occupied chimney, could not occur, and, therefore, the passage of the smoke of one chimney down another, would always be prevented; and lastly, by having only one outlet for smoke in every house, and that an object which may be made ornamental, we should ultimately get rid of the great deformity which arises from the present appearance of chimnies in buildings.

In all situations where it is practicable to make a cold-air flue, of considerable length under ground, the advantage is well worth securing. I have found by experience, that a cold air-flue of 50 yards in length, is capable of cooling the air in summer, to about an arithmetical mean, between the temperature of the air and the earth, and a similar advantage is produced by the earth warming the air in the winter season. The shape of the cold-air flue should be such as to present the greatest possible surface; the very contrary being essential to the best construction of flues for the warm air.

These facts will successfully lead to the means of cooling buildings in the tropical climates, and of warming the air when the winter's cold is much below the temperature of the earth.

On the Value of the Evidence from the Animal Kingdom, tending to prove that the Arctic Regions formerly enjoyed a milder Climate than at present. By the REV. JOHN FLEMING, D. D. F. R. S. E.

It was long a favourite opinion among naturalists, that all the species of animals or vegetables, which the omnipotent Creator ever called into being, still remain the inhabitants of this globe, independent of the dangers to which they have been exposed, or the changes which have taken place in their geographical distribution. The difficulties which attended the acknowledgment of this opinion, arising from the number of singular forms found imbedded in the regular strata, or distributed among the loose materials on the surface of the earth—forms indicating species which the neighbouring districts did not possess—were conceived to be in a great measure removed, by the supposition, that unknown regions might yet exhibit living examples, in addition to many species of which the naturalist had obtained no information. In proportion, however, as the progress of geography extended our acquaintance with distant regions, and failed to furnish the requisite examples, the opinions of naturalists experienced a corresponding change. The ancient creed was at length abandoned; and no one, acquainted with the subject, refused to acknowledge, that in the earth were preserved the relics of numerous species which have no longer a place among the living on this globe.

The characters of the extinct species, after this change in public opinion, presented to the philosophical observer, an extensive field of research and speculation. Prevented now from expending his resources, in seeking out the dwellings of animals which no longer

exist, his attention was directed to the characters of those extinct species, the relics of which the strata had preserved, with the view of tracing their relations with the living tribes. The bones of the mammoth, occurring in the loose strata, were speedily identified with those of an elephant. The shells and corals of the older strata were exhibited, as resembling the productions of equatorial seas; while the impressions of vegetables, found in the shale of our coal-fields, were traced to be analogous to the productions of tropical forests. The conclusion seemed to be warranted, by an extended induction, that our region once enjoyed a tropical climate, at which time our rivers were swarming with alligators, our lakes with tortoises, and our seas with corals; when our caves were the haunts of bears and hyænas, and our forests the resort of the elephant and tiger. Nay, that in those northern regions, now suffering, during so great a part of the year, all the rigours of an iron winter, the climate was once so mild as to permit the residence of the rhinoceros and the elephant.

Imposing as these conclusions certainly appear, their validity might, with propriety, have been called in question, when naturalists, ceasing to rely on general appearances, examined more narrowly specific characters, and announced, as a result of their labours, that the extinct animals, though generically related to the tropical kinds, were yet to be viewed as *distinct species*. The argument in favour of a *change of climate*, which these fossil remains formerly seemed to furnish, now unsupported by observation, was found to rest entirely on analogy. Yet, in spite of this change of character, it is still relied on with confidence, as yielding support to hypothetical views; and few geologists of eminence could be mentioned, in whose writings it has ceased to occupy a prominent place. Some anxiously seek for proofs of a change of climate, on the supposition that our planet was once fluid by heat, and is still in the act of cooling; while others, guided by their notions of magnetism or electricity, are equally sanguine in their expectations of perceiving proofs of change.*

If it be admitted that the extinct animals are different *in species* from the existing kinds, and here, we presume, there is no difference of opinion, we shall be able to bring the subject into that form in which accurate conclusions may be obtained, or the value of those previously announced brought to a suitable test. Indeed, the whole argument in favour of a change of climate, seems to depend on the value of *analogy*, as an instrument of research. Supposing ourselves acquainted with the habits and distribution of one species of a genus, can we predicate, with any degree of safety, concerning the habits and distribution of the other species with which it is generically connected? Geologists ought to have investigated this preliminary question with care, before they commenced their specu-

* Professor Link in his *Urwelt*, or Antediluvian World; Kruger in his *History of the Antediluvian World*; and other modern writers on geology, oppose the opinion of Cuvier, and advocate the view discussed by Dr. Fleming in this memoir.—EDITOR.

lations. Instead, however, of acting with such caution, they have assumed that the question may be answered in the affirmative; or, rather, it does not appear that they were aware of any difficulty in the case, or conceived for a moment that their regulating principle might have no higher authority than a *petitio principii*.

Geologists, it is true, were countenanced, to a certain extent, in reposing confidence in *analogy* as their guide, by the authority of the most zealous, enlightened, and successful comparative anatomist the world ever possessed, Baron Cuvier. Successful in the employment of this instrument, in several instances, assisted, however, by numerous observations, this anatomist, under the influence of prejudices which few can avoid, has stated his confidence in the certainty of its deductions, with a boldness, which is the more astonishing, as it is equally at war with his own admissions and well known facts. "Any one who observes only the print of a cloven foot, may conclude that the animal which left this impression, ruminates; and this conclusion is quite as certain as any other in physics, or in moral philosophy."—*Recherches sur les Ossements Fossiles*, i. 51. Observation had discovered many animals with cloven hoofs which ruminated; but, in such circumstances, would it be safe to infer that all cloven hoofed animals ruminate? Conceive ourselves contemplating the footmarks of a sheep and sow. Under the guidance of Cuvier's declarations, we would conclude that both ruminated,—an inference true in the one case, and false in the other. Observation here warns us against the employment of a guide so liable to deceive us. But this charge against analogy, may, perhaps, appear in greater strength, after the reader has perused the solution of the following questions.

1. *If two animals resemble each other in structure, will their habits be similar?*—If this question could be answered in the affirmative, it would greatly heighten the interest which is attached to the study of fossil remains, by giving to our observations an authority which at present they do not possess. The comparative anatomist has traced a considerable resemblance between the skeleton of the hippopotamus and the common ox. No analogy, in this case, would have led the inquirer to form even the slightest suspicions respecting the existence of those aquatic habits of the former animal, which constitute so singular a feature in its character. Let us place on a table the skeletons of the ermine, the polecat, and the otter, and the general resemblance of these to one another, would at once be admitted; and, confiding in our *analogies*, we might pronounce their habits to be similar. Observation, however, would convince us that these three species were different in their habits and propensities, though included by Linnæus in the genus *Mustela*. The common bear and arctic bear, exhibit equal resemblances of structure, and equal differences of habits. These facts, and multitudes of the same kind which might be produced, intimate the propriety of relying on analogy with caution, in all those cases to which our observation does not extend. The skeleton of the hippopotamus could not give any intimation of the diving powers of the animal, nor

would the bones of the feet of the otter lead to the supposition of its having webbed toes. Osteology, indeed, gives but very imperfect indications, even of external form, in many animals. Would the round caudal vertebræ of the seal, indicate the depressed tail of the animal, or the depressed bones of the face, in the whale, indicate the remarkable fulness of the outline of its head? We may agree with Cuvier in supposing that the mastodon had a proboscis like an elephant (to enable it to procure its food from the ground,) from the general resemblance of the two animals in structure, from the length of its legs, and the slight development of the toes; but when we remember the giraffe, with its head proportionally farther removed from the ground than the mastodon, able to provide food without a proboscis; and the hippopotamus and the dipper (*Cinclus aquaticus*), which are excellent swimmers, though seemingly ill suited for the exercise, we shall view the conjecture in no other light than a probability, and not remarkably strong.

2. *If two animals resemble each other in external appearance, will their habits be similar?*—It is seldom, indeed, that two animals resemble each other, in all their organs, so very closely as to render it difficult for the attentive observer to discriminate species. Some modifications of form and structure usually occur in the one species, which cannot be perceived in the other, and which serve to influence its habits. But even in those cases where approximations of form are the closest, do we perceive a similarity of actions? If this were the case, the study of Natural History would be comparatively easy, as the field of observation would be reduced within accessible limits. The truths of zoology, however, forbid the indulgence of such expectations. The habits of each species must be studied as a separate subject of investigation, permitting analogy to assist, but in no case to guide us. The examples to justify this statement, may be taken from any one of the classes of the animal kingdom. The common shrew frequents old walls, and dry, grassy, banks; while the water shrew dwells on the margins of ditches, and swims and dives with ease. The common mouse, the pest of houses, itself improvident, seeks after the storehouses of men; while the field mouse frequents gardens and fields, and is not only a storing animal, but susceptible of torpidity. How different the solitary or pairing habits of the porpoise, from the gregarious wandering grampus. In birds, the same difference of habit accompanies generic resemblances. The rock dove builds its nest in caves, (and hence the plan of doves-cots,) and delights to rest on a grassy bank; while the ring-dove frequents the forest, resting and breeding on trees. How dissimilar, in habit, the rook and the jack-daw, the heron and the bittern? Equally different the char, the sea-trout, and the common trout. Whether we contemplate *species*, in reference to their food, their haunts, their protection against foes, or the method of rearing their young, we find each exhibiting peculiarities, of which a knowledge of the habits of its congeners would not have given us the slightest

intimation.* But a third subject of inquiry yet remains to be investigated.

3. *If two animals resemble each other in form and structure, will their physical and geographical distribution be similar?*—Nearly the same anomalies present themselves, when considering animals in reference to their stations on the globe, as when viewing them in relation to their habits. Every species has its own appointed place, influenced in all cases by latitude, and even sometimes by longitude. The zebra delights to roam over the tropical plains, to which it is, in a great measure, restricted; while the horse can maintain existence, even throughout an Iceland winter. The buffalo, like the zebra, prefers a high temperature, and cannot thrive, even where the common ox prospers. The musk ox, on the other hand, though nearly resembling the buffalo, prefers the stunted herbage of the arctic regions, and is able, by its periodical migrations, to outlive a northern winter. The chacal (*Canis aureus*) inhabits Africa and the warmer parts of Asia; while the isatis (*Canis lagopus*) resides in the arctic regions. Species of the genus felis, likewise inhabit every climate, each limited in geographical distribution. The African hare and the polar hare, have their geographical distribution expressed in their trivial names. Ornithology might be called on to furnish examples equally illustrative of the question under discussion. The red grouse is confined to the United Kingdom, in its geographical distribution, and is a bird which we may consider as peculiarly our own; while the ptarmigan has a range of dwelling, extending to the higher northern latitude of 74°.

The resources against the vicissitudes of the seasons, appear to exhibit equally remarkable differences according to the species. Thus, while the grouse braves, unchanged in colour, the rigours of our winter, the ptarmigan assumes a white plumage: while the favourite redbreast spends his winter almost under our immediate protection, the nightingale betakes herself to a warmer climate. The yellow bunting remains with us throughout the year; the snow bunting only visits us in winter, and retires to spend the summer, and rear its young, on the rocks of Greenland.

From the preceding statements, which might have been extended to an almost indefinite length, the conclusion appears unavoidable, *that every species is controlled by its own peculiar laws*, and that no acquaintance with one species of a genus, however extensive and accurate, warrants us in predicating concerning the habits and distribution of any other species, even though very striking resemblances, in structure, and form, may prevail. What, then, is the amount of the argument, leading to the belief that the arctic regions once enjoyed a milder climate than they now possess, derived from the relics of animals found imbedded in the soil?—Remains of an elephant and of a rhinoceros, have been found in Siberia! These animals at present live under a warm climate; and when Siberia was peopled

* The reader will find some other illustrations of this subject, in my "Philosophy of Zoology," vol. ii. p. 88.

by such animals, its climate must have been much milder than in the present day!—If the relics of the elephant and rhinoceros, found in Siberia, belong to the *same species* which now dwell in equatorial regions, we must either suppose that they were transported to their present tomb, or, if they were the denizens of the country, that the climate of Siberia has greatly changed. In such circumstances, our conclusions would be supported by the truths of science, for, in reference to the *individuals of a species*, our knowledge of the ordinary habits and distribution of a few of these, qualifies us for judging respecting the remainder.* If, however, it shall be found that the relics of the elephant and rhinoceros of Siberia belong to *species different from those which now dwell in tropical forests*, our speculations must change their character, for the truths of zoology forbid us to reason concerning the *species of a genus*, in the same manner as we do with the *individuals of species*; and all our prejudices, associated with the *names* we use, must be dismissed from the mind.

Viewing, then, the Siberian elephant and rhinoceros, as *different in species* from those which we conceive peculiarly fitted to reside in a tropical climate, and the proof of this difference has been satisfactorily established, our conjectures respecting their original condition, must be conducted on widely different principles. If still unwilling to allow that these species ever resided in Siberia, but inclined to consider them as having been conveyed by some current of water from another and warmer region, we have to determine the locality of their residence at the very outset of our speculations. Now, these species no longer occur in a living state, in any region of the earth. Their former geographical distribution can be inferred only by the dispersion of their bones. These relics occur very frequently in the north of Europe, Asia, and America, in the higher latitudes, become scarcer as we proceed towards the south, and *do not occur within the geographical limits of the existing races*. It is vain, therefore, to have recourse to diluvian transportation, when we cannot point out the place from whence they may have been brought. If we admit that these extinct species lie buried in those very regions in which they formerly resided, and the whole circumstances of the case warrant the conclusion, what are the inferences which we may legitimately deduce? That as these species appeared to

* Sir Everard Home has, it is true, attempted to prove the identity of the Siberian and African rhinoceros, by considering the skull of a recent individual, brought by Mr. Campbell from Mashow, in South Africa (and which occupies a place in the museum of the London Missionary Society, and is recorded in the catalogue, p. 10,) as having a perfect resemblance to those of the Siberian species.—*Phil. Trans.* 1822. In the twenty-second number of the Edinburgh Philosophical Journal, I intimated my suspicions of the accuracy of this opinion, founded on the great difference in the physical and geographical distribution of the two animals; and the inquiries which I made in London, in the spring of the following year, justified the view which had been adopted. Baron Cuvier's inquiries, about the same time, led to a similar conviction, that the celebrated London anatomist had been betrayed into error, by a too hasty and superficial examination of the specimen from Cafraria.—*See Cuvier, Oss. Foss.* iv. 493.

have lived in Siberia, they, consequently, must have possessed habits suited to their geographical distribution. This is reversing the ordinary notions on the subject; for, instead of suiting the climate to the species, we consider the species as suited to the climate. Nor are we left in doubt on the subject. The museum of nature has furnished us with a specimen to which an appeal can be made. The entire carcass of a Siberian elephant, or mammoth, as it is termed by the Russians, was found about twenty-two years ago, by Mr. Adams, (the bones of which form the skeleton in the Museum of the Imperial Academy at Petersburg,) preserved in *ice*, near the mouth of the river Lena, on the shores of the Frozen Ocean. Did the skin present, externally, that thinness of hair, scaliness of surface, and naked appearance, which characterize the living elephants of the equatorial regions, or did its condition, as to hair, indicate an animal fitted, by its clothing, to reside in a cold climate? The covering was of three kinds:—*bristles* nearly black, much thicker than horse hair, and from twelve to sixteen inches in length;—*hair* of a reddish-brown colour, about four inches in length; and *wool* of the same colour as the hair, but only about an inch in length. Though much of the fur was lost, upwards of thirty pounds weight were gathered from the wet sand bank. Here, then, is a demonstration, that the Siberian elephant was not, from the abundance of its clothing, fitted for a warm country, but destined for a dwelling of an opposite character. In other words, that the Siberian elephant was fitted for braving the severity of a northern climate, and that at the period in which this individual died, there was freezing taking place in Siberia, much after the same manner as at present. To form an accurate conception of the Siberian elephant, or mammoth, we must not imagine an animal naked, like the African or Asiatic species, but enveloped in a shaggy, thick covering of fur, like the musk ox, impenetrable to rain or cold. The carcass of the Siberian rhinoceros, found on the banks of the Wilhoui, in 1770, by Pallas, gave similar indications of its hairy covering, being suitable to an arctic animal.

Perhaps there may be some readers, irritated at the overthrow of a favourite hypothesis, ready to offer the following objection. How could such animals, as the elephant and rhinoceros, find means of subsistence in the northern regions, which are so scantily supplied with herbage? There is no difficulty in conceiving the elephant capable of securing food, when we know that many of our largest quadrupeds at present people those regions; such, for example, as the musk ox, the moose deer, and the bison. The kind of food these ancient elephants employed, will, probably, never be ascertained, and we do not possess the means of forming even a feasible conjecture. We may know the kind of food the existing species prefer, but this yields no aid in determining the taste of the extinct species. Who is there acquainted with the gramineous character of the food of our fallow deer, stag, or roe, that would have assigned a lichen to the rein-deer?

Yet, reluctant to admit that Siberia was once peopled by elephants,

the reader may be disposed to ask, how could such animals outlive the winter? This question can only be answered by a reference to the history of animals in similar circumstances. The modern northern animals *migrate*, and we entertain little doubt that the Siberian elephant was equally disposed to the shifting of place, with the changes of the season.

Those who have been misled by the prejudices connected with the names *elephant* and *rhinoceros*, and, in consequence, have conceived the climate of Siberia to have been warm of old, to suit their supposed tropical animals, may yield to the force of the preceding arguments. Those, however, who imagine that our earth is red hot at the centre, as it was formerly at the surface,—that the period is not long passed by, since the crust became so cool as to allow *climate* to operate, will be inclined to retire from the untenable outpost, formerly occupied by the mammoth, to the more inaccessible strong holds of our lime quarries and coal pits. The strata, accompanying our coal metals, abound, say they, with the impressions of plants, which do not resemble the modern productions of our country. In order to find analogous forms, we must betake ourselves to warmer climes, and trace in the reeds, the palms, and the ferns, reared under a tropical sun, species resembling those relics which the older strata have preserved. And, if the fossil plants resemble tropical species, is not this a proof that our climate once resembled a tropical one? Two things very different are here confounded. Our fossil plants may resemble tropical plants; but if they are not *individuals of the same species*, the data which they furnish, however useful in tracing *affinities* of form or structure, furnish no clew whatever for determining geographical or physical *distribution*,—for it is with plants as with animals,—we may reason safely concerning the individuals of a species, but not concerning the habits and distribution of one species, from our knowledge of the characters of any other species of the genus to which it belongs. This country, cold as it is, may have had its palms, its cacti, and arborescent ferns, under a temperature similar to the present, due regard being had to species, not genera; for, at a comparatively recent period, and within the shade of the genealogical tree of our existing quadrupeds, Britain possessed an elephant, a rhinoceros, a hyæna, and a tiger.

[*Edin. New Philo. Journ.*

On the Natural Zero, according to Fahrenheit's Scale. By SIR
GEORGE CAYLEY, Bart.

GENTLEMEN,—I send you the following considerations respecting the natural zero, which, though, perhaps, not perfectly conclusive, yet lead to a strong probability that the point of absolute privation of transferable caloric, as respects temperature, takes place at 448 degrees of Fahrenheit's scale, below his 0°, taking such degrees of this scale as range between 32° and 212°, as the standard, and