The Pigmentation of Animals.[1]

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THE hue which a person presents depends upon two factors, to denote which no precise words exist, but which may be represented by the general terms *pigmentation* and *complexion*. In man these are quite distinct, and for that reason it is best to start with the consideration of the human skin, and from it to work backwards through some of the more primitive forms of life.

First, then, to obtain a clear idea of pigmentation. It consists in the laying down of a definite deposit of coloured substance in a definite layer of the skin. The pigment is laid down as a more or less uniform covering, it is in the deepest layer of the epidermis, and this fact alone suggests considerations which demand some reflection. "The deepest layer of the epidermis," or Malpighian layer, is that from which all the other layers grow. Its cells are in constant division and the offspring of each segmentation, or the daughter cells, all gradually work their way outwards, taking on certain characters at specific parts of their journey, and, therefore, as all the cells move outwards uniformly, endowing the successive layers of the epidermis with the characteristics proper to the advancing age of the cells.

Although the whole cell moves outwards and ultimately drops off, only the innermost part of the epidermis is pigmented (*i.e.* coloured with the black substance melanin). As an Indian student at Guy's Hospital once said: "We Indians do not shed our melanin." I have never seen a blister on the skin of a negro, but as I understand the mechanism of a blister it is as follows.[2] The lower layers of the epidermis are, like living tissues generally, pervious to water. The upper ones are, in comparison, water-tight. The lower layers become injured and inflamed; thither water is drawn, as to all inflamed areas, and because it cannot get away through the water-tight covering on top of it, the water forces up the cover from the layers beneath. If my conception of a blister is correct, it would follow that the portion of the skin above the blister on a negro would be colourless like our own, whilst that beneath the blister would be pigmented.

So much for pigmentation. To pass to complexion. By complexion I understand that element in hue which is variable from time to time, the element to which such words as "pale," "fresh," "ruddy," "sallow," "blue," "cyanotic," etc., apply. These words all have reference to the amount and nature of the blood which can be seen through the epidermis. Unlike pigmentation, the pigment involved is not melanin but hæmoglobin; unlike pigmentation, the part of the skin involved is the dermis not the epidermis; unlike pigmentation, the impression of hue is not due to a uniform layer of colour but to the integration of minute vessels; and, most pre-eminently unlike pigmentation, complexion is something which varies from moment to moment, which reflects the physical condition and the mental equilibrium of the individual.

Complexion then varies (*a*) with the thickness and consequent opacity of epidermis, through which the dermis is seen; and (*b*) with the calibre of the various vessels, arteries, capillaries, and veins of the underlying dermis. Of the veins we know but little as yet; of the capillaries much has been learned within the last six or seven years, and the following table, gleaned from the writings of Prof. Krogh, will give an idea of the relation of the colour and temperature of the skin to the calibre of the arteries and capillaries.

Calibre.		Skin.	
Arteries.	Capillaries.	Colour.	Temperature.
Shut	Shut	Pale	Cold
Open	Shut	Pale	Warm
Shut	Open	Blue	Cold
Open	Open	Red	Warm

Complexion is the expression of the play of the nervous system—in particular the sympathetic system—on the blood-vessels of the skin, but the nervous system can assert itself in two ways, first by direct action, *i.e.* by impulses passing along the fibres which directly supply the blood-vessels; and secondly, by indirect action; *i.e.* by stimulation of one or other of the endocrine glands which in turn secretes an active material into the blood. This material, when it is brought to the vessel wall, affects its calibre. We obtain the following scheme, then, for the factors which influence the colour of the human skin.

- Hue
  - Pigmentation—uncontrolled over short intervals of time.
  - Complexion—controlled by nervous system.
    - By direct stimulation.
    - Through endocrines.

Passing from man to the lower mammals we encounter a mechanism which dominates the situation, namely, the growth from the skin of hair. Hair is an outgrowth of the very part of the epidermis which in the negro is pigmented, and therefore the pigment in the hair is of the same order of things as that in the skin. In fact the question arises, quite naturally: "In an animal, which has coloured spots on a white ground, is the colour of the hair on the spots merely the expression of a corresponding pigmentation of the Malpighian layer of the skin from which the hair grows?" If you shave a spotted cat, it is a spotted cat still. But if you go further and cut sections of the skin, there appears to be no pigment in the Malpighian layer; the pigment is confined to the hair roots and the black colour of the spots is due to the visibility of the hair roots, through the epidermis. In the same way the pigment of the scalp of a European, though his hair be jet black, is

[1] Substance of four lectures on "The Colour of the Animal Creation" delivered at the Royal Institution on February 10, 17, 24, and March 3.

[2] In this connexion I came across an interesting example of the ignorance of learned persons on simple matters. Wishing to assure myself of the correctness or otherwise of the above view, I asked nine specialists, all of them medical men who had studied blisters, whether the seat of the blister was as I have described it, or, alternatively, was between the dermis and the epidermis. Of the nine, three took the latter view and six the view as given above. We consulted a number of pathology books which were at hand, but without gaining any further enlightenment.

confined to the hair. Presumably you could "change the spots" in the case of the leopard by pulling out all his hairs. But it is not so in all animals. Thus on the spots of the guinea-pig—and, I believe, of the Dalmatian hound—the Malpighian layer of the skin itself is pigmented, and it would look as though this were the more primitive and less specialised condition.

At a superficial view, it might be thought that, the skin being covered with hair, no question of complexion could arise, but this is not altogether so. Complexion, *i.e.* the variable changes in appearance wrought by the nervous system, changes its ground. In animals and birds, the nervous control of the position of the hairs and feathers respectively is a very real affair. In man it is negligible. We talk of our hair standing on end, but the actual phenomenon is not one of great consequence. In animals it is otherwise, and stimulation of the endings of these nerves which are responsible for the lie of the hairs—whether direct or endocrine—may alter the whole appearance of the animal.

One cannot pass the mechanism of pigmentation without some inquiry into its chemical basis: and here we are under a great debt to the late Huia Onslow, who devoted the last years of his life, recumbent as the result of a severe accident, to the study of the chemistry of animal pigmentation.

Put briefly, many of the phenomena are due to melanin, of which mention has already been made. Melanin itself is produced by the oxidation of one of the most common products of digestion, tyrosine, a colourless crystalline material. The oxidation may be partial or complete; in the former case a reddish pigment is formed, in the latter a pigment which appears black in sufficient concentration, but in a dilute form is more or less yellow or brown. The oxidation of the melanin is wrought by a ferment, tyrosinase, and should it not occur, the failure may be attributed to one or two reasons—(*a*) the ferment is not present, and (*b*) the ferment is prevented from doing its work by some third substance which overrides it. Either of these circumstances may occur and therefore there are two fundamentally different forms of whiteness. The first, due to the absence of ferment, is albinism; the second, due to the presence of an anti-ferment, is dominant whiteness of the ordinary kind, in which the eyes are pigmented. How different these two forms of whiteness are is shown by the way in which they are inherited. If an albino rabbit is bred with a pure black, the first generation are all black. If a rabbit with the anti-ferment is bred with a pure black, the first generation are all white.

In the chameleon, and more simply in the frog or lizard, is to be seen the complete fusion of pigmentation and complexion. The pigment is to be found in definite cells in the skin, as is the case in the negro. These cells do not, however, form a complete integument, and to these very cells the cutaneous nerve fibres are attached. The colour which the animal presents appears to depend on whether the pigment is diffused throughout the whole cell, in which case the animal is dark, or, alternatively, is concentrated in one locality, in which case the animal is light. Here I must acknowledge a debt of gratitude to two former colleagues, Dr. Alfred C. Redfield and Dr. L. T. Hogben, from one or other of whom I have gleaned most of what I know. Their work has dealt chiefly with the control of pigmentation by the nervous system, and has shown, in the animals which they have studied, how important is the endocrine factor. In a frog it is only necessary to inject a small quantity of pituitary extract in order to diffuse the pigment throughout the cells in the skin (melanophores), and so make the whole integument darken. In the lizard the same effect is produced by injection of suprarenal extract. In the chameleon the mechanism is more complicated because the pigment cells are more diverse in kind. It must not be supposed that a chameleon can present itself in all the colours of the rainbow. Of two animals which I had the opportunity of observing for about a year, one passed through all shades of brown from a light cream to something short of black, the other through the shades of green from a pale apple colour to a colour so dark as to be barely tinged with green. Let us take the case of the brown chameleon. In the light of modern knowledge, two kinds of cells in its skin may be considered as being the most important. Of these, one kind, the most superficial, were yellow, and probably changed little in colour; the other kind were situated behind the yellow ones, making a background for them. These latter were the true melanophores, and they sent tendrils towards the surface which surrounded the yellow cells. The melanophores were susceptible of endocrine action, presumably having nerve endings on which the endocrine substance could act. When the animal darkened, the black pigment in the melanophores, which hitherto had been localised in small areas, became diffused through the cells, pushing into the tendrils, at once tending to obscure the yellow cells from in front and to provide a background which could be seen through the yellow cells.

Why and when does the chameleon change its colour? The tradition is that it takes the colour of the ground on which it is. This tradition I never could verify, though I well remember an occasion on which the green chameleon got lost on a vine and was very difficult to find. It may be that in our climate chameleons are not very sensitive; just as in the Arctic we might not react very readily to the finer alterations of environment. The fact, however, that my family could make their chameleons darken by annoying them is all in line with the knowledge that their tint is ruled by their nervous systems, as is the human complexion.

Though such factors as heat and cold, light and darkness and mental condition play a large part in the colour changes of the animal creation, it is not intended completely to rule out the idea that animals can simulate the background on which they are placed apart from changes in temperature and illumination. The most remarkable examples of the way in which fish can simulate the backgrounds on which they are placed are proved beyond dispute. A flounder on a dark background will become dark, on a light background it will become light, on a speckled background it will become speckled. Further than this it cannot go; it cannot, for example, assume stripes or definite pattern out of sympathy with its background; and this ability to modify its colour is directly under the control of the actual nerves which go to the skin. It is not a roundabout endocrine mechanism. Cut the nerves going to a particular cutaneous area, and that area loses its power of simulating the background on which the fish is placed. Here at present the matter must be left until we attain to a more perfect knowledge of what protective coloration really means, for it must always be borne in mind that the object of protective coloration is to save the animal from its natural enemies, and not to save it from us.

What assumption is there that because a fish looks to us the same as the ground on which it lies, it will be similarly protected from its marine adversary, or that it may not be invisible to its enemy though appearing to us to be of a colour very discordant from its background? That such considerations are by no means fantastic may be shown by a very simple experiment. In our own eyes there are two complete mechanisms for the perception of colour; one resides in the rods of the retina, the other in the cones. We can use either at will, and they see colours quite differently. The cones we use in a light of ordinary intensity, the rods in a dim light. The room is completely dark, there is a blackboard on which are pinned two paper fish. Let in a little daylight—just a little—one fish is seen, it is greyish; a little more light is let in, it becomes brighter, and so with more light until there is some suggestion of the second fish, by which time the first is easily seen. Turn on the electric light, the second and invisible fish at once flashes out, a bright red, whilst the first, which is less obvious, is a royal blue. The switching on of the light transferred the seat of vision from the rods to the cones, but the colour scheme—red on black—which formed a complete protection to the rod-vision became dangerous when the cones were invoked. We need more knowledge of what life looks like to enemy-animals before we can discuss further the adequacy of the colour schemes of protectees.

The Hebrew University in Jerusalem.

THE inauguration of a new university is an event of interest to all engaged in academic and scientific pursuits, but the opening of the Hebrew University on Mount Scopus, by Lord Balfour, on April 1, aroused more than usual interest, not only among Jews but also among all civilised peoples. The new University is yet in its infancy. At present, a small but well-equipped chemical department is in existence, a micro-biological department is in preparation, a department of Jewish studies is in being, while active preparations are being made in connexion with the Einstein Institute of Physics and Mathematics, the foundation stone of which was laid on Thursday, April 2, by Sir Arthur Schuster. Nevertheless, in spite of its present smallness, the opening of the University was the occasion of a remarkable demonstration of enthusiasm on the part of world-wide Jewry, as well as of sympathy from a large number of universities and learned institutions, which were either represented at the opening ceremony or sent messages of greeting and goodwill.

Palestine is in the process of rebirth, and in all parts of the country there are evidences of great activity in agriculture, industry, and commerce, particularly on the part of the Jewish immigrants who are making Palestine their national home. The University and its associated institutions, like the excellently equipped Technical Institute at Haifa, the Botanical Research Institute at Tel-Aviv near Jaffa, and other institutions of a medical character, must evidently serve the country in the sense of directing the various economic developments. But the most important function of the University, and the function that appeals most to Jews as well as to non-Jews, is to constitute the intellectual centre of world-wide Jewry.

Jews were almost completely excluded from European university life until the nineteenth century, so that Jews figured scarcely at all in the scientific progress of the seventeenth and eighteenth centuries. But as soon as the universities of Europe were opened to Jews, members of this race began to play a rôle of considerable importance in the academic life of civilised humanity. Everybody interested in any branch of science can illustrate this statement for himself with reference to his own subject, and often he will be surprised to discover that men whose names stand in the front rank of the workers in the subject are of Jewish race or origin. In this connexion it is of interest to refer to the statement made by Lord Balfour at the opening ceremony, when he mentioned the remarkable fact, that the three great theories which have aroused the most general interest in all circles and in all countries, namely, the psycho-analytical theory, the creative evolution theory, and the theory of relativity, are all due to Jews, namely, Freud, Bergson, and Einstein.

While Jews have thus as individuals contributed to the intellectual progress of mankind, it nevertheless remains a matter of speculation as to how much Jewry as a body can contribute to the scientific life of humanity. It will be of the greatest interest to watch sympathetically the young institution on Mount Scopus, and observe in what measure it will tend to increase human resources in the scientific field.

Judging by the very considerable participation in the opening ceremony by the great universities of the world, it seems that there is a considerable amount of confidence in the success of the new University in Jerusalem. So far as Great Britain is concerned, the Universities of Oxford, Cambridge, London, Manchester, Liverpool, Leeds, Edinburgh, Aberdeen, etc., sent representatives to the opening ceremony, while messages of cordial greeting were received from other universities. The Royal Society, the British Academy, and other such bodies, were represented in person, and many others sent cordial wishes.

In the opinion of most people competent to judge, this confidence is not misplaced. In the first place, there can be no question of the existence of a sufficient number of distinguished Jewish men of science to direct the work of the new University. The appointments are being made with very great care and circumspection, and it is gratifying to be able to say that only considerations of eminence in research are allowed to govern the choice of professors and their colleagues.

In the second place, the Hebrew University in Jerusalem is not making the mistake that many lay advisers and critics wanted it to make, of embarking without delay on the task of training doctors, lawyers, engineers, teachers, etc. Palestine itself cannot absorb large numbers of such professional men, but more important still, professional men receiving diplomas