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The method, slightly modified, is also applicable—where most processes fail—to the retention and restoration of ancient ecclesiastical frescoes. In using the process, both for original work and for restorations, I confess I prefer to adopt a somewhat different plan for preparing the medium. I find the following directions to yield an excellent product, and to be very easy to carry out:—Dissolve three-quarters of an ounce of elemi in six ounces of oil of spike, in a flask, by the aid of heat: the fragments of bark in the elemi will sink to the bottom of the vessel; melt three ounces of white wax and one ounce of pure white paraffine in another flask; mix the two liquids together, and allow the impurities to settle. Put twenty-two liquid ounces of fine pale copal varnish—picture copal—in a tin can; keep the can plunged in boiling water for half an hour or more; pour the elemi and wax mixture (also hot), into the can, stir it, and keep warm some time longer. This preparation may be used, diluted, etc., exactly as previously directed.

THE PHILOSOPHY OF BIRDS' NESTS.

BY ALFRED R. WALLACE, F.Z.S., ETC.

BIRDS, we are told, build their nests by *instinct*, while man constructs his dwelling by the exercise of *reason*. Birds never change, but continue to build for ever on the self-same plan; man alters and improves his houses continually. Reason advances; instinct is stationary. This doctrine is so very general that it may almost be said to be universally adopted. Men who agree on nothing else, accept this as a good explanation of the facts. Philosophers and poets, metaphysicians and divines, naturalists and the general public, not only agree in believing this to be probable, but even adopt it as a sort of axiom that is so self-evident as to need no proof, and use it as the very foundation of their speculations on instinct and reason. A belief so general, one would think, must rest on indisputable facts, and be a logical deduction from them. Yet I have come to the conclusion that not only is it very doubtful, but absolutely erroneous; that it not only deviates widely from the truth, but is in almost every particular exactly opposed to it. I believe, in short, that birds do *not* build their nests by instinct; that man does *not* construct his dwelling by reason; that birds do change and improve when affected by the same causes that make men do so; and that mankind neither alter nor improve when they exist under conditions similar to those which are almost universal among birds.

Let us first consider the theory of reason, as alone determining the domestic architecture of the human race. Man, as a reasonable animal, it is said, continually alters and improves his dwelling. This I entirely deny. As a rule, he neither alters nor improves, any more than the birds do. What have the houses of most savage tribes improved from, each as invariable as the nest of a species of bird? The tents of the Arab are the same now as they were two or three thousand years ago, and the mud villages of Egypt can scarcely have improved since the time of the Pharaohs. The palm-leaf huts and hovels of the various tribes of South America and the Malay Archipelago, what have they improved from since those regions were first inhabited? The Patagonian's rude shelter of leaves, the hollowed bank of the South African Earthmen, we cannot even conceive to have been ever inferior to what they now are. Even nearer home, the Irish turf cabin and the Highland stone shelty can hardly have advanced much during the last two thousand years. Now, no one imputes this stationary condition of domestic architecture among these savage tribes to instinct, but to simple imitation from one generation to another, and the absence of any sufficiently powerful stimulus to change or improvement. No one imagines that if an infant Arab could be transferred to Patagonia or to the Highlands, it would, when it grew up, astonish its foster-parents by constructing a tent of skins. On the other hand, it is quite clear that physical conditions, combined with the degree of civilization arrived at, almost necessitate certain types of structure. The turf, or stones, or snow—the palm-leaves, bamboo, or branches, which are the materials of houses in various countries, are used because nothing else is so readily to be obtained. The Egyptian peasant has none of these, nor even wood. What, then, can he use but mud? In tropical forest countries, the bamboo and the broad palm-leaves are the natural material for houses, and the form and mode of structure will be decided in part by the nature of the country, whether hot or cool, whether swampy or dry, whether rocky or plain, whether frequented by wild beasts, or whether subject to the attacks of enemies. When once a particular mode of building has been adopted, and has become confirmed by habit and by hereditary custom, it will be long retained, even when its utility has been lost through changed conditions, or through migration into a very different region. As a general rule, throughout the whole continent of America, native houses are built directly upon the ground—strength and security being given by thickening the low walls and the roof. In almost the whole of the Malay Islands, on the contrary, the houses are raised on posts, often to a great height, with an

open bamboo floor; and the whole structure is exceedingly slight and thin. Now, what can be the reason of this remarkable difference between countries many parts of which are strikingly similar in physical conditions, natural productions, and the state of civilization of their inhabitants? We appear to have some clue to it in the supposed origin and migrations of their respective populations. The indigenes of tropical America are believed to have immigrated from the north—from a country where the winters are severe, and raised houses with open floors would be hardly habitable. They moved southwards by land along the mountain ranges and uplands, and in an altered climate continued the mode of construction of their forefathers, modified only by the new materials they met with. By minute observations of the Indians of the Amazon Valley, Mr. Bates arrived at the conclusion that they were comparatively recent immigrants from a colder climate. He says:—"No one could live long among the Indians of the Upper Amazon without being struck with their constitutional dislike to the heat. . . . Their skin is hot to the touch, and they perspire little. . . . They are restless and discontented in hot, dry weather, but cheerful on cool days, when the rain is pouring down their naked backs." And, after giving many other details, he concludes, "How different all this is with the Negro, the true child of tropical climes! The impression gradually forced itself on my mind that the Red Indian lives as an immigrant or stranger in these hot regions, and that his constitution was not originally adapted, and has not since become perfectly adapted, to the climate."

The Malay races, on the other hand, are no doubt very ancient inhabitants of the hottest regions, and are particularly addicted to forming their first settlements at the mouths of rivers or creeks, or in land-locked bays and inlets. They are a pre-eminently maritime or semi-aquatic people, to whom a canoe is a necessary of life, and who will never travel by land if they can do so by water. In accordance with these tastes, they have built their houses on posts in the water, after the manner of the lake-dwellers of ancient Europe; and this mode of construction has become so confirmed, that even those tribes who have spread far into the interior, on dry plains and rocky mountains, continue to build in exactly the same manner, and find safety in the height to which they elevate their dwellings above the ground.

These general characteristics of the abode of savage man will be found to be exactly paralleled by the nests of birds. Each species uses the materials it can most readily obtain, and builds in situations most congenial to its habits. The wren, for example, frequenting hedgerows and low thickets, builds

its nest generally of *moss*, a material always found where it lives, and among which it probably obtains much of its insect food; but it varies sometimes, using hay or feathers when these are at hand. Rooks dig in pastures and ploughed fields for grubs, and in doing so must continually encounter *roots* and *fibres*. These are used to line its nest. What more natural! The crow, feeding on carrion, dead rabbits, and lambs, and frequenting sheep-walks and warrens, chooses *fur* and *wool* to line its nest. The lark frequents cultivated fields, and makes its nest, on the ground, of grass lined with *horsehair*—materials the most easy to meet with, and the best adapted to its needs. The kingfisher makes its nest of the *bones* of the fish which it has eaten. Swallows use clay and mud from the margins of the ponds and rivers over which they find their insect food. The materials of birds' nests, like those used by savage man for his house, are, then, those which come first to hand; and it certainly requires no more special instinct to select them in the one case than in the other. But, it will be said, it is not so much the materials as the form and structure of nests, that vary so much, and are so wonderfully adapted to the wants and habits of each species; how are these to be accounted for except by instinct? I reply, they may be in a great measure explained by the general habits of the species, the nature of the tools they have to work with, and the materials they can most easily obtain, with the very simplest adaptations of means to an end quite within the mental capacities of birds. The delicacy and perfection of the nest will bear a direct relation to the size of the bird, its structure and habits. That of the wren or the humming-bird is perhaps not finer or more beautiful in proportion than that of the blackbird, the magpie, or the crow. The wren, having a slender beak, long legs, and great activity, is able with great ease to form a well-woven nest of the finest materials, and places it in thickets and hedgerows which it frequents in its search for food. The titmouse, haunting fruit-trees and walls, and searching in cracks and crannies for insects, is naturally led to build in holes where it has shelter and security; while its great activity, and the perfection of its tools (bill and feet), enable it easily to form a beautiful receptacle for its eggs and young. Pigeons, having heavy bodies, and weak feet and bills (imperfect tools for forming a delicate structure), build rude, flat nests of sticks, laid across strong branches which will bear their weight and that of their bulky young. They can do no better. The *Caprimulgidæ* have the most imperfect tools of all, feet that will not support them except on a flat surface (for they cannot truly perch), and a bill excessively broad, short, and weak, and almost hidden by feathers and

bristles. They cannot build a nest of twigs or fibres, hair or moss, like other birds, and they therefore generally dispense with one altogether, laying their eggs on the bare ground, or on the stump or flat limb of a tree. The hooked bills, short necks and feet, and heavy bodies of parrots, render them quite incapable of building a nest like most other birds. They cannot climb up a branch without using both bill and feet; they cannot even turn round on a perch without holding on with their bill. How, then, could they inlay, or weave, or twist the materials of a nest? Consequently, they all lay in holes of trees, the tops of rotten stumps, or in deserted ants' nests, the soft materials of which they can easily hollow out.

Now I believe that throughout the whole class of birds the same general principles will be found to hold good, sometimes distinctly, sometimes more obscurely apparent, according as the habits of the species are more marked, or their structure more peculiar. It is true that, among birds differing but little in structure or habits, we see considerable diversity in the mode of nesting, but we are now so well assured that important changes of climate and of surface have occurred within the period of existing species, that it is by no means difficult to see how such differences have arisen. Habits are known to be hereditary, and as the area now occupied by each species is different from that of every other, we may be sure that such changes would act differently upon each, and would often bring together species which had acquired their peculiar habits in distinct regions and under different conditions.

But, it is objected, birds do not *learn* to make their nest as man does to build, for all birds will make exactly the same nest as the rest of their species, even if they have never seen one, and it is instinct alone that can enable them to do this. No doubt this would be instinct if it were true, and I simply ask for proof of the fact. This point, although so important to the question at issue, is always assumed without proof, and even against proof, for what facts there are, are opposed to it. Birds brought up from the egg in cages do not make the characteristic nest of their species, even though the proper materials are supplied them, and the experiment has never been fairly tried of turning out a pair of birds so brought up into an enclosure covered with netting, and watching the result of their untaught attempts at nest-making. With regard to the song of birds, however, which is thought to be equally instinctive, the experiment has been tried, and it is found that young birds never have the song peculiar to their species if they have not heard it, whereas they acquire very easily the song of almost any other bird with which they are brought up. It is also especially worthy of remark that they must be taken

out of hearing of their parents very soon, for in the first three or four days they have already acquired a knowledge of the parent notes, which they will afterwards imitate. This shows that very young birds can both hear and remember, and it would be very extraordinary if they could live for days and weeks in a nest and know nothing of its materials and the manner of its construction. During the time they are learning to fly and return often to the nest, they must be able to examine it inside and out in every detail, and as their daily search for food invariably leads them among the materials of which it is constructed, and among places similar to that in which it is placed, is it so very wonderful that when they want one themselves they should make one like it? Again, we always assume that because a nest appears to us delicately and artfully built, that it, therefore, requires much special knowledge and acquired skill (or their substitute, instinct) in the bird who builds it. We forget that it is formed twig by twig and fibre by fibre, rudely enough at first, but crevices and irregularities, which must seem huge gaps and chasms in the little eyes of the builders, are filled up by twigs and stalks pushed in by slender beak and active foot, and that the wool, feathers, or horsehair are laid thread by thread, so that the result seems a marvel of ingenuity to us, just as would the rudest Indian hut to a native of Brobdignag.

But look at civilised man! it is said; look at Grecian and Egyptian and Roman and Gothic and modern Architecture! What advance! what improvement! what refinements! This is what reason leads to, whereas birds remain for ever stationary. If, however, such advances as these are required to prove the effects of reason as contrasted with instinct, then all savage and many half-civilized tribes have no reason, but build instinctively quite as much as birds do.

Man ranges over the whole earth, and exists under the most varied conditions, leading necessarily to equally varied habits. He migrates—he makes wars and conquests—one race mingles with another—different customs are brought into contact—the habits of a migrating race are modified by the different circumstances of a new country. The civilized race which conquered Egypt must have developed its mode of building in a forest country where timber was abundant, for there is no possibility of the idea of cylindrical columns originating in a country destitute of trees. The pyramids might have been built by an indigenous race, but not the temples of El Uksor and Karnak. In Grecian architecture, almost every characteristic feature can be traced to an origin in wooden buildings. The columns, the architrave, the frieze, the fillets, the cantelevers, the form of the roof, all point to an origin in some

southern forest-clad country, and strikingly corroborate the view derived from philology, that Greece was colonised from north-western India. But to erect columns and span them with huge blocks of stone or marble is not an act of reason, but one of pure unreasoning imitation. The arch is the only true and reasonable mode of covering over wide spaces with stone, and, therefore, Grecian architecture, however exquisitely beautiful, is false in principle, and is by no means a good example of the application of reason to the art of building. And what do most of us do at the present day but imitate the buildings of those that have gone before us? We have not even been able to discover or develope any definite mode of building best suited for us. We have no characteristic national style, and to that extent are even below the birds, who have each their characteristic form of nest, exactly adapted to their wants and habits.

That excessive uniformity in the architecture of each species of bird which has been supposed to prove a nest-building instinct we may, therefore, fairly impute to the uniformity of the conditions under which each species lives. Their range is often very limited, and they very seldom permanently change their country so as to be placed in new conditions. When, however, new conditions do occur, they take advantage of them just as freely and wisely as man could do. The chimney and house-swallows are a standing proof of a change of habit since chimneys and houses were built, and in America this change has taken place within about three hundred years. Thread and worsted are now used in many nests instead of wool and horse-hair, and the jackdaw shows an affection for the church steeple which can hardly be explained by instinct. The Baltimore oriole uses all sorts of pieces of string, skeins of silk, or the gardener's bass, to weave into its fine pensile nest, instead of the single hairs and vegetable fibres it has painfully to seek in wilder regions, and Wilson believes that it improves in nest-building by practice—the older birds making the best nests. The purple martin of America takes possession of empty gourds or small boxes stuck up for its reception in almost every village and farm in America, and several of the American wrens will also build in cigar boxes, with a small hole cut in them, if placed in a suitable situation. The orchard oriole of the United States offers us an excellent example of a bird which modifies his nest according to circumstances. When it is built among firm and stiff branches it is very shallow, but when, as is often the case, it is suspended from the slender twigs of the weeping willow, it is made much deeper, so that when swayed about violently by the wind, the young may not tumble out. It has been observed also that the nests built in

the warm Southern states are much slighter and more porous in texture than those in the colder regions of the north. Our own house-sparrow equally well adapts himself to circumstances. When he builds in trees, as he, no doubt, always did originally, he constructs a well-made domed nest, perfectly fitted to protect his young ones; but when he can find a convenient hole in a building or among thatch, or in any well-sheltered place, he takes much less trouble, and forms a very loosely-built nest.

A curious example of a recent change of habits has occurred in Jamaica. Previous to 1854, the palm swift (*Tachornis phœnicobea*) inhabited exclusively the palm trees in a few districts in the island. A colony then established themselves in two cocoa nut palms in Spanish Town, and remained there till 1857, when one tree was blown down, and the other stripped of its foliage. Instead of now seeking out other palm trees, the swifts drove out the swallows who built in the Piazza of the House of Assembly, and took possession of it, building their nests on the tops of the end walls and at the angles formed by the beams and joists, a place which they continue to occupy in considerable numbers. It is remarked that here they form their nest with much less elaboration than when built in the palms, probably from being less exposed.

A fair consideration of all these facts will, I think, fully support the statement with which I commenced this article, and show that the mental faculties exhibited by birds in the construction of their nests are the same in kind as those manifested by mankind in the formation of their dwellings. These are, essentially, imitation, and a slow and partial adaptation to new conditions. To compare the work of birds with the highest manifestations of human art and science is totally beside the question. I do not maintain that birds are gifted with reasoning faculties at all approaching in variety and extent to those of man. I simply hold that the phenomena presented by their mode of building their nests, when fairly compared with those exhibited by the great mass of mankind in building their houses, indicate no essential difference in the kind or nature of the mental faculties employed. If instinct means anything, it means the capacity to perform some complex act without teaching or experience. It implies innate ideas of a very definite kind, and, if established, would overthrow Mr. Mill's sensationalism and all the modern philosophy of experience. That the existence of true instinct may be established in other ways is not improbable, but in the particular case of birds' nests, which is usually considered one of its strongholds, I cannot find a particle of evidence to show the existence of anything beyond those lower reasoning powers which animals are universally admitted to possess.