Ephemeris for Greenwich Midnight.

1898.	App. α h. m. s.	App. δ ° ′ ″	log Δ
Feb. 1·5	17 25 1·63	−10 53 56·4	
3·5	34 33·95	11 17 21·0	0·1527
5·5	44 14·66	11 39 50·2	
7·5	17 54 3·34	−12 1 18·5	0·1457

The nearest bright star to the comet during this period is ρ Serpentis, which rises about four hours in advance of the sun.

ROWLAND'S TABLES.—In the December number of the *Astrophysical Journal*, tables of *corrections* and *additions* to Prof. H. A. Rowland's table of solar spectrum wave-lengths are given. The errors in wave-length have been carefully determined for the whole table, but the identification of solar lines with the lines of the elements in the spectrum of the electric arc has been revised only from wave-length 3722 to 4175. Therefore the corrections and additions to the identifications have been given only for the most important lines between these limits. A few small solar lines have been added to the table.

The changes in wave-length are few, most of them being additions to the identifications.

NEBULÆ NEAR CASTOR.—Prof. Barnard records in the *Astronomical Journal* (No. 422) a list of new nebulæ which he found with the 12-inch equatorial when he first went to Mount Hamilton, and which have remained unpublished until now. There are five within less than a degree of Castor, whose positions here given are reduced to 1860·0—the epoch of Dreyer's New General Catalogue.

No.	α h. m. s.	δ ° ′	Description.
1	7 24 23	+31 44·4	Close p. 10 mag. star.
2	7 24 43	+31 35·5	Small, faint.
3	7 25 12	+31 40·5	Small, 3 S ∗s in curve 2′ p. ±
4	7 25 27	+31 40·5	Very, very faint.
5	7 25 59	+31 31·0	Small, faint.

Prof. Barnard remarks that he has discovered several nests of these nebulæ, but in most other cases the individual nebulæ are very much smaller.

DR. KARL NECKER.—The name of yet another astronomer has to be added to the death roll of last year. Dr. Karl Necker, who occupied the position of assistant in various observatories, was unfortunately killed in a railway accident at Cairo, to which town he had removed for the benefit of his health. Born in 1867, and with his University career only completed in 1893, he entered first the Strassburg Observatory as a temporary assistant, but after a few months removed to Vienna, and in the Küffner Observatory devoted himself to making a series of observations on the prime vertical. When Dr. Halm left Strassburg to occupy his present position at Edinburgh, Dr. Necker returned to fill the vacancy thus created, and was engaged in the fundamental meridian work. But his health compelled him to take long rests, and finally he was recommended to reside in Cairo, where he hoped to secure a position in the Khedival Observatory. This hope was defeated by his tragic death, while making a short excursion to the Sinai Peninsula.

INSTINCT AND INTELLIGENCE IN ANIMALS.[1]

BIOLOGY is a science not only of the dead but of the living The behaviour of animals, not less than their form and structure, demands our careful study. Both are dependent on that heredity which is a distinguishing characteristic of the organic world. And in each case heredity has a double part to play. It provides much that is relatively fixed and stereotyped; but it provides also a certain amount of plasticity or ability to conform to the modifying conditions of the environment. Instinctive behaviour belongs to the former category; intelligent behaviour to the latter. When a caterpillar spins its silken cocoon, unaided, untaught, and without the guidance of previous experience; or when a newly-mated bird builds her nest and undertakes the patient labours of incubation before experience can have begotten anticipations of the coming brood; we say that the behaviour is instinctive. But when an animal learns the lessons of life, and modifies its procedure in accordance with the results of its individual experience, we no longer use the term instinctive, but intelligent. Instinct, therefore, comprises those phases of active life which exhibit such hereditary definiteness as fits the several members of a species to meet certain oft-recurring or vitally-important needs. To intelligence belong those more varied modes of procedure which an animal adopts in adaptation to the peculiar circumstances of its individual existence. Instinctive acts take their place in the class of what are now generally known as congenital characters; intelligent acts in the class of acquired characters.

But the study of instinct and intelligence in animals opens up problems in a different field of scientific investigation. They fall within the sphere not only of biological but also of psychological inquiry. And in any adequate treatment of their nature and origin we must endeavour to combine the results reached by different methods of research in one harmonious doctrine. This involves difficulties both practical and theoretical. For those invertebrates, such as the insects, which to the naturalist present such admirable examples of instinctive behaviour, are animals concerning whose mental processes the cautious psychologist is least disposed to express a definite opinion. While the higher mammalia, with whose psychology we can deal with greater confidence, exhibit less typical instincts, are more subject to the disturbing influence of imitation, and, from the greater complexity of their behaviour, present increased difficulties to the investigator who desires carefully to distinguish what is congenital from what is acquired.

Nor do the difficulties end here. For the term "instinct" is commonly, and not without reason, employed by psychologists with a somewhat different significance, and in a wider sense than is necessary or even desirable in biology. The naturalist is concerned only with those types of behaviour which lie open to his study by the methods of direct observation. He distinguishes the racial adaptation which is due to congenital definiteness, from that individual accommodation to circumstances, which is an acquired character. But for the psychologist instinct and intelligence comprise also the antecedent conditions in and through which these two types of animal activity arise. The one type includes the conscious impulse which in part determines an instinctive response; the other includes the choice and control which characterise an intelligent act. When a spider spins its silken web, or a stickleback builds the nest in which his mate may lay her eggs, the naturalist describes the process and seeks its origin in the history of the race; but the psychologist inquires also by what impulse the individual is prompted to the performance. And when racial and instinctive behaviour is modified in accordance with the demands of special circumstances, the naturalist observes the change and discusses whether such modifications are hereditary; but the psychologist inquires also the conditions under which experience guides the modification along specially adaptive lines. Each has his part to play in the complete interpretation of the facts. And each should consent to such definitions as may lead to an interpretation which is harmonious in its results.

In view, therefore, of the special difficulties attendant on a combined biological and psychological treatment of the problems of animal behaviour, I have devoted my attention especially to some members of the group of birds in the early days of their life. And I shall therefore draw my examples of instinct and intelligence almost entirely from this class of animals. The organisation and the sensory endowments of birds are not so divergent from those of man, with whose psychology alone we are adequately conversant, as to render cautious conclusions as to their mental states altogether untrustworthy; when hatched in an incubator they are removed from that parental influence which makes the study of the behaviour of mammals more difficult; while the highly developed condition in which many of them first see the light of day affords opportunity for observing congenital modes of procedure under more favourable circumstances than are presented by any other vertebrate animals. Even with these specially selected subjects for investigation, however, it is only by a sympathetic study and a careful analysis of their behaviour that what is congenital can be distinguished from what is acquired. For from the early hours of their free and active life, the influence of the lessons taught by experience makes itself felt. Their actions are the joint product of instinct and intelligence, the congenital modes of behaviour being liable to continual modification in adaptation to special circumstances.

[1] A Friday evening discourse delivered at the Royal Institution, on January 28, by Prof. C. Lloyd Morgan.

Instinct appears to furnish a ground-plan of procedure which is shaped by intelligence to the needs of individual life. And it is often hard to distinguish the original instinctive plan from the subsequent intelligent modification.

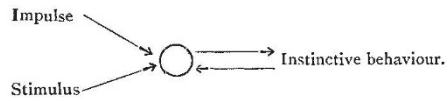
It is not my purpose to describe here in detail, as I have done elsewhere, the results of these observations. It will suffice to indicate some of the more salient facts. In the matter of feeding, the callow young of such birds as the jackdaw, jay, or thrush, instinctively open wide their beaks for the food to be thrust into their mouths. Before the eyes have opened the external stimulus to the act of gaping would seem to be either a sound or the shaking of the nest when the parent bird perches upon it. Under experimental conditions, in the absence of parents, almost any sound, such as a low whistle, lip-sound, or click of the tongue, will set the hungry nestlings agape, as will also any shaking or tapping of the box which forms their artificial nest. And no matter what is placed in the mouth the reflex acts of swallowing are initiated. But even in these remarkably organic responses the influence of experience soon makes itself felt. For if the material given is wrong in kind or distasteful, the effect is that the bird ceases to gape as before to the stimulus. Nor does it continue to open the beak when appropriate food has been given to the point of satisfaction. These facts show that the instinctive act is prompted by an impulse of internal origin, hunger, supplemented by a stimulus of external origin, at first auditory but later on, when the eyes are opened, visual. They show also that when the internal promptings of hunger cease, owing to satisfaction, the sensory stimulus by itself is no longer operative. And they show, too, that the diverse acts of gaping and swallowing become so far connected, that the experience of distasteful morsels tends, for a while at least, to prevent further gaping to the usual stimulus.

With those birds which are active and alert soon after hatching, the instinctive acts concerned in feeding are of a different character. At first, indeed, the chick does not peck at grains which are placed before it; and this is probably due to the fact that the promptings of hunger do not yet make themselves felt, there being still a considerable supply of unabsorbed yolk. Soon, however, the little bird pecks with much, but not quite perfect, accuracy at small near objects. But here again experience rapidly plays its part. For if distasteful objects, such as bits of orange-peel, are the first materials given, pecking at them soon ceases; and if this be repeated, the little bird cannot again be induced to peck, and may even die of starvation. This makes it very difficult to rear by hand some birds, such as plovers, whose natural food, in due variety, is not readily obtainable. It must be remembered, too, that under natural conditions the parent bird calls the young and indicates with her beak the appropriate food; and this appears to afford an additional stimulus to the act of pecking. Pheasants and partridges seem to be more dependent on this parental guidance than domestic chicks, and they are more easily reared when they have somewhat older birds as models whose pecking they may imitate. Passing allusion may here be made to a type of instinctive response in some respects intermediate between the upward gaping of the jay and the downward pecking of the chick. It is seen in the young moorhen, which pecks upwards at food held above it and cannot at first be induced to take any notice of food on the ground. Under natural conditions it is fed by the parent, which holds the food above the little bird as it floats on the water.

We have then, in these simple instinctive acts, examples of behaviour which is congenitally definite in type for each particular species; of actions which are the joint product of an internal factor, hunger, and an external factor, sensory impressions; of complex modes of procedure which subserve certain vital needs of the organism. It should be mentioned, however, that the relative definiteness of instinctive responses has been subjected to criticism from a psychological source. It has been urged that the nutritive instincts, the play instincts, the parental instincts, those of self-preservation and those concerned in reproduction, are so varied and multifarious, that definiteness is the last thing that can be predicated of them. Varied and multifarious they are indeed; and each of the groups above mentioned contains many differing examples. But that is because we are dealing with comprehensive classes of instinctive behaviour. The fact that the group of fishes includes organisms of such wide structural diversity, as the salmon, the globe-fish, the eel, and the sole, does not affect the fact that these species have a relatively definite structure each after his kind. It is only when we treat a group of fishes as if it were an individual fish that we are troubled by indefiniteness of structure. And it is only when we deal with a group of instincts, comprised under a class-name, as if it were a particular instinctive act, that we fail to find that definiteness which, to the naturalist, is so remarkable.

From the physiological point of view, instinctive procedure would seem to have its origin in an orderly group of outgoing neural discharges from the central office of the nervous system giving rise to a definite set of muscular contractions. And this appears to have an organic basis in a congenital preformation in the nervous centres, the activity of which is called into play by incoming messages, both from internal organs in a state of physiological need, and from the external world through the organs of special sense. The naturalist fixes his attention chiefly on the visible behaviour which is for him the essential feature of the instinctive act. But in view of the requirements of psychological interpretation it is advisable to comprise under the term instinct, in any particular manifestation of its existence, the net result of four things: first, internal messages giving rise to the impulse; secondly, the external stimuli which co-operate with the impulse to affect the nervous centres; thirdly, the active response due to the coordinated outgoing discharges; and fourthly, the message from the organs concerned in the behaviour by which the central nervous system is further affected. Now I shall here assume, without pausing to adduce the arguments in favour of this view, that consciousness is stirred in the brain, only by incoming messages. If this be so, the outgoing discharges which produce the behaviour are themselves unconscious. Their function is to call forth adaptive movements; and these movements give rise to messages which, so to speak, afford to consciousness information that the instinctive act is in progress. Hence I have urged that the instinctive *performance* is an organic and unconscious matter of the purely physiological order, though its effects are quickly communicated to consciousness in the form of definite messages from the motor organs. I have not denied that the stimuli of sight, touch, hearing and so forth, also have conscious effects; I do not deny (though here I may have spoken too guardedly) that the initiating impulse of internal origin, is conscious. In both these cases we have messages transmitted to the central office of the brain. What I have ventured to urge is that the consciousness of instinctive behaviour, *in its completed form*, does not arise until further messages come in from the motor organs implicated in the performance of the act, lodging information at the central office concerning the nature of the movements.

A diagram will perhaps serve to make this conception clearer.



The circle represents the brain, in some part of which consciousness arises through the effects of incoming nerve-currents. Under the influence of the two primary groups of messages, due to impulse and to sensory stimulus, consciousness is evoked, and the brain is thrown into a state of neural strain, which is relieved by the outgoing discharge to the organs concerned in the instinctive behaviour. It is this outgoing discharge which I regard as unconscious. But the actions which are thus produced give rise to a secondary group of incoming messages from the moving limbs. This it is which gives origin to the consciousness of instinctive behaviour as such. And I regard it as psychologically important that these incoming messages are already grouped, so as to afford to consciousness information, rather of the net results of movement than of their subsidiary details.

So much for our general scheme. If now we turn to the instinctive behaviour concerned in locomotion, we find a congenital basis upon which the perfected activities are founded. There is no elaborate process of learning to walk on the part of the chick; ducklings and moorhens a few hours old swim with perfect ease when they are placed in water; these birds also dive without previous practice or preliminary abortive attempts; while young swallows, if their wings are sufficiently large and strong, are capable of short and guided flights the first time they are committed to the air. In these cases neither the internal impulse, nor the sensory stimuli, are so well defined as in the case of the nutritive activities. The impulse probably takes the

form of an uneasy tendency to be up and doing, perhaps due to ill-defined nervous thrills from the organs of locomotion which are in need of exercise. The sensory stimuli are presumably afforded by the contact of the feet with the ground, or with the water, and by the pressure of the air on the wing-surfaces. It is a curious fact that, if young ducklings be placed on a cold and slippery surface, such as that of a japanned tea-tray, they execute rapid scrambling movements, suggestive of attempts to swim, which I have never seen in chicks, pheasants, or other land-birds.

It will not be supposed that I claim for perfected locomotion, so admirably exemplified in the graceful and powerful flight of birds, an origin that is wholly instinctive and unmodified by the teachings of experience. Here as elsewhere instinct seems to form the ground-plan of activities which intelligence moulds to finer and more delicate issues. This is the congenital basis on which is built the perfected superstructure. And if our opportunities for observation, and our methods of analysis, were equal to the task, we should be able to distinguish, in the development of behaviour, the congenital outline from the shading and detail which are gradually filled in by the pencil of experience.

The difficulties which render this analysis at the best imperfect are, therefore, twofold. In the first place, intelligence begins almost at once to exercise its modifying influence; and in the second place, many instinctive traits do not appear until long after intelligence has begun its work. Much of the intelligent detail of the living picture is filled in before the instinctive outlines are complete. The term "deferred instincts" has been applied to those congenital modes of procedure which are relatively late in development. The chick does not begin to scratch the ground, in the manner characteristic of rasorial birds, till it is four or five days old; nor does it perform the operation of sand-washing till some days later; the moorhen does not begin to flick its tail till it is about four weeks old; the jay does not perform the complex evolutions of the bath till it has left the nest and felt its legs, when the stimulus of water to the feet, and then the breast, seems to start a train of acts which, taken as a whole, are of a remarkably definite type. The development of the reproductive organs brings with it, apart from the act of pairing, a number of associated modes of behaviour—nest-building, incubation, song, dance, display, and strange aerial evolutions—which are presumably in large degree instinctive, though of this we need more definite evidence. For it is difficult to estimate with any approach to accuracy the influence of imitation. There seems to be no reason for doubting that, when an animal grows up in the society of its kind, it is affected by what we may term the traditions of its species, and falls into the ways of its fellows, its imitative tendency being subtly influenced by their daily doings. The social animal bears the impress of the conditions of its peculiar nurture. Its behaviour is in some degree plastic, and imitation helps it to conform to the social mould.

The exact range and nature of the instinctive outline, independently of those modifications of plan which are due to the inherent plasticity of the organism, are, therefore, hard to determine. And if, as we have good grounds for believing, the growth of intelligent plasticity, in any given race, is associated with a disintegration of the instinctive plan, congenital adaptation being superseded by an accommodation of a more individualistic type, to meet the needs of a more varied and complex environment, the problems with which we have to deal assume an intricacy which at present defies our most subtle analysis.

We must now turn to the consideration of the manner in which individual accommodation through the exercise of intelligence under the teachings of experience, is brought about. And it will be well to pave the way by adducing certain facts of observation.

Although the pecking of a young chick under the joint influence of hunger and the sight of a small near object, would seem to belong to the instinctive type, the selection of appropriate food, apart from the natural guidance of the hen, seems to be mainly determined by individual experience. There is no evidence that the little bird comes into the world with anything like hereditary knowledge of good and evil in things eatable. Distasteful objects are seized with not less readiness than natural food such as grain, seeds, and grubs. The conspicuous colours of certain nasty caterpillars do not appeal to any inherited power of immediate discrimination so as to save the bird from bitter experience. They seem rather to serve the purpose of rendering future avoidance, in the light of this bitter experience, more ready, rapid, and certain. Bees and wasps are seized with neither more nor less signs of fear than large flies or palatable insects. Nor does there seem to be any evidence of the hereditary recognition of natural enemies as objects of dread. Pheasants and partridges showed no sign of alarm when my dog quietly entered the room in which they were kept. When allowed to come to closer quarters, they impudently pecked at his claws. A two days chick tried to nestle down under him. Other chicks took no notice of a cat, exhibiting a complete indifference which was not reciprocated. A moorhen several weeks old would not suffer my fox-terrier to come near his own breakfast of sopped biscuit, but drove him away with angry pecks until the higher powers supervened.

It is not, of course, to be inferred from these observations that such an emotion as fear has no place in the hereditary scheme, or that the associated acts of hiding, crouching, or efforts to escape do not belong to the instinctive type. I have seen little pheasants struck motionless, plovers crouch, and moorhens scatter at the sound of a loud chord on the violin, or of a shrill whistle. A white stoneware jug, placed in their run, caused hours of uneasiness to a group of birds, including several species. But there is no evidence that, in such cases, anything like hereditary experience defines those objects which shall excite the emotion. It is the unusual and unfamiliar object, especially after some days of active life amid surroundings to which they have grown accustomed; it is the sudden sound, such as a sneeze, or rapid movement, as when a ball of paper is rolled towards them, that evokes the emotion. Hence, if the parent birds are absent, the stealthy approach of a cat causes no terror in the breasts of inexperienced fledglings. But when she leaps, and perhaps seizes one for her prey, the rest scatter in alarm, and for them the sight of a cat has in the future a new meaning.

The elementary emotions of fear, anger, and so forth, stand in a peculiar and special relationship to instinct. At first sight they seem to take rank with the internal impulses which are the part-determinants of instinctive behaviour. The crouching of a frightened plover or landrail, the dive of a scared moorhen, result partly from the external stimulus afforded by the terrifying object, partly from the emotional state which that object calls forth. But in their primary genesis I am disposed—here following to some length the lead of Prof. Wm. James—to assign to such emotions an origin similar to that of the consciousness which follows on the execution of the instinctive act. Assuming, as before, that consciousness owes its genesis to messages which reach the sensorium through incoming nerve-channels, the sensory stimuli, afforded, let us say, by the sight of a terrifying object, do not seem, in the absence of inherited experience, capable of supplying messages which in themselves are sufficient to generate the emotion of fear. Now, the well-known accompaniments of such an emotional state are disturbances of the heart-beat, the respiratory rhythm, the digestive processes, the action of the glands, and the tone of the minute blood-vessels throughout the body. And all these effects are unquestionably *produced* by outgoing discharges from the central nervous system. But they are *felt* as the result of incoming messages, like vague and disquieting rumours, transmitted to the central office from the fluttering heart, the irregular breathing, the sinking stomach, and the disturbed circulation. Is it not therefore reasonable to suppose that the emotion, in its primary genesis, is due to the effect on the sensorium of these disquieting messages? If this be admitted as a working hypothesis—and it cannot at present claim to be more than this—we reach, at any rate, a consistent scheme. As primary messages to the central office of consciousness we have, on the one hand, those due to stimuli of the special senses, and, on the other hand, those resulting from the conditions of the bodily organs, taking the form of a felt craving for their appropriate exercise. These co-operate to throw the brain into a state of unstable equilibrium or neural strain, which is relieved by outgoing streams of nervous energy. And these in turn fall into two groups; first, an orderly set of discharges to the voluntary muscles concerned in behaviour, and secondly, a more diffuse group of discharges to the heart, respiratory apparatus, digestive organs, glands, and vascular network. In so far as these are outgoing discharges, they do not directly affect consciousness. But there quickly returns upon the sensorium an orderly group of incoming messages from the motor apparatus concerned in instinctive behaviour, and a more indefinite group from the heart and other visceral

organs. The former gives the well-defined consciousness of activity; the latter the relatively ill defined feelings which are classed as emotional. But so swift is the backstroke from the body to the brain that, ere the instinctive behaviour is complete, messages from the limbs—and, under the appropriate circumstances, from the heart—that is to say, of both instinctive and emotional origin—begin to be operative in consciousness, and the final stages of a given performance may be guided in the light of the experience gained during its earlier stages.

The exact manner in which consciousness exercises its guiding influence, is a matter of speculation. Perhaps the most probable hypothesis is that the cerebral hemispheres are an adjunct to the rest of the central nervous system, and exercise thereon by some such mechanism as the pyramidal tract in the human subject, a controlling influence. Given an hereditary ground-plan of automatic and instinctive responses the cerebral hemispheres may, by checking here and enforcing there, limit or extend the behaviour in definite ways. In any case, from the psychological point of view, their action is dependent on three fundamental properties: first, the retention of modifications of their structure; secondly, differential results according as these modifications have pleasurable or painful accompaniments in consciousness; and thirdly, the building of the conscious data, through association, into a system of experience. The controlling influence of this experience is the essential feature of active intelligence. Or, expressed in the almost obsolete terminology of the older psychology, intelligence is the faculty through which past experience is brought to bear on present behaviour.

Prof. Stout, whose careful work in analytical psychology is well known, has done me the service of criticising, in a private communication, my use of the phrase "past experience," urging that present experience is not less important in determining behaviour than that which is past and which can only be operative through its revival in memory. The criticism is valid in so far as it shows that I have not been sufficiently careful to define what I mean by past experience. But I certainly had in mind, though I did not clearly indicate, the inclusion of what Mr. Stout regards as present experience. My conception of "present," as I have elsewhere described it, is that short but appreciable period of time, occupying only some small fraction of a second, which is comprised in the fleeting moment of consciousness. All anterior to this, if it were but a second ago, I regard as past—past, that is to say, in origin, though still operative in the limited field of the present moment. When we are reading a paragraph and near its close, the net result of all that we have read in the earlier sentences, is present to influence the course of our thought. But the very words—"all that we *have* read"—by which we describe this familiar fact, imply that the guiding experience originated in a manner which demands the use of the past tense. Still I am none the less grateful to Mr. Stout for indicating what to many may have seemed a serious omission in my interpretation. Suffice it to say that if we include under the phrase "present experience" the occurrences of five minutes, or even of five seconds ago (all of which I regard as past), I most fully agree that present experience (in this sense) exercises a most important guiding influence.

We have distinguished four classes of messages affecting consciousness in the central office of the sensorium: first, stimuli of the special senses; secondly, internal cravings; thirdly, motor sensations due to bodily activity; and fourthly, emotional states. These are combined in subtle synthesis during the growth of experience, and are associated together in varied ways. Into the manner in which experience grows we cannot enter here. It will be sufficient to indicate very briefly the effects of this growth on the behaviour of animals in the earlier stages of their life. This may be considered from a narrower or from a broader standpoint. In the narrower view we watch how, within the field of a widening synthesis, the particular associations are formed. We see how, within experience, the taste and appearance of certain caterpillars or grubs become so associated that for the future the larva is left untouched. Or we see how the terrible pounce of the cat has become so associated with her appearance as thenceforth to render her an object of fear to enlightened sparrows. But of the physiological mechanism of association we know little.

There is a familiar game in which a marble is rolled down an inclined board at the bottom of which are numbered compartments. The lower part of the board is beset with a series of vertical pins so arranged that the marble rebounding from one to another pursues a devious course before it reaches its destination. But if we tie threads from pin to pin we may thus direct the course of the marble along definite lines. Now the brain may be roughly likened to a set of such pins, and the marble to an incoming nerve current. The congenital structure is such that a number of hereditary threads connect the pins in definite ways, and direct the discharge into appropriate channels. But a vast number of other threads are acquired in the course of individual experience. These are the links of association which direct the marble in new ways. Observation of behaviour can only give us information that new directing threads have been introduced. The psychology of association can only indicate which pins have been connected by linking threads. Even such researches as those of Flechsig can at present do no more than supplement the psychological conclusion by general anatomical evidence. Of the details of brain modification by the formation of association fibres we are still profoundly ignorant.

Nor when we turn from the narrower to the wider point of view are we in better case. We are forced to content ourselves with those generalities which are the makeshift of imperfect knowledge. Still, even such generalities are of use in showing the direction in which more exact information is to be sought. And we can, perhaps, best express the net result of acquired modification of brain-structure by saying that every item of experience makes the animal a new being with new reactive tendencies. The sparrows, which yesterday were unaffected by the stealthy approach of the cat, garrulously scatter to-day because they are not the same simple-minded sparrows that they were. The chick comes into the world possessed of certain instinctive tendencies—with certain hereditary directing threads. But at the touch of experience its needs are modified or further defined. New connecting threads are woven in the brain. On the congenital basis has been built an acquired disposition. The chick is other than it was, and reacts to old stimuli with new modes of behaviour.

In its early days the developing animal is reading the paragraph of life. Every sentence mastered is built into the tissue of experience, and leaves its impress on the plastic, yet retentive brain. By dint of repetition, the results of acquisition become more and more firmly ingrained. Habits are generated; and habit becomes second nature. The organism which to begin with was a creature of congenital impulse and reaction becomes more and more a creature of acquired habits. It is a new being, but one with needs not less imperious than those with which it was congenitally endowed.

All of this is trite and familiar enough. But it will serve its purpose if it help us to realise how large a share acquired characters take in the development of behaviour in the higher animals, and how fundamentally important is the plasticity of brain-tissue, and its retentiveness of the modifications which are impressed on its yielding substance.

Such being the relations of intelligence and instinct in the individual, what are their relations in the evolution of the race? Granting that instinctive responses are definite through heredity, how has this definiteness been brought about? Has it been through natural selection? Or are the acquired modifications of one generation transmitted through heredity to the next? Is instinct inherited habit? Darwin, who wrote before the transmission of acquired characters was seriously questioned, admitted both. And Romanes, to whose ever-kindly sympathy I am deeply indebted, still adhered to this view in spite of modern criticism. There is not much in my own observational work which has any decisive bearing on the question. But there are one or two points which are perhaps worthy of consideration. The part played by acquisition in the field of behaviour is the establishment of definite relations between particular groups of stimuli and adaptive responses. If this be so, and if acquired modifications of brain-structure be transmitted, we might reasonably expect that the sight of a dog would have a similar effect on young pheasants to that which it has on their parents. But this does not appear to be the case. Again, one might reasonably expect that the sight of water would evoke a drinking response in recently hatched birds, just as the sight or scent of a Yucca flower excites a definite response in the Yucca moth. But here, too, this is not so. Thirsty chicks and ducklings seem to be uninfluenced by the sight of water in a shallow tin. They may even run through the liquid and remain unaffected by its presence. But if they chance to peck at a grain at the bottom of the tin, or a bubble on the water, as soon as the beak touches the liquid, *this* stimulus at once evokes a drinking response again and again repeated. Why does the touch of

water in the beak excite a congenital response, while the sight of water fails to do so? I believe it is because under natural conditions the chicks peck at the water in imitation of the mother, who thus shields them from the incidence of natural selection. Under these circumstances there is no opportunity for the elimination of those who fail to respond at the mere sight of water, and consequently no selective survival of those who do thus respond. But though the hen can lead her young to peck at the water, she cannot teach them the essential movements of beak, mouth, and gullet, which are necessary for the complex act of drinking. In this matter she cannot shield them from the incidence of natural selection. Those which, on pecking the water, failed to respond to the stimulus by drinking, would assuredly die of thirst and be eliminated. The rest would survive and transmit the congenital instinctive tendency. Thus it would seem that when natural selection is excluded a special mode of behaviour has not become congenitally linked with a visual stimulus; but, when natural selection is in operation, this behaviour has become so linked with a touch or taste stimulus in the beak, Similarly in the case of the pheasants and the dog. The parent birds warn the young of his approach, and thus prevent the incidence of natural selection. Hence there is no instinctive response to the sight of a terrier.

No doubt there are many cases of complex behaviour, seemingly instructive, which are difficult to explain by natural selection alone, and which have the appearance of being due to the inheritance of acquired habits. I have, however, elsewhere suggested that acquired modifications may, under the conditions of natural selection, foster the development of "coincident" variations of like nature and direction, but having their origin in the germinal substance. But into a consideration of this hypothesis I cannot here enter. Without assuming a dogmatic attitude, I am now disposed to regard the direct transmission of acquired modes of behaviour as not proven.

Thus we come back to the position, assumed at the outset, that heredity plays a double part It provides, through natural selection or otherwise, an outline sketch of relatively definite behaviour, racial in value; it provides also that necessarily-indefinite plasticity which enables an animal to acquire and to utilise experience, and thus to reach adaptation to the circumstances of its individual life. It becomes, therefore, a matter of practical inquiry to determine the proportion which the one kind of hereditary legacy bears to the other. Observation seems to show that those organisms in which the environing conditions bear the most uniform relations to a mode of life that is relatively constant, are the ones in which instinct preponderates over intelligent accommodation; while those in which we see the most varied interaction with complex circumstances, show more adaptation of the intelligent type. And the growth of individual plasticity of behaviour, in race-development, would seem to be accompanied by a disintegration of the definiteness of instinctive response, natural selection favouring rather the plastic animal capable of indefinitely varied accommodation than the more rigid type whose adaptations are congenitally defined.

I have dealt, it will be observed, only with the lower phases and earlier manifestations of intelligence. Its higher development, and the points in which it differs from the more complex modes of human procedure, offer a wide and difficult field for careful observation and cautious interpretation. I have recently attempted further investigations in this field; but they concern rather the relation of intelligence to logical thought than that of instinct to intelligence, which forms the subject of this discourse.

THE DUKE OF DEVONSHIRE ON TECHNICAL EDUCATION.

AT Eastbourne on Saturday last the Duke of Devonshire addressed the students of the art and technical classes, and in the course of his remarks he referred to educational questions of more than local interest. His remarks upon proprietary and private schools call attention to what is probably the weakest link in our educational system. In order to qualify for an assistant mastership in an elementary school, it is necessary for a teacher to serve a term of years, during which period his knowledge of the theory and practice of teaching is periodically tested; but in our private and proprietary schools any one can be a teacher, whether he possesses qualifications or not. In other words, the elementary school teacher must prove his efficiency, while the teacher in the middle-class schools—the respectable proprietary establishments—may or may not be competent to impart instruction. The result is that some of our higher-grade primary schools are the best organised and equipped institutions for teaching elementary science in the country, while the science which figures in the prospectuses of many private schools is entirely unworthy of the name. Unfortunately, the sons of artisans and shopkeepers are compelled to leave school at an early age, and so cannot take full advantage of the facilities provided by the higher-grade schools. On the other hand we have the private schools where the age of leaving is later, but there the facilities for scientific instruction are inadequate. The general result is that only a small proportion, either of the artisan class or of the sons of commercial men, receive technical instruction. It is, of course, not suggested that all private schools are inefficient, but a large proportion of them are, when considered as schools in which science is taught; and the Duke of Devonshire has done a public service in pointing out the need of subjecting them to some system of supervision.

The following is abridged from the *Times* report of the Duke of Devonshire's address:—

PROPRIETARY AND PRIVATE SCHOOLS.

I suppose that there are in Eastbourne a larger number of proprietary and private schools than in almost any other town of the same size in the country. It would be extremely interesting to have full information as to what these schools are doing and the nature of the instruction which they provide. I doubt very much whether there is any one here, or whether there is anybody anywhere, who has the means of forming or giving a complete account of what the proprietary and private schools of any particular district in the country are doing, or what is the nature of the instruction which they are providing. That appears to me to point to the need for some better organisation of education than we at present possess. Of the students who are receiving their education in the numerous proprietary schools here and in other similar schools in the country there are many, no doubt, whose future would not be dependent upon their own exertions, and who are only educating themselves, or being educated by their parents, to make them good citizens and cultivated people; but there must be a very large number in addition who are looking forward to entering into some profession or another, or into some branch of industry or of commerce. And to the parents of such students it would be of immense value and importance to have full knowledge and full information upon the character of the education which is being given at these proprietary and private schools. Some of them, no doubt, are more efficient; some are less efficient than others; but, even amongst those which are the most efficient, there must be some which are capable of giving a more valuable hint and direction of instruction to those who are going to enter upon industrial and commercial pursuits than those which may be in other directions equally efficiently organised; and it would be of the very greatest importance, in my opinion, to the schools themselves, to the parents, and to the community at large if means were at our disposal to know more of the manner in which these schools are organised and of the work which they are doing.

TECHNICAL EDUCATION ABROAD.

Foreign nations have anticipated us to a very great extent in realising the close connection which exists between education and industrial and commercial success. That is a fact which is being brought home to us almost daily in various directions of the increasing competition to which we find ourselves in every quarter exposed. It is a subject which, as your chairman has reminded you, I have frequently discussed on previous occasions, and I am not going to enter into it at any length again to-night. I will only say that the urgency of this question is now recognised by those who are educational experts or educational enthusiasts. The urgency of the question is coming to be recognised by practical men of business. Only the other day the education authority of Manchester sent out a deputation of its members to ascertain what provision was being made in Germany and Switzerland for the industrial and commercial education of the people. They published a most valuable report, in which they spoke almost with dismay of the completeness with which the education of those who were leading and directing the manufacturing and commercial enterprise of those countries was being organised; and they urged upon their fellow-citizens, in the very strongest terms, that they should not allow themselves to be left behind in the race, but that they should make an effort for the organisation of the education of