a food fish, pure and simple, the latter combining a gamey disposition with excellent food qualities. These fish are anadromous, entering the fresh water for the purpose of spawning and passing a large part of the year at sea or in the salt water. Attention will be called to the experimental introduction of these fishes to the west coast, although several other important food-fish, among them the black bass (*Micropterus salmoides*) and catfish (*Ameiurus nebulosus*) might also be mentioned in this connection.

The introduction of shad fry to the west coast was first undertaken as long ago as 1871, when 12,000 young fish were deposited in the Sacramento River, under the auspices of the California Fish Commission. After that the experiment was taken up by the U. S. Fish Commission and carried on until 1886, during which time 609,000 young shad were placed in the Sacramento River, 600,000 in the Willamette River, 300,000 in the Columbia River and 10,000 in the Snake River.

Two or three years after the first fish were planted a few more or less mature examples were obtained in the Sacramento River; as additional deposits were made, the number of marketable fish began to increase, and the fish gradually distributed themselves along the entire coast of the United States north of Monterey Bay, until finally they have come to rank next to salmon in abundance among the river fishes of the west coast.

The U. S. Commissioner of Fish and Fisheries, in his annual report for 1887, speaking of the small plants of shad fry made in the Sacramento River at Tehama, says:

"From these slender colonies, aggregating less than one per cent of the number now annually planted in our Atlantic slope rivers, the shad have multiplied and distributed themselves along 2,000 miles of coast from the Golden Gate of California to Vancouver Island in British Columbia. They are abundant in some of the rivers, common in most of them, and occasional ones may be found everywhere in the estuaries and bays of this long coast line.

"Prior to our experiments on the west coast it was a dictum of fish culture that fish planted in a river would return to it when mature for the purpose of spawning. The result of these experiments has been to demonstrate