would obviously be fallacious if we were to form an estimate of the general state of aggregation from that of the few masses we can judge of in our immediate vicinity; but we should require to know the condition of a region of an extent that we have no chance of overlooking, and under the principles of the kinetic theory, the local variations of the states of aggregation (doublets) from one mass to another, (or differences in local fluctuations of velocities of the masses) would fluctuate within wide limits. In order to have an idea of the actual (mean) state of aggregation, a being would be required that could (on a comparative scale) sweep over the universe with the same facility as we sweep through the streets of a town representing a multiple countless millions of times that of the mean distance of the detached portions of matter composing the gas. We are led to apply the principles of the kinetic theory to the case of the universe not so much as a speculation, but rather as a necessary deduction following from a known principle that detached masses moving freely in space (as the stellar masses are observed to do) and at such distances apart that gravity between the several masses is incompetent to deflect the path of the masses once in motion, would, upon the alternative to which these considered motions were regulated under the mutual encounters in accordance with the principles of the kinetic theory. Only in the relatively near approach of the masses to one another does gravity come sensibly into play and deflect the path, causing under certain conditions rotation about a common center (doublets), or, perhaps, by direct impact, nebulae with but feeble rotation, &c.

To carry the analogy again to the smaller scale-case of a gas, it is there known that the molecules are in some cases feebly impelled towards each other at a near approach, the path of the molecule being thus deflected at its termination, whereby the conditions are given for causing a temporary rotation of the pair of molecules about a common centre, in an analogous way. The relatively vast distances of the stellar masses, compared with their dimensions, would, it is obvious, be a rule, an extremely long mean path before the encounters, corresponding to a proportionally long epoch of time adapted to the conditions of life. The apparent extreme simplicity of the means to the end by the application of the kinetic theory to the case would at least not seem to be out of harmony with its truth.

Thus to which these considerations lead would be that the universe has attained its final state of temperature equilibrium (if we set no fixed limit to its past existence), in the sense that if we were able to measure the temperature (or contained energy) of a sufficiently large part of masses through a sufficiently distant region, we should find that in every such equal region throughout the universe the temperature (or contained energy) would be the same; just as (on a smaller scale) in the case of a gas, if we could measure the temperature of some thousands of molecules in a given region, we should find that though the temperature differed to a practically unlimited extent from molecule to molecule, yet the temperature of every such equal region was the same.

1 Just as in the case of a condensed gas, the unformity of temperature of states of aggregation, &c., does not apply to the individual unit lump of matter (molecules) forming the gas (which may be in vastly different states from one to the other)—but to unit volumes containing vast numbers of such units. This being understood, the next to be considered is the state of temperature of the states of aggregation, &c., would not apply to the unit lump of matter (or the molecule) but to unit volumes. In fact the universe may be regarded as a larger scale gas, with the difference that the central force producing the aggregated lump of matter that move as wholes is not chemical action but gravitic action. If we imagine a relatively small region of the universe being on a small scale analogous to a single condensed molecule of gas in a state of normal temperature equilibrium. It would exhibit the expected affinities of molecules of different states of aggregation in an aggregate of gas molecules in scattered parts growing in a state of dissociation, &c., and he would form a perfectly white vacuum, in which a mere point of view, as an observer connected with the unit lump of matter of the universe (stellar region, &c.), might see the rest from his narrow pole region.

2 The eccentric flashing out of stars, as if due to some sudden convulsion through a remote time, and the possibility of a world's appearance in a state of inanimate existence, from the extremity of the universe, though not out of the region, or even the range in astronomy; though, from the extremely limited view of the universe, it would be unreasonable to expect such phenomena to be of frequent occurrence.
natural species we are so much accustomed to apply the term reversion or atavism to the reappearance of a lost part that we are liable to forget that its disappearance may be equally due to this same cause. As every modification, whether or not due to reversion, may be considered as a case of variation, the important list or conclusion arrived at by the mathematician Delbœuf, may be here applied; and I will quote Mr. Murphy’s condensed statement (“Habit and Intelligence,” 1879, p. 241) with respect to it: “If in any species a number of individuals, bearing a ratio not infinitely small to the entire number of births, are in every generation born with any particular variation which is neither beneficial nor injurious to its possessors, and if the effect of the variation is not counteracted by reversion, the proportion of the new variety to the original form will constantly increase until it approaches indefinitely near to equality.” Now in the case advanced by Fritz Müller the cause of the variation is supposed to be atavism to a very remote progenitor, and this may have wholly prevailed over any tendency to atavism to more recent progenitors; and of such prevalence analogous instances could be given.

CHARLES DARWIN

Blumenau, St. Catharine, Brazil, January 21, 1879

My Dear Sir,

If I remember well, I have already told you of the curious fauna which is to be met with between the leaves of our Bromeliæ. Lately I found, in a large Bromeliæ, a little frog (Hyloides sp.), bearing its eggs on the back. The eggs were very large, so that nine of them covered the whole back from the shoulders to the hind end, as you will see on the photograph accompanying this letter, Fig. 1 (the little animal was so restless that only after many fruitless trials a tolerable photograph could be obtained). The tadpoles, on emerging from the eggs, were already provided with hind-legs; and one of them lived with me about a fortnight, when the fore-legs also had made their appearance. During this time I saw no external branchie, nor did I find any opening which might lead to internal branchies.

There is here another locality in which a peculiar fauna lives, viz., the rocks of waterfalles, which are of very frequent occurrence in almost all our mountain rivulets. On these rocks, along which the water is slowly trickling down, or which are continually wetted by the spray of the waterfall, there live various beetles not to be met with anywhere else, larvae of diptera and caddis-flies, and a tadpole remarkable for its unusually long tail.

The paper of caddis-flies living on the rocks of waterfalles (I examined three species belonging to the Hydroscyphida, Hydrometridæ, and Sericostomatidae [Helicocephala]), as well as those living in the Bromeliæ (a species belonging to the Lepidopyridæ), are distinguished by a very interesting feature. In other caddis-flies the feet of the second pair of legs (and in some species those of the first pair also) are fringed in the pupa with long hairs, which serve the pupa, after leaving its case, to swim to the surface of the water for its final transformation. Now neither on the surface of bare or moss-covered rocks, nor in the narrow space between the leaves of Bromeliæ, the pupae have any necessity, nor would even be able, to swim, and in the four species living on such localities which I examined, and which belong to as many different families, the feet of the pupæ are quite hairless, or nearly so, while in allied species of the same families or even genera (Helicocephala) the fringes of the legs, used for swimming, are well developed.

This portion of the useless fringes in the caddis-flies inhabiting the Bromelii and waterfalls appears to me to be of considerable interest, because it cannot be considered, as in many other cases, as a direct consequence of disuse; for at the time when the pupæ leave their cases and when the fringes of their feet are proving either useful or useless, these fringes as well as the whole skin of the pupæ, ready to be shed, have no connection whatever with the body of the insect; it is therefore impossible that the circumstance of the fringes being used or not for swimming, should have any influence on their being developed or not developed in the descendants of these insects. As far as I can see, the fringes, though useless, would do no harm to the species, in which they have disappeared, and the material saved by their not being developed appears to be quite insignificant, so that natural selection can hardly have come into play in this case. The fringes might disappear casually in some individuals; but, without selection, this casual variation would have no chance to prevail. There must be some constant cause leading to this rapid abortion of the fringes on the feet of the pupæ in all those species in which they have become useless, and I think this may be atavism. For caddis-flies, no doubt, are descended from ancestors which did not live in the water, and the pupæ of which had no fringes on their feet. Thus there may even now exist in all caddis-flies an ancestral tendency to the production of hairless feet in the pupæ, which tendency in the common species is vitoriously counteracted by natural selection, for any pupæ, unable to swim, would be mercilessly drowned. But as soon as swimming is not required and the fringes consequently become useless, this ancestral tendency, not counterbalanced by natural selection, will prevail, and lead to the abortion of the fringes.

I do not remember having seen, in any list of cistogamous plants, the Pimentum doce. These curious little aquatic plants, which Lindley placed near the Pipersaceæ, Kuth the Juncagines and Alismaceæ, and which Saccis considers as being of quite dubious affinity, cover densely the stones in the rapids of our rivers; on the branches which come above the surface of the water, there are pedunculated, open, fertile flowers; but there are numerous sessile flower-buds also on the branches.