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NATURE STUDIES

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BY

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'Let knowledge grow from more to more'—TENNYSON

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PREFACE.

The Essays in this volume are some among the contributions to Knowledge (the weekly journal,—but also, I trust, to knowledge itself) during the first ten months of its existence. Others by the same Authors and Mr. Ranyard form "Leisure Readings," the fifth volume of the "Knowledge Library Series." The object in all these Essays has been that which the projectors of Knowledge have had in view,—to bring scientific facts before the public in simple but correct words, without perplexing readers, on the one hand, by recondite descriptions or technical terms, and without derogating, on the other hand, from the dignity of science.

Richard A. Proctor.

London, *December*, 1882.

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CHARLES R. DARWIN.

BY R. A. PROCTOR.

CHARLES DARWIN, the Newton of Biology, died on Wednesday, April 19, 1882, aged 73 years. He was born on February 12, 1809, at Shrewsbury. His father was Dr. R. W. Darwin, F.R.S.; his grandfather Dr. Erasmus Darwin, F.R.S., author of "The Botanic Garden," "Zoonomia," and other works. Shrewsbury Grammar School may fairly be proud of the circumstance that the most eminent naturalist of the nineteenth century was trained under her care. In 1825 Darwin left Shrewsbury for Edinburgh, where he attended the University lectures for a period of two years, at the end of which he entered at Christ College, Cambridge. He took his degree in 1831. In this year he learned that Captain Fitzroy had offered to share his cabin with any competent naturalist who would accompany him in H.M.S. *Beagle*, which was about to sail on a voyage of circumnavigation. Darwin tendered his services, and, doubtless, the world owes to this circumstance, more

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than to any other, the wideness of Darwin's views as a naturalist, and the noble generalisation with which his name will in all future time be associated. The voyage of the *Beagle* has been described by himself in one of the most delightful works in the English language. The charm of foreign travel to a mind imbued, as Darwin's was, with a sense of the significance of all Nature's teachings, is graphically presented in the "Journal of Researches into the Geology and Natural History of the Various Countries visited during the Voyage of H.M.S. *Beagle* Round the World."

Returning home with shattered health, but with his mind prepared to search successfully into the secrets of Nature, Darwin was in no haste to propound crude or immature speculations. The facts he had observed seemed, he tells us, to "throw some light on the origin of species—that mystery of mysteries, as it has been called by one of our greatest philosophers." But fanciful imaginings were not the means by which this light was to be concentrated. It would be well if every one who desires to advance the interests of science would bear in mind how our great naturalist proceeded at this stage of his researches. "It occurred to me," he says, "that something might, perhaps, be made out by patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it." Perhaps a few months might be thought no unsuitable period within which to arrange and systematise the observations which were available for Darwin's purpose. But no. "After five years' work," he says, "I allowed myself to speculate on the subject, and drew up some short notes. These I enlarged in 1844 into a sketch of the conclusions which seemed to me probable." But even then he regarded his labours as only beginning. He was engaged during many more years in steadily pursuing the great object of his researches. Prevented by impaired health from working continuously for any great length of time, he returned again and again to his labours, affording, as Dr. Lankester has well remarked, "a noteworthy example of what difficulties may be overcome by untiring zeal, great perseverance, and a remarkable amiability and kindness of disposition." During the interval, too, which preceded the publication of his "Opus Magnum," he published many valuable contributions to scientific literature. Among these may be specially mentioned his "Monograph of the Family Cirripedia"—that is of the class of animals to which the familiar barnacles and sea acorns belong. It is strange now to find that this work was spoken of in 1856 as that on which Darwin's future reputation would be founded. "His great work," says his biographer in that year, "and that on which his reputation as a zoologist will doubtless depend, is his 'Monograph of Cirripedia.' The excellent style, the great addition made to the existing knowledge of the family to which it is directed, and the remarkable caution exercised by the author in coming to his conclusions, render this work a model of the manner in which such works should be written." This was high praise, and praise bearing in a specially interesting manner on the estimate we are to form of that great work which was all this time in preparation. It is well to recognise that the chief characteristic of the man who has put forward the most daring biological theory of the present century was "remarkable caution in coming to conclusions."

In the year 1858, when the labours of Darwin on his theory of the origin of species were as yet unfinished, Mr. Wallace, who was then engaged in studying the history of the Malayan Archipelago, sent him a memoir embodying the same general conclusions to which he had himself been led, and requested that he would forward it to Sir Charles Lyell. This memoir was published in the third volume of the "Journal of the Linnæan Society." Sir C. Lyell and Sir Joseph Hooker, both of whom knew of Darwin's work, suggested to him that it would be advisable to publish with Wallace's memoir some brief extracts from his own manuscripts. This was accordingly done, and an abstract—necessarily imperfect, Darwin said—of the new theory of the origin of species by natural selection was published on November 24, 1859. It will be in the recollection of most of our readers with what a storm of mingled ridicule and indignation the new theory was received. Wild views spread on every hand as to its nature, and even those who had the means of mastering Darwin's reasoning joined in misrepresenting and ridiculing his doctrines. A considerable time elapsed before the general public would consent to inform themselves as to the real nature of the theory which they had been all but unanimous in abusing. Yet of this self-same theory, Professor Huxley (who, from the beginning, was one of its most earnest, eloquent, and laborious advocates) said ten years later before the Royal Institution of Great Britain, that so rapidly had it established itself in favour, that he began to think it would shortly require for its welfare a little healthful opposition. This would not be the place to discuss at length "the theory of natural selection (that is, of the preservation of favoured races in the struggle for existence)." Presented briefly, it amounts to this, that during a long course of descent, species, not only of animals, but of plants, are modified by the selective preservation of slightly varied forms, adapted somewhat better than their fellows to the circumstances in which they are placed. How far this doctrine of the modification of species extends, even Darwin himself has not claimed to assert with confidence; but he went very far. "I cannot doubt," he said, "that the theory of descent, with modification, embraces all the members of the same class. I believe that animals have descended from at most only four or five progenitors, and plants from an equal or lesser number." He looked forward even farther, however. "Analogy would lead me one step further," he said, "namely, to the belief that all animals and plants have descended from some one prototype; but this inference is chiefly grounded on analogy, and it is immaterial whether or not it be accepted. The case is different with the members of each great class, as the Vertebrata, the Articulata, &c., for here we have distinct evidence that all have descended from a single parent." Daring as these views seem even now, it is difficult to recall how much more daring they were when Darwin first propounded them. To a large proportion of the naturalists of our day Darwin's theory seems almost beyond question; the young and rising naturalists in particular, of whom Darwin expected with confidence that they would be able "to view both sides of the question with impartiality," have justified his confidence; but when he announced his theory, there were not twenty living men who were likely to receive it with favour. It was in an especial manner on account of its supposed bearing on religious questions that the Darwinian theory when first propounded was repugnant to the feelings of many conscientious men. Gradually, however, it was felt that the new theory, rightly understood, tended to raise instead of to degrade, as was alleged, our conceptions of the scheme of creation. To quote the noble words with which Darwin concluded his treatise:—"From the war of nature, from famine and death, the most exalted object which we are capable of conceiving—namely, the production of the higher animals—directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms, or into one; and that whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been and are being evolved."

In the "Origin of Species" Darwin had not actually expressed his views as to the ancestry of man, though he had left them to be very clearly inferred. "It seemed to me sufficient to indicate that by this work 'light would be thrown on the origin of man and his history,'" for this implied that man "must be included with other organic beings in any general conclusion respecting his manner of appearance on this earth." But in the "Descent of Man," Darwin dealt at length and boldly with that subject on which he had hitherto deemed it well to be reticent. He presented man as co-descendant with the catarhine, or "down-nostrilled" monkeys, from a hairy quadruped, furnished with a tail and pointed ears, and probably a climber of trees. Nay, he traced back the chain of descent until he found, as the progenitor of all the vertebrate animals, some aquatic creature provided with gills, hermaphrodite, and with brain, heart, and other organs imperfectly developed. The treatise in which this view is presented falls in no respect behind Mr. Darwin's other great work in closeness of reasoning and grasp of facts. The portion of the work—more than one-half—bearing on sexual selection, if somewhat less satisfactory and conclusive, forms yet a most important contribution to the wide subject of the genesis of species. The closing words of this treatise may fitly here be quoted. After speaking of the distaste with which many persons would probably regard his conclusions as to the descent of man, and then touching on the hopes which the advance of the human race in past ages seems fairly to justify, he says we are not, however, concerned "with hopes or fears, but only with the truth as far as our reason allows us to discover it. I have given the evidence to the best of my ability, and we must acknowledge, as it seems to me, that man with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men, but to the humblest living creature, with his god-like intellect which has penetrated into the movements and constitution of the solar system—with all these exalted powers—man still bears in his bodily frame the indelible stamp of his lowly origin."

After the publication of his first great work, Darwin continued to gather evidence tending to strengthen his theory. In 1862 he published his remarkable work on the "Fertilization of Orchids;" and in 1867 his "Domesticated Animals and Cultivated Plants, or the Principles of Variation, Inheritance, Reversion, Crossing, Interbreeding, and Selection under Domestication." In 1872 Mr. Darwin published "The Expression of the Emotions in Man and Animals;" in 1875, "Insectivorous Plants;" in 1876, "Cross and Self-Fertilization in the Vegetable Kingdom;" and in 1877, "Different Forms of Flowers in Plants of the same Species." Only the year before his death appeared his work upon earthworms, in which he traced the operations of worms in gradually covering the surface of the globe with a layer of mould.

NEWTON AND DARWIN.

BY R. A. PROCTOR.

In Charles Darwin science has lost one who has done more than any since Newton to extend men's recognition of the wideness of the domain of law. When Copernicus and Kepler and Newton removed the earth from the central position in the universe, which had so long been assigned to it, they taught men to appreciate more justly than before the vast extension of the universe in space. The earth, which had seemed to surpass in importance every orb in existence, was seen to be a mere point in the solar system, and in turn the solar system was seen to be a mere point in the universe of stars, the stellar system (though so vast that it appeared infinite by comparison with all that men had heretofore imagined respecting space), to be as nothing in the real universe. With the widening of men's ideas respecting space should have come a widening of their ideas respecting time, until from of the few thousands of years over which they had extended their survey, they had learned to recognise the millions of years belonging to the lifetime of a planet, the far longer intervals measuring the duration of solar systems, and finally the eternities in which these periods of time, vast though they seem, are utterly lost. But with this widening of men's conceptions as to space and time, should have come also a widening of their ideas respecting the operation of law. Within the petty domains of space which they had surveyed, the growth of a plant or an animal seemed naturally to belong to the domain of development; but wider and grander processes of evolution seemed as far outside men's thoughts as the infinite star depths in which modern science believes, or the vast periods of time during which modern science sees that planets and solar systems have existed. Newton taught men how wide in *space* is the domain of law, and rightly understood, what Newton taught should have shown men how long also in *time* last processes of development according to fixed law. Yet precisely as men were far readier to accept the doctrine of infinite (or practically infinite) space, than that of inconceivably vast periods of time, so also were they far readier to believe in a law like that of universal gravitation, operating throughout regions of space practically without limit, than to perceive (what this in fact implied) that in time, as in space, the domain of law must be to our conceptions—limitless.

It came, therefore, as a shock even to many of the more thoughtful among us, when Darwin propounded a law of Nature, less grand than Newton's great law, in that instead of ranging visibly throughout infinitudes of space, it dealt only with the families of living creatures inhabiting this earth, but grander in relation to time (or rather in its more obvious relation to time), in that it required us to believe in processes of development operating throughout tens and hundreds of thousands—nay, throughout millions of years. Men were not prepared to extend on a sudden their conceptions of time in the same degree, or in anything like the same degree, that they had perforce extended their conceptions of space. The more profound, indeed, had already seen that this was only a logical consequence of the widening of our ideas of space,—that the vastness of God's domain involved its correspondingly extended duration. But Darwin was the first to give definite tangible evidence of the practically infinite extension of time during which the processes going on all around us have gone on in the past, and (presumably) will go on in the future. The universe, as Newton presented it, might have been framed in a second by an Almighty Being, to last an hour, or a year, or a century, and then to be replaced by some new order of things; though everything in it, even as thus presented, suggests that in duration, as in extent, it was, and is, and will be infinite to our conceptions. But Darwin showed the traces of long-past æons, of long-past æons of æons, traces affording evidence as clear to the eye of science as is the evidence of the vastness of space afforded by the faint rays of telescopic stars.

I do not know whether the grandeur of the universe, as pictured by Newtonian astronomy, or the vastness of past and future time, as pictured by the Darwinian system, is the more impressive. Certainly there can be imagined nothing much more wonderful than those vast depths of space in which we are absolutely compelled to believe since Newton established the great law which bears his name. But if there is aught grander than this, aught more solemn in its impressiveness, it is the thought of the immeasurable vistas of past time, during which the races inhabiting earth came into being under the action of the laws assigned to them; the still vaster time-intervals belonging to the generation of systems of worlds; the periods so vast that we cannot regard them otherwise than as infinite, during which not solar systems, but whole galaxies of such systems, and systems of such galaxies—nay, higher and higher orders of such systems, absolutely without end, as without beginning—came into existence.

That this widening of our conceptions of time as of space, and thence the widening of our ideas as to the domain of law, and consequently the recognition of the infinitely perfect nature of the laws of the universe (for only very excellent laws can work for long, and only perfect laws can work for ever) should have been regarded as antagonistic to religion in its wider and nobler sense, can only be regarded as resulting from the blindness, or the perversity, or the wrong-headedness, of the ignorant. That some of the fancies of dogmatic religion, some parts of the complex systems which the Rabbinistic type of erudition has invented in all religions, should seem incompatible with these developments of our knowledge and still wider enlargements of our conceptio s, can be understood. But *that* religion, in which all men may (in which all reasoning men *must*) agree, has been rendered infinitely grander—infinitely more impressive by our new knowledge. It has also been rendered infinitely more reasonable. Men had spoken of God as Omnipresent and Almighty, but they had assigned a mere point in space as his domain; they had described him as Eternal, but they had recognised his influence as existing for the merest second of time; and finally they had in words attributed all Wisdom to him, while in fact they had limited his wisdom to the provision of laws capable of operating but imperfectly, and for a brief period. Science shows now the infinite domain of the Omnipresent, its inconceivably vast duration, the perfection of the laws which so rule it that they operate throughout all space and all time. Yet a few who cannot raise their eyes from this petty earth to the heavens, or extend their thoughts to perceive the perfection of the laws governing a universe for all time (as we know time) find no nobler teaching in these grandest revelations of science than that "God is set on one side in the name of universal evolution." It is as though men who had observed but the working of a clock's escapement should regard the discovery of the train of wheels leading to the escapement-wheel proof positive that no reasoning mind had fashioned the mechanism. That which the bigoted on either side, the religious and the irreligious fanatic alike, agree in regarding as the disproof—if admitted—of a Being working "in and through all things," affords in reality the most overwhelming evidence, the solemnest demonstration that such a Being exists: though science must say of Him now as was said of old by Elihu, "as touching the Almighty, we cannot find him out."

DREAMS.

BY EDWARD CLODD.

THE remarks which follow some questions concerning the attitude of science towards dreams, asked in one of the earlier numbers of *Knowledge,* indicate how belief in their quasi-supernatural character lurks in the minds of intelligent persons who would resent being called superstitious.

Certainly, the antiquity and persistence of that belief are small matter of wonder when we reflect that the phenomena of dreaming are precisely of a character to sustain that feeling of mystery which man's surroundings awaken within him; but an inquiry into its origin and growth may best dispel it, while such an inquiry will add its witness to that of the "great cloud of witnesses" concerning the survival, often in least suspected form, of rude primitive philosophies among the elaborated beliefs of civilised races.

The youngest and most vigorous of the sciences, Anthropology, has already made us familiar with the nature of a vast body of evidence, uniform in character, unearthed from old river-valleys, caverns, mounds, and tombs, witnessing to the primitive savagery of man and his slow uprising therefrom; but such evidence touches us only on the intellectual side. Even should desired skeletons of veritable men of miocene times—still better, of the "missing" *homo simius*—turn up, we should yet be within the limits of palæontology and zoology. Such relics of our remote ancestry would remain specimens only—"a little less than kin." It is not until the evidence from the Drift and from surface remains (about which *Knowledge* may hereafter tell its readers more in detail) gives place to that supplied by immaterial relics—articulate speech, myths which were for the time real, and sufficing explanations to him—that man touches us as *fellow*-man, as *thinker*,[1] striving to read "the riddle of the painful earth," and to peer into the mysteries of being.

Now, for the purpose of this inquiry, it is needful to have understanding of the mental condition of

[1] "Man, a derivative root, means to think. From this we have the Sanskrit *manu*, originally thinker, then man."—Max Müller's *Lect. Lang.* I., 437.

races in low stages of culture, and, generally, it may be said that the modern savage is, as the primitive savage was, in a state of "fog" concerning the nature and relation of what is in the mind to what is outside it. In this he may perchance command the sympathy of the modern philosopher, there being this important difference between the two, that while the philosopher speculates upon the nature of the connexion between his mind and the external world, and confesses that "his knowledge of matter is restricted to those feelings of which he assumes it to be the cause," the savage has no capacity for such thought at all. He has nothing in his slender stock of words corresponding to the terms "objective" and "subjective;" that stock has no substantive verb "to be"—as, indeed, few of the languages of the world have ever had. He cannot distinguish between an idea and an object, an illusion and a reality, a substance and its image or shadow; and under bodily ailment, indigestion born of gorging, or delirium caused by starving, gives shape and substance, a "local habitation and a name," to "airy nothings," spectres of diseased or morbid imagination. Misled by superficial resemblances, he jumps at the most absurd conclusions; ignorant of the necessary relation between cause and effect, he is "carried about with every wind of" fancy; nor has he the capacity, which is the measure of intellectual growth, to strip the special of its accidents, and sink it in the general.

For example, he gives a different name to the tails of various animals, but has no name for "tail" in general; he can speak of sunshine, candle, fire-flame, &c., but "light" is an abstract term which he is unable to grasp. Such is his confusion between a thing and its symbol, that the name of a man is held to be an integral part of himself; he shrinks from revealing his own, lest the man to whom he imparts it injures him through it; still more does he recoil from naming the dead, or powers credited with baleful influence. He dreads having his portrait taken, feeling that some part of himself has gone in the process; the better the likeness, the more has "virtue gone out of him." Catlin relates that he caused great commotion among the Sioux by drawing one of their chiefs in profile. "Why was half his face left out?" they asked; "Mahtoochega was never ashamed to look a white man in the face." The chief himself did not take offence, but Shonka, the Dog, taunted him, saying, "The Englishman knows that you are but half a man; he has painted but one-half of your face, and knows that the rest is good for nothing." Which led to a quarrel, and in the end Mahtoochega was shot, the bullet tearing away just that part of the face which Catlin had not drawn.

We may now more clearly understand how the savage will interpret phenomena of a more complex order, and why he can interpret these only in one way. The phantasies which have flitted across the brain in coherent order or unrelated succession when complete sleep was lacking, leave the traces of their passage on the memory, and they are strong of head and heart, "true peptics who have no system," as Carlyle says, whose awakened consciousness is not affected by the harmonious or discordant, the painful or pleasant, illusions which have composed their dreams. But while for us they fill an empty moment in the telling, albeit now and again causing "eerie" feelings, and quickening such remains of superstition as slumber in the majority of us, they are to the untrained intelligence of the savage as solid as the experiences of his waking moments, true not only "while they last," but for ever afterwards. And the limits of his language only deepen the confusion within him when he tells what he has seen, and heard, and felt, and whither he has been. For the speech cannot transcend the thought, and therefore can represent neither to himself nor to his hearers the difference between the illusions of the night and the realities of the day. The dead relations and friends who appear in dreams and live their old life; with whom he joins in the battle or the chase; with whom, the toils over, he sits down to feast, not, like the Psalmist, in the presence of his enemies, but upon succulent slices of the enemies themselves; the foes with whom he struggles, the wild beasts from which he flees, or in whose grip he feels himself, and, shrieking, awakens his squaw; the long distances he travels to dreamlands beyond and above—are all real, and no "baseless fabric of a vision." The belief is strengthened by that intensified form of dreaming called "nightmare,"[1] when gaping, grinning spectre-monsters sit upon the breast, stopping breath and paralysing motion, which has helped to create the vast army of nocturnal demons that fill the folk-lore of the world, and that under infinite variety of hideousness have had lodgment for centuries in the beliefs of higher races.

What Schoolcraft says of the Indian mind, that "a dream or a fact is alike patent to it," applies throughout the whole range of the lower culture, a marked and wide-spread form of the confusion being in the belief that the soul leaves the body during sleep. Among the Zulus, when dead relatives appear to a man in his sleep, he concludes that their spirits still live, and the savage notion, that a sleeper should not be wakened, because of the possible absence of his soul, finds some continuity in the belief of mediæval times, that trance and catalepsy were proofs of the temporary departure of the soul from the body. Hence, as Mr. Fiske has remarked, "it was no easy matter for a person accused of witchcraft to prove an *alibi*; for to any amount of evidence showing that the body was innocently reposing at home and in bed, the answer was obvious, that the soul may, nevertheless, have been in attendance at the witches' Sabbath, or busied in maiming a neighbour's cattle!"

Keeping in mind what has been said about savage mental philosophy, it is not surprising that the inference drawn from the phenomena of dreams is belief

[1] *i.e.* Night spirit. A.S. märe, nymph.

in a double existence. Besides that waking self of which the savage is hazily conscious, there must be *another self*, which, roaming the world while the body is at rest, sees and does the things dreamed. Waking, the savage knows, or will be told, that whatever his dreams reveal to the contrary, he has not moved from the place where he lay down; therefore it is that ghost-soul—that *other* self—which has been away on the strange or familiar errand. And such belief in another self—*in* the body, yet at times not *of* it—is confirmed by daily experience. There are the suspensions of consciousness witnessed in swoon, apoplexy, catalepsy, and other forms of insensibility. Then there are the phenomena of shadows and reflection, actual existences to the savage, mocking doubles of himself. The shadow accompanies, goes before, or follows him by sunlight and by moonshine, disappearing mysteriously only when they are withdrawn or intercepted. Still more complete in its mimicry is the reflection of himself—the image repeating every gesture, while perchance, as he stands shouting by the stream, the echo of his voice is thrown back from the hill-side, and adds confirmation to his notion of duality. How else can man at low stages of thinking, ignorant of the laws that govern the reflection of both sound and light, interpret the shadow and the echo? Hence it is that we find the word for "shadow" chosen to express this other self in both barbaric and civilised speech, from the dialects of both North and South American and African tribes, to the classic and modern languages, as witness the *skia* of the Greeks, the *manes* or *umbra* of the Romans, and the *shade* of our own tongue. Did the limits of a brief paper allow, it would be easy to show, from the evidence of language, how man explained to himself the mode in which this other self makes the passage from the body to the external world, and wherein lay the difference between the sleeping and waking, the living and lifeless body. It must suffice to say that throughout the entire savage and civilised world, the life, the spirit, the soul of man has been identified with *breath*. Not with that alone; but with the blood, the heart, &c., although chiefly and universally with the act of breathing, "so characteristic of the higher animals during life, and coinciding so closely with life in its departure."

It is interesting to watch the primitive nebulous theories of another self, a vaporous, ethereal, or otherwise unsubstantial, impalpable thing, condensing into theories of semi-substantiality, or of rude or refined resemblance to the body, theories which become indispensable to account for the appearance of both the living and the dead in dreams, when their persons were clasped, their forms and faces seen, their voices heard.

Such theories differ not in kind, but only in degree of refinement, and unite, as Dr. Tylor remarks, "in an unbroken line of mental connexion," the savage fetish worshipper and the civilised psychologist adding their welcome witness to the similar working of untrained intelligence in different ages among different races on corresponding levels of culture, and therefore to the underlying unity of our race. This we shall realise only as we realise that the laws of mind, like those of matter, are uniform, and approximately calculable in their operation; the phenomena of one interrelated and interdependent as are the phenomena of the other, and equally the subjects of observation and comparison, if not by identical methods, yet on like principles.

It would be an interesting and informing chapter in the history of the illusions through which man has made continuous, and as yet unaccomplished, passage to the truth, to show how belief in indwelling spirits, of fitful habit and varying form, was enlarged to belief in souls in the lower animals, in plants, and in lifeless things, from stars to stones; how the phantasms of the brain have filled earth, sea, and sky with spirits innumerable, from white-winged celestials to the degraded ghosts of haunted houses. But this would be an undue extension of the subject, for the completeness of which some reference must be made to the part played by dreams as supposed media of communication between gods and men, and as monitions of coming events.

The awe and wonder excited in the savage mind by waving trees and swirling waters, by drifting cloud, whistling wind, and stately march of sun and moon—all invested by him with personal life and will—were immensely quickened by his dreams. In their unrelated and bewildering incidents, the powers indwelling in all things around him seemed to come nearer than in the more monotonous events of the day, uttering their warnings and conveying their messages. There needed but slender data to reach conclusions. Let the death of a friend be dreamt of, and the event follow; or a hunting-feast fill the half-torpid fancy, and a day's privation give the lie to the dream; the arbitrary relation is made. Lord Bacon says:—"Men mark the hits, but not the misses," and a thousand dreams unfulfilled count as nothing against one dream fulfilled. Out of that a canon of interpretation is framed by which whole races of men will explain their dreams, never staying to wonder that the correspondences are not more frequent and minute than they really are.

"To this delusion," says Cornelius Agrippa, an ancient rationalist, "not a few great philosophers have given a little credit . . . . so far building upon examples of dreams, which some accident hath made to be true, that thence they endeavour to persuade men that there are no dreams but what are real." When Homer says that "dreams, too, from Jove proceed,"[1] painting the vividness and agonising incompleteness of those passing visions; when Tertullian says that "we receive dreams from God, there being no man so foolish as never to have known any dreams come true," both classic and patristic opinion are

[1] "Iliad," Book I., 77.

clearly survivals from the lower culture, its lineal and thinly-disguised descendants. For the savage, the bard, and the theologian lived in days when the conception of orderly sequence was unthinkable to them; where the arbitrary act was wrought, the isolated or the conflicting influence manifest, there the deity or the devil was present; while for us, could we discover where law is not, thence God would seem to have withdrawn.

The passage from the crude interpretation of his dreams by the savage to the formal elaboration of the dream-oracle is obvious, the more so as this latter was only one of many modes by which it was sought to divine the will of heaven, and read that "book of fate" hidden from men. This dream-lore, as ancient records far back to Accadian times show, not only called into existence a class of men whose position as interpreters of royal and other dreams ensured them commanding place, but gave rise to a mass of literature most prolific in classic times. It maintained an almost canonical supremacy down to the Middle Ages, finding its befitting level in our day in the "Libri dei Sogni" which the Italian lottery-gambler consults, and in the "Imperial Dream-Book" by which the English domestic forecasts whether King Cophetua or Police-sergeant X 32 is to be her fate!

At this nether depth, Science, content with having shown the persistence of primitive modes of thinking in all subsequent interpretation of his own nature by man; finding its evidence and the warrant of its conclusions in that human experience which the sources of our knowledge cannot transcend; may well let the matter rest. It need not concern itself with denials that dreams have been sent as warnings from Heaven to man; this were as foolish as to take pains to disprove the existence of ghosts, or to seriously challenge the predictions in Zadkiel's *Vox Stellarum.* Science need not argue; it explains; and to such matters explanation is death. For the changes which revelation of the order of nature and the establishment of that doctrine of continuity, which has no "favoured-nation" clause for man, involve, will bring about, in quiet and unmourned, the departure of belief in dreams as omens or warnings, just as they have brought about the decay of belief in witchcraft and astrology.

HONEY ANTS.

BY GRANT ALLEN.

The Garden of the Gods in Colorado is a bit of show-scenery of the true American type—a green amphitheatre, studded with vast ledges and cliffs of red sandstone, weathered here and there into chimneys or pillars, in which a distorted fancy traces some vague resemblance to the sculptured forms of the Hellenic gods. Hither, a few years since, Dr. McCook, of Philadelphia, went on his way to New Mexico, where he wished to study the habits and manners of a famous, little-known insect, the honey ant. To his surprise, he accidentally stumbled here upon the very creatures he had set out to find. There are two kinds of entomologists: one kind, now, let us hope, rapidly verging to extinction, sticks a pin through his specimens, mounts them in a cabinet, gives them systematic names, and then considers that he has performed the whole duty of a man and a naturalist; the other kind, now, let us hope, growing more usual every day, goes afield to watch the very life of the creatures themselves at home, and tries to learn their habits and customs in their own native haunts. Dr. McCook belongs to the second class. He forthwith pitched his tent (literally) in the Garden of the Gods, and proceeded to study the honey ants on the spot.

Like many other ants, these little honey-eaters are divided into different castes or classes; for besides the primary division into queens or fertile females, winged ants or males, and workers or neuters, the last-named class is further sub-divided into three castes of majors, minors, and minims or dwarfs. But the special peculiarity which gives so much interest to this species is the fact that it possesses, apparently at least, a fourth caste, that of the honey-bearers, whose abdomen is distended till it is almost spherical by a vast quantity of nectar stored within it. Dr. McCook opened several of the nests, and found these honey-bearers suspended like flies from the ceiling, to which they clung by their legs and appendages. All over the vaulted dome of the ant-hill, these little creatures were clustered in numbers, their yellow bodies pressed tight to the roof, while their big round stomachs hung down behind from the slender waist, perfect globes of translucent tissue, showing the amber honey distinctly through the distended skin. They looked like large white currants, or sweet-water grapes; and as they were actually filled with grape-sugar, the resemblance was really quite as true inside as out.

Where did the honey come from? That was the next question. Everybody knows that ants are very fond of sugar, and they often steal the nectar in flowers which the plant has put there to entice the fertilising bee. So much damage do they do in this way, that many plants have clothed their stalks with hairs, or sticky glands, on purpose, in order to prevent the ants from creeping up the stem and rifling the nectary. In other cases, however, plants actually lay by honey to allure the ants, when they have anything to gain from their visits, as in the case of those Central American acacias, mentioned by Mr. Belt, which have a nectar-gland on the leaf-stalk to attract certain bellicose ants, which so protect them from the ravages of their leaf-cutting congeners. Of course, everybody has heard, too, how our own species sucks honeydew from the little aphides, or plant-lice, which have often been described as ant-cows. But it is not in either of these ways that the honey-ants get their sugar. Dr. McCook had a little trouble in settling this matter at first, for the honey-ants are a nocturnal species, and he had to follow them through the thick scrub, lantern in hand; still, he satisfactorily settled at last that they obtain the nectar from the galls cn an oak, where it must simply be exuded as an accidental product of injury. The workers take it home with them, and give it to the honey-bearers, who swallow but do not digest it. They keep it in their crops ready for use, exactly as bees keep it in cells of the honey-comb. When the workers are hungry they caress a honey-bearer with their antennæ, whereupon she presses back a little of the nectar up her throat, and the workers sip it from her mouth. The honey-bearers, in short, have been converted into living honey-jars. They are thus passively useful to the community, for in this curiously-ordered commonwealth "they also serve who only stand and wait."

How could such a strange result as this have been brought about? Dr. McCook, though not himself an avowed evolutionist, has supplied us with facts which seem to suggest the proper answer to this difficult question. He has shown that the rotunds (as he calls them) are not, in all probability, a separate caste, but are merely certain specialised individuals taken at haphazard from the worker-major class. He himself saw in the nests many worker-majors, which seemed at that moment actually in course of transformation into honey-bearers. Now, it is easy enough to understand why these social insects should wish to store up food against emergencies. At all times, the queen, the young female ants, the males, and the grubs or larvæ are entirely dependent upon others for support. Hence, alike among bees and ants, stores of food are habitually laid by, sometimes in the form of honey in combs and bee-bread, as with the hive-bee; sometimes in the form of seeds and grains, as with the harvesting ants. During the winter months or the rainy season, when food fails outdoors, there must be some reservoir at home to meet the demand of the starving community. Under such circumstances, any trick of manner which tended to produce a habit of storing food would be highly useful to the nest as a whole; and taking nests as units in the struggle for existence, which they really are, those nests which possessed any such trick would survive in seasons when others might perish. So the tendency, once set up, would grow and be strengthened from generation to generation, those ants which stored most food being most likely to tide over bad times, and to hand on their own peculiarities to the other swarms or nests which took origin from them.

A set of primitive ants, living upon the honey of the oak-galls, have no tendency to produce wax, like bees, because their habits with regard to their larvæ do not lead them to make such cells at all. The eggs and grubs simply lie about loose amongst the chambers of the ant-hill, instead of being confined in regular hexagonal cradles. Hence the bees' mode of honey-storing is practically impossible for them: they have not the groundwork habit from which it might be developed. But the ants have a crop, or first stomach, in which they store their undigested food, before passing it into the gizzard, exactly as in fowls. When ants come back from feeding, whether on flowers, on aphides, or on galls, their crops are very much distended; and they can bring back the food to their mouths from these distended crops, to supply the grubs and their other helpless dependents in the nest. If therefore some of the ants were largely to over-eat themselves, they would be able to feed an exceptionally large number of dependants.

Dr. McCook observed that some very greedy workers, returning to the nest, fastened themselves upon the roof in the same position as the honey-bearers, and in fact seemed gradually to grow into rotunds. The other ants would soon learn that such lazy, overgrown creatures were the best to go to for food; and, in time, these gorgers might easily become specialised into a honey-bearing set of insects. The workers would bring them honey, which they would store up and disgorge as needed for the benefit of the rest as a whole. If the honey passed into their gizzards and was digested, they would be a positive dead loss to the community, and so the tendency would soon be eliminated by natural selection, because the nests possessing such workers could not hold their own in bad times against neighbouring communities. But as only a very small quantity is ever digested—just as much as is necessary to keep up the sedentary life of such immovable fixtures—the effect is about the same as if the honey were stored in cells of wax. The ants, in fact, utilise the only good vessel or utensil they have at their disposal, the flexible and extensible abdomen of their own comrades.

The greatest difficulty is to understand how the workers first acquired the habit of feeding these lazy members to such repletion; but as all ants "take toll" of one another, this is much less of a crux than it looks at first sight. A very greedy ant, which not only ate much itself while out foraging, but also took toll of all others in the nest, after it was too full to move about readily, would be in a fair way to become a rotund. And as it would thus be performing a useful function for the rest, at the same that it was gratifying its own epicurean tastes, the habit would soon become fixed and specialised, till at last we should get just such a regular and settled form of honey-storing as we see in this Colorado species. Indeed, another totally distinct type of ant in Australia has arrived at exactly the same device quite separately, as so often happens in nature under similar circumstances. Whatever benefits one creature under any given conditions will also benefit others whose conditions are identical; and thus we often get adaptive resemblances between plants and animals very widely removed from one another in genealogical order.

COLOURS OF ANIMALS.

BY DR. ANDREW WILSON, F.R.S.E.

There is a suggestive passage in Butler's "Hudibras," which maintains that—

> "Fools are known by looking wise,
> As men find woodcocks by their eyes."

And if the axiom be correct, that a poet is only great when he is true to nature, it must be admitted that Butler has been singularly felicitous in this metaphor. Whoever has seen a woodcock in its ordinary summer plumage may form a good idea of the truth of the poetic remark. As that bird moves about amongst the fallen leaves of autumn, the greys and browns and yellows of its feathers mingle so beautifully with the like tints of its surroundings, that the animal is absolutely concealed from any view but the practised eye of the sportsman. As has been remarked of the bird in question, even the very conspicuous and ornamental tail becomes hidden from view in a most singular fashion. Below, these tail-feathers exhibit a white colour tinted with a silver sheen and marked with a deep black. Nothing more conspicuous than such an ornament can well be imagined; yet the tail and its belongings are, nevertheless, wonderfully concealed. For, as the bird reposes, these under lines and tints are placed downwards; and above, the ashen-grey tints mingle perfectly with the bird's surroundings. As the woodcock, therefore, rests amid its background of wood and foreground of fallen leaves, every line of its plumage is made to assimilate so closely with the objects around, that the bird's presence, even a short distance off, is not suspected.

The woodcock is by no means alone in this harmony betwixt its plumage and its surroundings. The sand-grouse of the deserts, for instance, exhibit a like harmony. These birds cannot be detected, even as they run, amidst the sand of their haunts, so closely imitated in the dull tints of their plumage is the tone of the desert wild. The well-known case of the ptarmigan is even more extraordinary still. In summer the bird shows a plumage of pearly grey, which conceals it perfectly as it lies on its bed of Scottish heather, mingled with the lichen and its kith and kin. But when the winter snows descend and coat the hill-sides with a mantle of white, then a kindly nature still contrives concealment for the ptarmigan in a fresh suit of colour. The pearly greys of the summer are replaced by a plumage of snowy whiteness, and, save for its dark eye, there is little risk of the discovery of the bird by the unwary or unpractised sportsman. The grouse and common partridge are not less perfectly protected. The hues of the grouse match the tints of the heather, and the partridge is almost as difficult to discover—say, in a ploughed field—as the ptarmigan on the hill-side. The birds just mentioned are all *rasorial* birds; that is, they are allied to the type of the common fowl, and are typically ground-livers. Their tints, therefore, assimilate with those of the ground and with ground vegetation; and whatever may be the ultimate philosophy which shows the origin of such harmonies, it is very plain that the utilitarian is bound to read "protection" in every line of the story. Escape from their enemies must be favoured by the correspondence in colour to which we allude. The harmonies of colour present the safest, and therefore the best foil, to the keenness of sight of the eagle, and to the agility of the falcon and its kind. It is different, indeed, with the songsters of the wood and grove. With well-developed powers of flight, and with a close refuge amid the foliage of the wood, the appearance of bright hues and tints in these birds is by no means disadvantageous. Another law—that of the development of colour in relation to sex—has taken precedence of the regulation of colour as a means of protection. If concealment be necessary, nature will teach the art of hiding in other ways than that whereby she contrives to make the partridge face danger with a stillness that almost rivals that of the stones, trustful in the harmony of her plumage that so closely matches her heather bed.

But there are wider fields open to the naturalist's survey of colour and its meanings. Suppose that we peer for a moment into the class of fishes, we shall find the adaptation of colour to surroundings illustrated in a very apt degree. Whoever has tried to spear a sole or flounder, for example, well knows that the excitement of the sport consists in the endeavour to follow out the axiom of Mrs. Glasse, and on the principle which that worthy lady laid down about "first catching your hare," to first catch your flounder. You cautiously and softly paddle out to shallow water in your punt, and you drift over the flat, sandy beach at a depth of from two to three feet. Below, the water is as clear as crystal. Here and there you see a lazy starfish on the march, exerting himself to the utmost, as he slowly extends ray after ray, and crawls at the rate of about a mile a month or so, by aid of his hundreds of sucker-feet. The sand-eels annoy you as they burrow downwards and send up little clouds of dust on your approach; but the flounders you came to spear—where are they? and echo seems but to answer "Where?" But the practised sportsman bids you learn (as in all other sciences and arts) the first lesson—namely, how to see and observe. As your boat creeps along, he points to what seems a mere sandy lump, but in which his keener eye has detected the merest wriggle of a fin. Dash! goes the spear, and up comes a flounder, and as you watch the ground, you see dozens, it may be, of similar sandy patches swimming off in rapid alarm. The flounder's "back," —it is really the *side* of the fish,—on which it lies is white enough, as we know; but the "other side" is as close a representation of a sandy patch as you can either see or imagine. Small wonder then that in flounder-spearing you experience the difficulties which nature throws in the way of capture through likeness in colour to the animal's surroundings. It is the same with soles, turbot, and with the skates and angel-fishes. Watch the first flounder you see resting on the sandy bed of the Aquariam-tank, and you will receive ample proof of the truth of the foregoing remarks. And should you chance to see the lazy "monk," or angel-fish, as it lies prone, heavy, and indolent in the highest degree in the flow of its tank, you may again understand something of the value of colour as a means of protection to animal life.

In the case of those "queer fishes," the little sea-horses, or hippocampi, with heads like horses, and with a body which, at large, reminds one most forcibly of some figure from the Heralds' College on a crest, concealment is effected in a slightly different fashion from that prevalent among the soles. Here the body, as a rule, possesses long streamers or fringes that mimic the seaweeds; so that, as the animal reposes, its body may well enough represent a stone, to which are attached fragments of marine vegetation. The Australian sea-horses, which live among red sea-weeds, have streamers of that hue attached to their bodies, and the mimicry and imitation of their surroundings are thus very complete. Even their near neighbours, the pipe-fishes, with green bodies, when they fasten themselves to some fixed object, and "loll" in the water, may closely resemble an inert piece of green weed.

Amongst even the highest animals, protective colouring is common. A lion's hue matches the sand, as a tiger's stripes, according to Mr. Wallace, imitate very closely the foliage and trees amidst which it crouches. The camel's coat is sandy like its desert; and the rabbits offer as plain examples as any of the colour-harmony in question. The polar bear is white, like the arctic fox in winter dress; and the nocturnal rats and moles are dressed in shades the opposite of the ghost-like hues that become so conspicuous at night. But, descending to still lower grades of life, we may discover examples of this "mimicry," not only of surroundings, but also of lifeless or inorganic objects, and of, it may be, plant structures as well, on the part of animals. The so-called "stick insects," or "walking twigs," as they are often called—the *Phasmidæ* of the naturalist—present us with the most perfect reproductions of bits of dried twigs. A figure of one of these insects is before me as I write. It is represented climbing on the delicate branch of a shrub, and but for the expectation of what one is looking for, there would be considerable difficulty in determining which is insect and which plant. The bodies of these "twig insects"—which belong, by the way, to the *Orthoptera*, or that order which harbours the familiar crickets and grasshoppers—are represented by mere lines. The wings have disappeared, and it has been remarked, that in their gait these insects exhibit a peculiar habit of using their legs in a singularly awkward fashion, and thus apparently aid the illusion of the spectator that he is regarding a dried twig, moved erratically by the wind.

More extraordinary still are the "leaf insects"; near allies, indeed, of the "walking-sticks." Here "mimicry" of the plant proceeds so far as to fully justify the eminent naturalist's remarks, that it is strange to find the animal assuming a mimetic disguise and apeing the actor's art. The wings in the "leaf insects" exactly imitate leaves. The venation, or arrangement of the veins in the leaf, is clearly seen, and in one form (*Phyllium*) even the chest and legs of the animal assume leaf-like characters. When such an insect rests amid foliage, the value of such a close resemblance to its plant surroundings as a means of protection can be readily understood. In some "leaf insects"—all of which are tropical species—the wings resemble leaves that are dried and withered. In others, the minute fungi that attack leaves are imitated. Mr. A. R. Wallace tells us that one of the "walking-sticks" obtained by him in Borneo "was covered over with foliaceous excrescences of a clear olive-green colour, so as exactly to resemble a stick grown over by a creeping moss or Jungermannia. The Dyak who brought it me assured me it was grown over with moss, though alive, and it was only after a most minute examination that I could convince myself that it was not so."

Lastly, there may be noticed in connexion with these curious traits of animal life, the fact that certain animals, themselves harmless and inoffensive, may assume the exact appearance of offensive neighbours. In this respect, certain butterflies are *facile principe*.

Certain South American butterflies, known collectively under their family name of *Heliconidæ*, exhibit a brilliant colouration, but likewise possess a very strong odour; and, it may be presumed from the sequel, a highly disagreeable taste as well. They are highly conspicuous insects, and the under sides of their wings are as brilliantly coloured as the upper surfaces; so that, even in repose, and when resting with the wings apposed over the back, they are readily enough seen. Their colours are prominent, not to say gaudy. Yellows, reds, and whites commingle with blacks, blues, and other tints in a striking fashion. They are, further, by no means rapid flyers, and, putting the foregoing circumstances of their gaudy colour and their slow movements together, no group of animals would seem more liable to the attacks of bird-enemies than these Helicon butterflies. Yet the reverse is the case. So far from being decimated, their race flourishes apace, and this result is clearly due to the strong odour and nauseous taste they possess. The mere touch of a Helicon is in itself a pungent matter, which reminds one of nothing so much as the persistence of the musk-rat's secretion, or the still more awful effluvium of the American skunk. Their neighbour butterflies may fall victims by the score to the rapacity of their feathered enemies, but the Helicons are spared from even the semblance of attack.

So far there seems nothing unusual or striking in a group of butterflies being protected, through strong odour and worse taste, from their natural enemies, the birds. But now comes the most curious phase of this history. Another and distinct family of butterflies, known as the *Leptalidæ*, allied to the common white cabbage butterfly, and removed from the Helicons, also possesses representatives in South America. There are no points of agreement between the Leptalides and the Helicons, save, indeed, that both are butterflies. Furthermore, the Leptalides are entirely destitute of the nauseous odour and of the strong taste of the Helicons, and in respect of their more agreeable presence, should become a prominent article—as do other butterflies—in the bill of fare of the birds. Yet, strangely enough, the Leptalides escape persecution; and the reason is not far to seek or difficult to find. When they are carefully examined, certain species of the Leptalides are seen to be exact *facsimiles*, in colour and appearance, of the stinking Helicons! Naturalists at first classed both as Helicons, until a closer examination showed the difference between these butterflies, and likewise proved that the Leptalides had thus "mimicked" in the plainest possible manner the colours of their strong-smelling neighbours. Nor are the colours alone imitated. The very shape of the Helicon's wings is reproduced in those of the Leptalides, and the "feelers" likewise mimic those of the former group. Again, special forms of Leptalides "mimic" special forms of Helicons. The flight has become of similar character in both species, and the habits have been also slavishly copied.

Such instances as these certainly present "food for thought" to the reflective mind. It is the business of philosophy to account for facts by placing the facts in scientific juxtaposition—philosophy, in this light, is the thread upon which the pearls of knowledge are strung. What, then, it may be asked, is the philosophy which can explain the curious resemblances seen in the animal world, ranging from, say, a mere likeness in tint to the surroundings (as in the flounder or woodcock), through more intensified likenesses, to the exact "mimicry" and to the slavish copy of colour and form, as in the butterflies?

A first and highly-important feature in the consideration of the case is found in the fact that there is a gradation in the degree of "mimicry." From the mere sand or ground tinting of the flounder to the exact colouring of the butterflies is, of course, a wide step, but it is one which is bridged over by intermediate examples and stages. Then, secondly, we discover a purpose or use in the disguises: that purpose, apart from any considerations of its origin, being the protection of the animal from its enemies, and the consequent good and increase of its race. Thirdly, it appears possible to account for these curious transformations and disguises by finding an *initial* step. It is the old story of *le premier pas qui coûte,* applied to natural history research; and this first step is found in the solid axiom, that every living species is liable to *variation* and change. Next succeeds the consideration that such varieties as are produced have to "struggle for existence." Suppose a number of white varieties produced in a cold, snowy region, along with varieties of more conspicuous colours. It is evident that, whilst the white varieties would escape from their enemies, the darker-coloured individuals would succumb. Thus the white race comes to the front, and holds its own, and its perpetuation and increase becomes a matter of surety. Summing up the argument, we find that two factors are at work in bringing about these wonderful colour likenesses in the animal world. The one is variation, producing the colour-varieties; the other is the circumstances of life, which weed out the weak and give the battle to the strong, which latter are those whose colours best suit their surroundings. This is the philosophy which natural history to-day lays down for our acceptance. Nay, more, it is a philosophy which explains far more important facts of life than mere mimicry. It is "evolution and development" reduced to their plainest and fundamental terms—in a word, Darwinism in a nutshell, as illustrated by the variation and change that all life knows, and by the warring of that life bringing the best of its units to the front of the battle.

A WINTER WEED.

BY GRANT ALLEN.

A DAY or two of warm weather, wafted to us by the westerly breezes, has brought out the daisies on the lawn as vigorously as if it were May, instead of January. The sward is dappled all over with their little timid white blossoms in a way that quite defies the decencies of the season. The fact is, modest and shrinking as they seem to be, daisies are very hardy and hard-working small plants, which never miss an opportunity of pushing their way in the world; and no doubt they have their reward, for probably no other flowering kind—except, perhaps, one or two grasses—have been half so successful in colonising the fields and hill-sides as these unobtrusive, wee things have been. In the spring, they are the very earliest plants to bloom; and since the early flower catches the bee, they begin setting their seed before the other blossoms are well awake; all through the summer and autumn they go on blooming uninterruptedly; and even when winter comes, they are ready at a moment's notice to take advantage of any brief gleam of sunlight which may happen to occur, putting forth their pretty buds fearlessly, and alluring the last stray insects of the season to visit their tiny golden bells.

Here in my hand I have grubbed up one entire daisy-plant, root and all, with my cane; and when one comes to look closely at its structure, the secret of its success in life is not difficult to decipher. In the first place, there are the leaves. These we seldom notice when we are examining a daisy, because they are so very retiring and unobtrusive. They lie flat upon the ground, in a small, round, spreading rosette, pressed as tightly as possible against the soil beneath. That is one of the tricks by means of which the daisy secures itself a place in the world. It grows generally in open pastures and commons covered with grass; and as the grass tends always to raise its tall blades as high as possible, the daisy might easily be overshadowed by that powerful competitor. Now, there are two ways in which different plants living in such circumstances can avoid being elbowed out of existence. One way is by sending up taller and bigger leaves than the grasses, so as to intercept the air and sunlight; and this is the plan adopted by such weeds as dock, burdock, coltsfoot, and some plantains. As a rule, however, such tactics can only be followed by plants which possess a reserve fund of food-stuffs laid by in their roots or stocks, for otherwise the young leaves would be choked and starved before they could grow high enough to overtop the competing grasses. Or, to put it more definitely, those kinds alone have succeeded in this way which happened to develope both large leaves and rich reserves of starch at one and the same time. The second plan is that followed by the daisy, the hoary plantain, and many other field-weeds. These plants have learnt to press their foliage closely down in a little circle upon the ground, so as to prevent any grasses from growing up around them and intercepting the sun and air. In other words, such individuals among them as happened to display this tendency, in a slight degree, survived the best; and among their descendants, such as carried it out further and further, spread most afield, while such as fell short of the desired quality, got killed off young by neighbouring weeds. Thus, at last, the daisy acquired its present successful habit of growing close to the ground, and so checking competition in the bud, or, rather, in the very seedling.

But why, it may be objected, do not all other plants do the same? The answer is, because all are not adapted for the same sort of life as the daisy. One kind survives in virtue of one point of vantage, another kind survives in virtue of another. The English meadow plantains are three closely-allied types of weed, hardly differing from one another in any essential point; yet each of them has solved this problem of foliage in a separate way. The great plantain sends up big, broad leaves on longish stalks, something like those of garden lettuce, which overtop most of its neighbours; the hoary plantain spreads a little tuft close to the earth, like the daisy; and the ribwort plantain meets the grasses on their own ground, by reducing its leaves to mere long, thin, lance-like blades. In each case, the explanation must be accepted on its own merits, without prejudice to different explanations elsewhere. The forms of leaves, indeed, are among the most difficult problems of botany, and it must not be supposed that we can account for them all at once by a single simple and easy formula. One might as well ask why the rabbit is not as big as the red deer, or why the fox is smaller than the lion. Each fills its own niche in nature; so each has been developed into exact correspondence with that particular niche and no other. And different means often subserve exactly the same end. The fleetness of the hare is produced by quite other adaptations than the fleetness of the stag; the foliage of the daisy succeeds by being compact and rounded, the foliage of the buttercup by being cut up into numerous small divergent segments. In short, whatever accidental habit happens to give a plant or animal any advantage in the struggle for existence is perpetuated in its descendants, and gradually perfected by natural selection, and thus the most diverse means often lead up in the long run to the same end.

The reason why the daisy is able to send up buds and blossoms at a moment's notice seems equally clear. The buds are always lying by in readiness close to the little perennial tufted stock. I cut it down the middle with my pocket-knife, and see, in the centre of the tuft, there are two or three unopened flower-buds even now lurking unseen and waiting for their turn to appear. Practically speaking, the daisy is an evergreen, for it always has green leaves upon it all the year round; and these green leaves are perpetually engaged, summer and winter, in manufacturing starch from the carbonic acid of the air, which starch is at once laid by in the root-stock to feed the young flowers when they are ready to sprout. So the moment a little warm weather arrives, the bud begins to start into life, and is supplied with food from the starch laid by in the root, as well as from the constant gains of the ever-busy leaves. All annual plants have to grow from the seed in a single season, and they have to produce a large number of leaves before they have digested food enough in these their expanded stomachs to feed the future flowers and seed; so that they cannot begin blossoming till comparatively late in the season. But the daisy, being a perennial, with slightly starchy root and practically persistent foliage, gets the start of them from the beginning, so as to put forth its flowers at the earliest possible moment.

And now let me look briefly at this flower itself. It is made up, as everybody knows, of two parts. The centre, or disk, is yellow, while the outer rays are white. But if one pulls it to pieces, one sees that the disk is really composed of many separate little golden bells, each one something like a harebell on a very small scale. The daisy head, in fact, is not one flower, but a whole lot of distinct flowers crowded together into a single truss. Taking one of the little central yellow bells in detail, I find that its petals are not separate, as in the buttercup, but are all united together into a long tube. The ancestors of the daisy had doubtless ages ago five distinct petals, like those of the buttercup; but at some time or other these petals showed a tendency to coalesce, and as this tendency proved useful to the plant, by more certainly securing its fertilisation by insects, it rapidly grew through survival of the fittest into a fixed habit, not only of the daisy, but of all the great group of flowers to which it belongs. The reason why the tubular shape is more useful than the arrangement with five spreading petals becomes clear enough if we recollect that the insect has to thrust its proboscis down to the bottom of the tube, past the pollen-bearing stamens and the sensitive pistil, in order to reach the tiny drop of honey concealed within. In doing so, a little of the pollen naturally adheres to his proboscis, and is then brushed off against the sensitive surface of the next blossom which he visits, so as thus to impregnate and fertilise its seed. To this day, however, the daisy still retains a reminiscence of the distant period when it possessed five separate petals; for each of the central florets has a vandyked edge of five points, these points being the last representatives of the original distinct flower leaves in its remote progenitors.

The tubular arrangement is common to many flowers besides the daisy family; but the daisies and their allies have carried their development one step further than the rest, for they have learnt to collect several tiny blossoms together into a single compact head, and thus to bid for the attention of insects far more powerfully than they could do in single display. More than that, in the daisy itself, and one or two others of its near relations, the outer florets of each head have become flattened into long ornamental rays, so as to play the part of petals to the compound group. In this way they make the little bunch very noticeable to all passing insects. The ray florets, when closely examined, look like tubes split down one side and opened out, so as to produce as much show as possible. They are the attractive part of the flower-head, and they do little active work themselves, having no stamens and no pollen, but laying themselves out mainly to look pretty alone. For this purpose they are coloured white, with pinky tips, instead of being yellow, like the central florets. Yet, of course, the whole plant is ultimately benefited by this arrangement, because the insects are thus induced to visit the entire little colony at once, and by carrying pollen from one floret to another, to fertilise the whole row of yellow bells then open. For if you look intently into a daisy, you will see that it does not open all over at the same time, but begins opening from the edge, and gradually proceeds towards the centre; so that in most daisies you will find a row or two of over-blown florets outside, a row just open or opening half-way through, and a lot of unopened little buds in the very middle. Doubtless, this arrangement also conduces to the good of the plant, by ensuring the highest and best sort of cross-fertilisation—that which is obtained by impregnating the blossoms of one individual with pollen brought from those of another.

A POISONOUS LIZARD.

BY DR. ANDREW WILSON, F.R.S.E., F.L.S.

THE possession of a poison-apparatus is by no means a common event in the animal world; although, indeed, very diverse animals are possessed of offensive means of this kind. Low down in the animal scale we find the jelly-fishes, sea-anemones, and their neighbours, possessing these curious stinging organs called "thread-cells," the virulence of which many an unwary bather has experienced to his cost. Each thread-cell is really a minute bag, tensely filled with fluid, and containing, coiled up in its interior, a thread or filament. When, from any cause—as by pressure, for example—the cell is ruptured, the fluid escapes, and if the thread and fluid together come in contact with the tissues of any animal liable to be affected, the animal in question will be paralysed, or even killed. In this way the *Hydra*, or "fresh-water polype," captures its prey; and even in the lower deeps of the animal world (as amongst the *Infusoria*, for example), these thread-cells appear to be represented. Higher up in the animal series, we come upon the poison-apparatus of insects, carried in their tails, as also is the "sting" of the scorpion. The centipede's poison-fangs are situated, on the contrary, in its mouth. Amongst the shell-fish, or *Molluscs*, no poison-secretions occur. In fishes, as the lowest Vertebrates, we certainly know of one or two cases in which an approach to a poison-apparatus is found. The frogs and toads, "ugly" though they may be, are not yet "venomous," Shakespeare notwithstanding. Acrid and irritating secretions may be poured out from the skin-glands of these animals. Such secretions are seen typically developed in the toads; but they are not 'poisonous," in the common sense in which we use that term.

It is in the class of reptiles that the venomous attains its full development. Here, in the group of the snakes, we reach the acme of poison evolution. A typically poisonous snake, like the rattlesnake or viper, possesses two elongated and hollow "fangs," borne on its upper jaw. These fangs are merely largely-developed teeth, and their hollow interiors each communicate by means of a canal with the poison gland. This gland, placed in front of and below the eye on each side, is merely a modified *salivary gland*, and corresponds to that gland in man known as the *parotid*, and which becomes enlarged in children suffering from "mumps." It is highly interesting to find that whilst the poison-secretion of a snake is merely permanently modified *saliva*, we know of cases among quadrupeds in which the fluid of the mouth becomes temporarily venomous. The case of the rabid dog is the most familiar example of this fact; and it is curious to reflect on the similarity in nature which exists between the virus of animals so widely separated as are snakes and mammals.

The class of lizards is well known to be related to that of snakes by many ties of structural kinship. Both are groups of the reptilian class, and we find certain lizards (*e.g.*, the harmless blind-worm of Britain,) which may be as destitute of legs as any snake. No lizard, until quite recently, was known to be poisonous, or to possess any structures suggestive of the possession and manufacture of a poisonous secretion. Horrible, ungainly, and ugly as many lizards are, no fear of evil consequences could have been experienced in handling them, and naturalists would have given a very decided negative to any inquiry respecting the existence of a poison-secretion in the lizard group. But as it is the unexpected which happens proverbially in political and social life, so zoological existence has been startled by the news that a truly poisonous lizard has at length been discovered.

This reptile is named the *Heloderma horridum*, and hails from the neighbourhood of Puebla. It is, therefore, a denizen of the New World, and has found its way to the reptile-house in the London Zoo' through the kindness of Sir John Lubbock. The traditions of the lizard are, it appears, unfavourable, if its Indian character is to be believed. The natives appear to regard it as a malignant deity, and are said to endeavour to propitiate the supposed evil power by the offer of sacrifices to the lizard-god. When first brought to London, the reptile was regarded as an interesting example of a rare species of lizard. Like the rest of its brethren, it was believed to be thoroughly and completely harmless. True, stories had now and then been circulated by travellers in Mexico, that there existed in that country a lizard, or reptile of allied nature, whose bite was believed to be terribly fatal. But naturally enough, without evidence of the existence of such an animal, naturalists relegated the story to the domain of legend and exaggeration. Without direct evidence of such a statement, no man of science, basing his views of lizard-nature on the exact knowledge to hand, would have hesitated in rejecting the story as, at least, improbable. Yet it is clear that the stories of the New World may have had an actual basis of fact; for the *Heloderma horridum* has been, beyond doubt, proved to be poisonous in as high a degree as a cobra or a rattlesnake.

At first the lizard was freely handled by those in charge at Regent's Park, and being a lizard, was regarded as harmless. It was certainly dull and inactive, a result probably due to its long voyage and to the want of food. Thanks, however, to the examination of Dr. Günther, of the British Museum, and to actual experiment, we now know that *Heloderma* will require in future to be classed among the deadly enemies of other animals. Examining its mouth, Dr. Günther found that its teeth formed a literal series of poison-fangs. Each tooth, apparently, possesses a poison-gland; and lizards, it may be added, are plentifully supplied with these organs as a rule. Experimenting upon the virulence of the poison, *Heloderma* was made to bite a frog and a guinea-pig. The frog died in one minute, and the guinea-pig in three. The virus required to produce these effects must be of singularly acute and powerful nature. It is to be hoped that no case of human misadventuro at the teeth of *Heloderma* may happen. There can be no question, judging from the analogy of serpent-bite, that the poison of the lizard would affect man. The sacrifice of a guinea-pig and a frog may be, and most probably will be, cited by rabid anti-vivisectionists as a cruel experiment. Sensible persons will apply another term to the test whereby the virulence of the lizard was established, and humanity thereby placed on its guard. Forewarned is forearmed, whether we consider the case of a burglarious attack on our premises or the bite of a lizard.

BIRDS WITH TEETH.

BY THOS. FOSTER.

In the year 1861 a feather was found in a slab of lithographic stone from Solenhofen, which Hermann von Meyer assigned to an animal as yet not otherwise known, which he called *Archæopteryx lithographica*. Later in the same year, a large portion of the skeleton of Archæopteryx was discovered in the same formation. There were impressions of feathers radiating fanwise from each of the fore-limbs. But Prof. Andreas Wagner, in a report to the Royal Academy of Sciences in Munich, expressed the opinion that the creature was not a bird, but a reptile, whose natural covering presented a deceptive resemblance to feathers. He called it the *Griphosaurus*, which (considering he had not seen the fossil remains) was very obliging on his part. Von Meyer, however, regarded the impressions as representing real feathers, belonging to the same animal as the feather he had already discovered. The fossil was secured for the British Museum in 1862. It is contained in two slabs of Solenhofen limestone; one representing the surface of tidal mud on which the bird lay at the time of its death, the other the layer deposited over the dead body. The lower slab shows the impressions of the tail, wings, and parts of the skeleton. The right shoulder-blade and upper arm (wing), as well as both the forearms, are well preserved. The head, the neck, and the backbone are wanting. Two of the digits of the wing (wing-fingers we may call them) are free, and armed with sharp claws or recurved spurs. The right lower limb is well preserved, consisting of the thigh-bone, the tibia or larger lower leg-bone, and the tarso-metatarsal bones, or bones of the upper foot To the metatarsus, four toes are articulated, one hind-toe and three fore-toes, which are jointed as with birds, and armed with strong recurved claws. "The foot," says Mr. Woodward, from whose description the above has in the main been taken, "agrees well with that of a true perching bird, but from the fanwise and rounded arrangement of the wing-feathers, it would appear to have been a bird of feeble flight."

Without entering further into the peculiarities of this creature, we note that while a few naturalists were doubtful as to its being really a bird, the majority were very confident that it was so. Professor Owen, in particular, pointed out that in one respect in which it differed most from modern birds it resembles the embryonic bird. Its tail-bones diminished gradually to the last, whereas in modern birds, the last vertebra of the tail is almost always the largest. But, said Owen, "All birds in their embryonic state exhibit the caudal vertebra distinct, and in part of the series [of embryonic changes] gradually decreasing in size to the pointed end one." The two-fingered and free condition of the wing-hand, that is of what corresponds to the hand in the bird's fore-limbs (which Owen pleasantly described as "the biunguiculate and less confluent condition of the manus"), he did not account for in the same way as a feature of an embryonic bird; but in some modern species the forward wing-finger supports a claw, and the Screamer has two claws. All who at that time examined the fossil agreed that in all probability the creature had a beak like a bird.

But Mr. John Evans noticed somewhat later (besides a rounded mass which he took for part of the brain-pan, with a cast of the brain) what he regarded as a fossil jaw, on the slab on which lies the fossil body of the bird. It had been supposed to be the beak of Archæopteryx, but "great was my surprise," writes Mr. Evans, "when I detected along its right-hand margin, towards the apex, the distinct impression in the slab of four teeth, still attached to it. The teeth themselves remain adhering to the counterpart, and are easily recognised by the lustre of their enamel." The teeth are thus described by Mr. Woodward: "The three which remain in a vertical position with regard to the jaw are about one-tenth of an inch long, and at intervals of about one-fifth of an inch. They consist of a slightly tapering, flattened, enamelled crown, about a twenty-fifth of an inch in width, and obtusely pointed, set upon what is apparently a more bony base, which widens out suddenly into a semi-elliptical form, so that at the line of attachment to the jaw the base of one tooth comes in contact with that of the next. So sudden and extensive is this widening of the base, that at first it gave me the impression that the teeth were tricuspidate, with the middle cusp far longer than the others. The front tooth of the four, which slopes forward from the rest, and is rather smaller than the others, shows little, if any, similar enlargement of its base. Of the fifth, which lies across the base of the foremost of the four, only a part is visible. There appears to be a well-defined line at the base of the teeth along their junction with the jaw, but I can offer no opinion as to the method of their attachment."

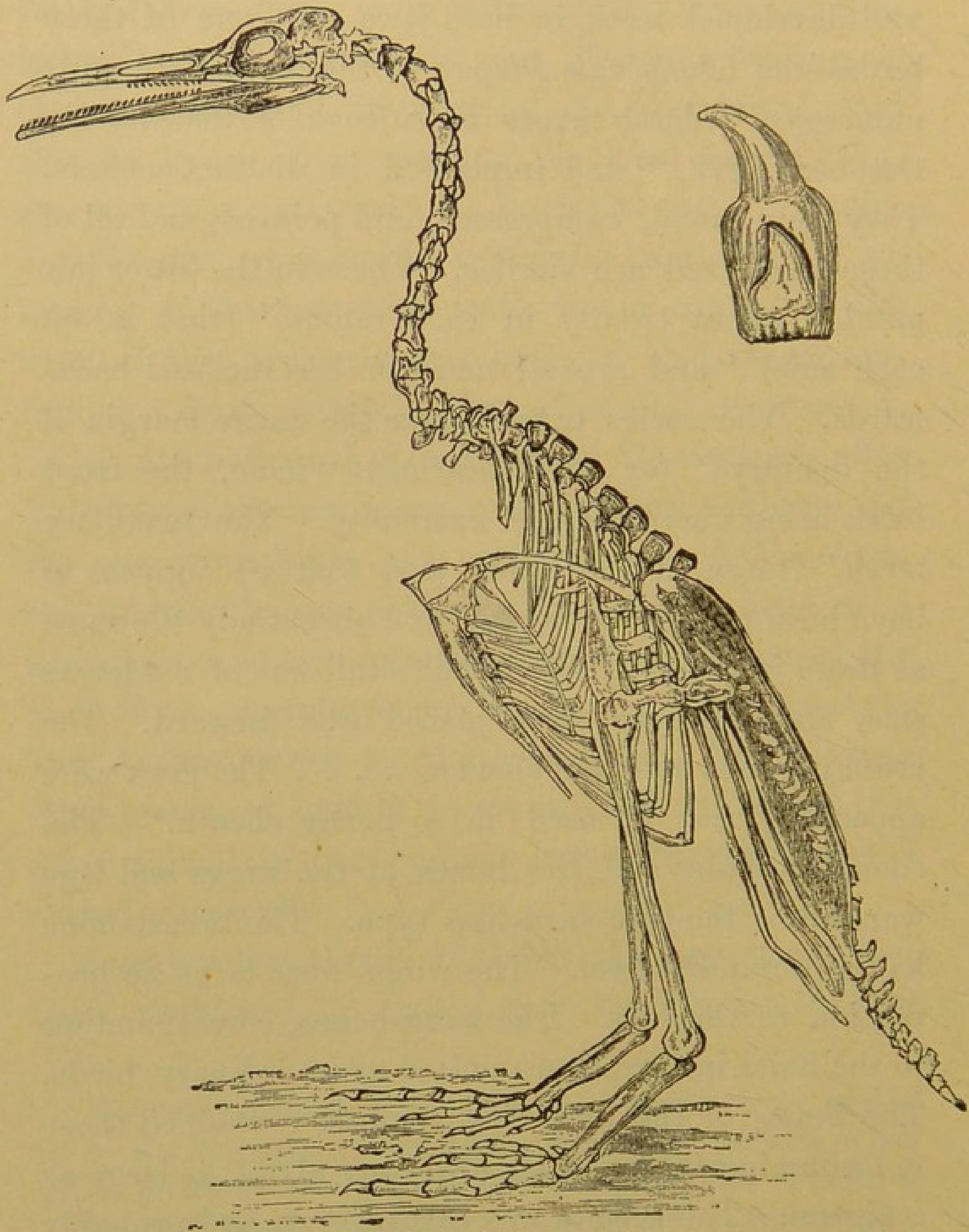
It seemed so unlikely when the above description was written that a jaw armed with teeth could belong to a creature manifestly bird-like, that many supposed the jaw belonged to some fish, though the jaws and teeth of fossil fishes from the same bed were found to be unlike this. Hermann von Meyer, referring to the drawings sent to him by Mr. Woodward, said that he knew of no teeth of the kind in the lithographic stone; nor were the teeth like those of Pterodactyles (the great reptiles with bat-like wings). "An arming of the jaw with teeth would contradict the view of the Archæopteryx being a bird or an embryonic[1] form of bird. But, after all," he proceeds, "I do not believe that God formed his creatures after the systems devised by our philosophical wisdom. Of the classes of birds and reptiles, as we define them, the Creator knows nothing, and just as little of a prototype or of a constant embryonic condition of the bird which might be recognised in the Archæopteryx. The Archæopteryx is, of its kind, just as perfect as other creatures, and if we are not able to include this fossil animal in our system, our shortsightedness is alone to blame."

Probably the theory that the Archæopteryx had teeth would still be regarded as little better than an

[1] The word embryonic is here used with reference to the species, not to the individual. It signifies a form which creatures of the species presented before the type of the species had become, as it were, distinct and established. Traces of such past forms of a species are recognisable in the embryonic development of later representatives of the species.

assumption, had not other and more complete evidence been obtained. Professor Marsh discovered two fossil birds in the cretaceous shale of Kansas, which had well-developed teeth in both jaws. Of one of these birds—the *Ichthyornis Dispar*—"the teeth were quite numerous," Marsh wrote in *Silliman's Journal* for October, 1872, "and implanted in distinct sockets. They were small, compressed, and pointed, and all of those preserved are similar. Those in the lower jaw number about twenty in each ramus" (that is, on each side) "and are all more or less inclined backwards. The series extend over the entire margin of the dentary" (or tooth-bearing) "bone, the front teeth being very near the extremity. The maxillary teeth" (those in the upper jaw, that is) "appear to have been equally numerous, and essentially the same as those in the mandible. The skull was of moderate size, and the eyes were placed well forward. The lower jaws are long and slender. . . . . The jaws were apparently not encased in a horny sheath." The shoulder-blades and the bones of the wings and legs were all of the true bird-like type. The breast-bone had a prominent keel. The wings were large in proportion to the legs. The wing-bones, corresponding to the hand in man, were united as in ordinary birds. The bones of the hinder extremities resembled those in swimming birds. The bird was about as large as a pigeon. The species was carnivorous, and probably aquatic. Professor Marsh called the other form discovered by him *Apatornis celer*.

Later, Professor Marsh announced that having re-examined another fossil bird—a large diving-bird nearly six feet high, found in the same cretaceous



formation as the *Ichthyornis*—he found that it also had *teeth in both jaws, not in sockets*, like the Ichthyornis, *but in grooves,* as in *Ichthyosaurus,* the great lizard-formed marine reptile.

The skeleton of this toothed bird is pictured in our illustration. Professor Marsh called it the *Hesperornis Regalis.* Before the discovery of teeth, Professor Marsh had unhesitatingly classed the *Hesperornis* as a gigantic diver, though recognising peculiarities of structure. But recently, in a monograph on the Extinct Toothed Birds of North America, he called attention to its resemblance in certain respects to the ostrich. He says that if these characters are to be "regarded as evidence of real affinity, the *Hesperornis* would be essentially a gigantic swimming ostrich." Professor Huxley, on the other hand, says that the bird is "in a great many respects astonishingly like an existing diver or grebe—so like it, indeed, that had this skeleton been found in a museum, I suppose, if the head had not been known, it would have been placed in the same general group as the divers and grebes of the present day."

The teeth seem to have been admirably adapted to aid a diving-bird (like a grebe) in catching its slippery prey. In the *Odontopterix toliapicus* of Owen, the bony denticles were inclined at a considerable angle, but with the points forward; yet Professor Owen concluded that even such projections (they could not properly be called teeth) must have greatly assisted the bird in holding captured fish. In the existing bird the *Merganser serrator,* the tooth-like serrations are inclined with the points backwards. These serrations, however, were not teeth, but merely tooth-like extensions of the horny covering of the beak. The teeth of the *Ichthyornis* and *Hesperornis*, as is shown by the smaller figure (showing a tooth, and, within it, a tooth forming to take its place) were unmistakably teeth. It does not take away from their dental character that they were set in a groove in *Hesperornis* and *Archæopteryx*, instead of in separate sockets, as in higher-toothed races and in *Ichthyornis*.

It should be added that Professor Marsh has examined the specimen of *Archæopteryx* in the British Museum, and fully satisfied himself that it belongs to the class of toothed birds. "The teeth seen on the same slab with this specimen agree so closely with the teeth of *Hesperornis*, that" he "identified them at once as those of birds, and not fishes."

He describes the leading characters of the ancestral bird in the following terms:—"In the generalised form to which we must look for the ancestral type of the class of birds, we should expect to find the following characters: Teeth in grooves; vertebræ biconcave" (that is, the bones of the backbone shaped somewhat as we see them in fish); "breastbone without a keel; tail longer than the body; bones of the hand and wrist, as also those of the foot, free; the bones of the pelvis separate; the sacrum" (or hind bone of the pelvis) "formed of two vertebræ; four or more toes directed forward; feathers rudimentary or imperfect."

If we consider the circumstances under which, according to the theory of evolution, the race of birds came into existence, we can understand that the ancestral creatures whence birds are descended presented many features in which they were not only unlike the birds of our time, but unlike any other race of existing animals. Were they not also, in all probability, very unlike each other? Probably there were much wider differences among the various orders of animals which included all the ancestry of the modern bird at the time when first *any* of the characteristics now regarded as avian first existed, than there are now among all the orders of existing birds. This certainly appears from the evidence obtained, not only respecting toothed birds, but also respecting those bird-like animals of which Huxley and others have shown that they were closely akin to reptiles—were, in fact, biped reptiles. We believe that the same holds with every species now existing, even with man—that, for instance, if we could have brought before us in rapid review all those creatures from which the human race of our time has descended (taking only those which belonged to one particular epoch, before man, specialised as we now find him, existed), we should not only find a far wider range of difference among these creatures than among the human races of the present day, but a wider range of difference than even exists between men and apes. There are *à priori* reasons for this view as regards the human race; but, apart from these, the evidence collected by Mivart in his work, "Men and Apes," while not, we think, available to show that there is no kinship between the Simian and Human races, seems only explicable on the assumption that the Simian ancestors of man differed widely *inter se.*

THE FIJI ISLANDS.[1]

The ideas generally entertained respecting the Fiji Islands and their inhabitants are not such as to encourage the idea that life to white men would be very pleasant there. Probably most persons who have not followed the changes which have recently taken place in this important group of islands, suppose that the Fijians are still, as they used to be considered, the most barbarous of all the Polynesians, addicted frightfully to cannibalism, and little changed from those who, as Herbert Spencer puts it, possessed such "extreme loyalty," that if the king willed it, a Fijian cheerfully stood unbound to be knocked on the head. The days are passed, however, when a Fijian king could register by a row of many hundred stones the number of human victims he had eaten. The Conservative Fijian sighs in vain for the good old times when the king's will reigned supreme. A visitor has

[1] "A Year in Fiji: an Inquiry into the Botanical, Agricultural, and Economical Resources of the Colony." By J. Horne, F.L.S., &c., Director of Woods and Forests, and Botanical Gardens, Mauritius.

now only to take with him, as Mr. Horne did, a circular letter of introduction written in Fijian to all the chiefs, to find himself a welcome guest at (instead of upon) their hospitable tables. "In each village some one, generally the schoolmaster, 'teacher,' or native clergyman, was found, who could read and explain the letter to the people, who were at all times attentive listeners." The Sunday schools are well attended, and most of the rising generation of Fijians can do something in the way of reading, writing, and ciphering. In fact, with a few guides and an interpreter, a little sugar, tea, coffee, and biscuits, mats for sleeping upon, a rug or so, and a mosquito net, the visitor can enjoy himself immensely in the Fiji Islands, as Mr. Horne's work shows in almost every page.

While the cool weather lasts, Europeans in Fiji can wear with comfort clothing adapted to an English summer; "indeed, at this season, the weather is delightful, finer than the best summer weather in England." In the hot weather, it is true, the heat is oppressive, while storms of thunder and heavy rain are more frequent than pleasant. With reference to the rainfall, by the way, which even for a tropical country is very heavy, Mr. Horne notes a circumstance of considerable interest. "Previous to and during 1861–2 the low hills around Levuka were thickly wooded. Since that time the woods have been cut down, and the number of days on which rain falls has been reduced from 256, the average for 1861–2, to 149, the average for 1865–6 and 1876–7. It would seem that the number of showers diminished simultaneously with the cutting of the trees. The average rainfall has not diminished, however, and with an annual rainfall of 118 inches the Fijians may be well satisfied, especially as the rain falls most abundantly during the warm or summer season, when vegetation most requires it. It was absolutely necessary, moreover, to clear the forest region, for the thick woods afforded shelter to the mountaineers, who, on several occasions, appeared in large numbers, and threatened to sack the town and murder the white settlers. "These marauders came from Lasoni, in the centre of Ovalan, just across the mountains from Levuka; stole down upon the town, plundered the goods of the settlers, and then made off into the woods, where it was useless and dangerous to follow them." Unfortunately, since the woods were cleared the rain falls more torrentially than before, and carrying away the loose soil on the surface, where the ground is steep, does great damage to both soil and vegetation.

The Fiji islands number in all 255, having an entire area of about 7,403 square miles, or about 738,350 acres. The largest island of the group, Vili Levu, has an area 4,112 square miles, while the next in size, Vau na Levu, has an area of 2,432½ square miles. The others are all much smaller. About eighty of the islands are inhabited, the white population being about 2,000 (in 1874), the natives numbering about 140,500. As regards communication with the outside world, Fiji is not badly off. Twenty-four hours after the arrival of the mail from San Francisco at Sydney, a fine steamer of 1,000 to 1,500 tons leaves for Levuka, the voyage occupying seven or eight days. The steamer remains at Levuka nearly a week, and leaves with the mails for England in time for them to be transhipped to one of the Peninsular and Oriental steamers at Sydney. From Melbourne there is direct steam communication with Suva and Levuka once every five weeks. There is also regular steam communication between Levuka and Auckland (New Zealand) and between Levuka and the Friendly Islands. A visit to the Fiji Islands during the cool season would be pleasant for any one who enjoys change of scene; but it is clear from Mr. Horne's book that the naturalist (especially the botanist) would find such a visit at once interesting and profitable.

The natives are hospitable, as also (which is of more importance, perhaps) are the white settlers. The Fijians are daring sailors, and good customers to the boat-builders, who have taken the place of the native canoe-builders. The natives play a number of athletic games, among which may be mentioned throwing the *tinika*, or reed, wrestling, and a game which is something like tennis, a little like cricket, and a great deal like skittles. They throw the tinika (an oval-shaped piece of wood about four inches long and two in diameter at the thickest part) a distance of about 300 yards, or thrice as far as our best cricketers can throw a cricket-ball. The natives are subject to elephantiasis, and consider their children neither strong nor healthy till they have experienced an ulcerous disease, which they call *coko*. A kind of ophthalmia is not uncommon, but it lasts only a few days, both natives and settlers being subject to it. The natives have succumbed in great numbers to epidemics of measles, and many consider that the population has, in consequence, become greatly decreased. But Mr. Horne considers that the many abandoned "patches" may indicate rather a change in the habits of the people than a diminished population.

The animals indigenous to Fiji are bats, flying foxes, and a small rat. The ten species of snakes found there are all harmless. Pigs, introduced from Tonga (where Cook left them), run wild in the forests. There are wild ducks, snipe, sand-pipers, wild pigeons, and beautiful golden orange doves, as well as parrots or parroquets. Whales and porpoises are found in the seas round the group, which swarm with many kinds of fish, edible and otherwise. Sharks abound, and travel long distances from the sea to the deep pools in the rivers, which must render them less pleasant to bathers than they otherwise would be.

Mr. Horne's book is full of interesting facts, and though it has been specially written in response to an official invitation, it will be found very pleasant reading. There is a copious index—indeed, the index is a little too copious, a passing word in the text being, in many cases, all that is found to bear on a carefully-paged index-heading. The facts gathered together here are the fruits of a year of faithful and laborious research.

HYACINTH BULBS.

BY GRANT ALLEN.

If we were not so familiar with the fact, we would think there were few queerer things in nature than the mode of growth followed by this sprouting hyacinth bulb on my mantelpiece here. It is simply stuck in a glass stand, filled with water, and there, with little aid from light or sunshine, it goes through its whole development, like a piece of organic clockwork as it is, running down slowly in its own appointed course. For a bulb does not grow as an ordinary plant grows, solely by means of carbon derived from the air under the influence of sunlight. What we call its growth we ought rather to call its unfolding. It contains within itself everything that is necessary for its own vital processes. Even if I were to cover it up entirely, or put it in a warm, dark room, it would sprout and unfold itself in exactly the same way as it does here in the diffused light of my study. The leaves, it is true, would be blanched and almost colourless, but the flowers would be just as brilliantly blue as these which are now scenting the whole room with their delicious fragrance. The question is, then, how can the hyacinth thus live and grow without the apparent aid of sunlight, on which all vegetation is ultimately based?

Of course, an ordinary plant, as everybody knows, derives all its energy or motive-power from the sun. The green leaf is the organ upon which the rays act. In its cells the waves of light propagated from the sun fall upon the carbonic acid which the leaves drink in from the air, and by their disintegrating power, liberate the oxygen while setting free the carbon, to form the fuel and food-stuff of the plant. Side by side with this operation the plant performs another, by building up the carbon thus obtained into new combinations with the hydrogen obtained from its watery sap. From these two elements the chief constituents of the vegetable tissues are made up. Now the fact that they have been freed from the oxygen with which they are generally combined gives them energy, as the physicists call it, and, when they recombine with oxygen, this energy is again given out as heat, or motion. In burning a piece of wood or a lump of coal, we are simply causing the oxygen to re-combine with these energetic vegetable substances, and the result is that we get once more the carbonic acid and water with which we started. But we all know that such burning yields not only heat, but also visible motion. This motion is clearly seen even in the draught of an ordinary chimney, and may be much more distinctly recognised in such a machine as the steam-engine.

At first sight, all this seems to have very little connexion with hyacinth bulbs. Yet, if we look a little deeper into the question, we shall see that a bulb and an engine have really a great many points in common.

Let us glance first at a somewhat simpler case, that of a seed, such as a pea or a grain of wheat. Here we have a little sack of starches and albumen laid up as nutriment for a sprouting plantlet. These rich food-stuffs were elaborated in the leaves of the parent pea, or in the tall haulms of the growing corn. They were carried by the sap into the ripening fruit, and there, through one of those bits of vital mechanism which we do not yet completely understand, they were selected and laid by in the young seed. When the pea or the grain of wheat begins to germinate, under the influence of warmth and moisture, a very slow combustion really takes place. Oxygen from the air combines gradually with the food-stuffs or fuels—call them which you will—contained in the seed. Thus heat is evolved, which in some cases can be easily measured with the thermometer, and felt by the naked hand—as, for example, in the malting of barley. At the same time motion is produced; and this motion, taking place in certain regular directions, results in what we call the growth of a young plant. In different seeds this growth takes different forms, but in all alike the central mechanical principle is the same: certain cells are raised visibly above the surface of the earth, and the motive-power which so raised them is the energy set free by the combination of oxygen with their starches and albumens. Of course, here, too, carbonic acid and water are the final products of the slow combustion. The whole process is closely akin to the hatching of an egg into a living chicken. But, as soon as the young plant has used up all the material laid by for it by its mother, it is compelled to feed itself just as much as the chicken when it emerges from the shell. The plant does this by unfolding its leaves to the sunlight, and so begins to assimilate fresh compounds of hydrogen and carbon on its own account.

Now it makes a great deal of difference to a sprouting seed whether it is well or ill provided with such stored-up food-stuffs. Some very small seeds have hardly any provision to go on upon; and the seedlings of these, of course, must wither up and die if they do not catch the sunlight as soon as they have first unfolded their tiny leaflets; but other wiser plants have learnt by experience to lay by plenty of starches, oils, or other useful materials in their seeds; and whereever such a tendency has once faintly appeared, it has given such an advantage to the species where it occurred, that it has been increased and developed from generation to generation through natural selection. Now what such plants do for their offspring, the hyacinth, and many others like it, do for themselves. The lily family, at least in the temperate regions, seldom grow into a tree-like form; but many of them have acquired a habit which enables them to live on almost as well as trees from season to season, though their leaves die down completely with each recurring winter. If you cut open a hyacinth bulb, or, what is simpler to experiment upon, an onion, you will find that it consists of several short abortive leaves, or thick fleshy scales. In these subterranean leaves the plant stores up the food-stuffs elaborated by its green portions during the summer; and there they lie the whole winter through, ready to send up a flowering stem early in the succeeding spring. The material in the old bulb is used up in thus producing leaves and blossoms at the beginning of the second or third season; but fresh bulbs grow out anew from its side, and in these the plant once more stores up fresh material for the succeeding year's growth.

The hyacinths which we keep in glasses on our mantelpieces represent such a reserve of three or four years' accumulation. They have purposely been prevented from flowering, in order to make them produce finer trusses of bloom when they are at length permitted to follow their own free will. Thus the bulb contains material enough to send up leaves and blossoms from its own resources; and it will do so even if grown entirely in the dark. In that case the leaves will be pale yellow or faintly greenish, because the true green pigment, which is the active agent of digestion, can only be produced under the influence of light; whereas the flowers will retain their proper colour, because their pigment is always due to oxidation alone, and is but little dependent upon the rays of sunshine. Even if grown in an ordinary room, away from the window, the leaves seldom assume their proper deep tone of full green; they are mainly dependent on the food-stuffs laid by in the bulb, and do but little active work on their own account. After the hyacinth has flowered, the bulb is reduced to an empty and flaccid mass of watery brown scales.

Among all the lily kind, such devices for storing up useful material, either in bulbs or in the very similar organs known as corms, are extremely common. As a consequence, many of them produce unusually large and showy flowers. Even among our native English lilies we can boast of such beautiful blossoms as the fritillary, the wild hyacinth, the meadow-saffron, and the two pretty squills; while in our gardens the tiger lilies, tulips, tuberoses, and many others belong to the same handsome bulbous group. Closely-allied families give us the bulb-bearing narcissus, daffodil, snowdrop, amaryllis, and Guernsey lily; the crocus, gladiolus, iris, and corn-flag; while the neighbouring tribe of orchids, most of which have tubers, probably produce more ornamental flowers than any other family of plants in the whole world. Among a widely-different group we get other herbs which lay by rich stores of starch, or similar nutritious substances, in thickened underground branches, known as tubers; such, for example, are the potato and the Jerusalem artichoke. Sometimes the root itself is the store-house for the accumulated food-stuffs, as in the dahlia, the carrot, the radish, and the turnip. In all these cases, the plant obviously derives benefit from the habit which it has acquired of hiding away its reserve fund beneath the ground, where it is much less likely to be discovered and eaten by its animal foes. For it is obvious that these special reservoirs of energetic material, which the plant intends as food for its own flower or for its future offspring, are exactly those parts which animals will be likely unfairly to appropriate to their personal use. What feeds a plant will feed a squirrel, a mouse, a pig, or a man, just as well. Each requires just the same free elements, whose combination with oxygen may yield it heat and movement. Thus it happens that the parts of plants which we human beings mainly use as food-stuffs are just the organs where starch has been laid by for the plant's own domestic economy—seeds, as in the pea, bean, wheat, maize, barley, rice, or millet; tubers, as in the potato and Jerusalem artichoke; corms, as in the yam or tara; and roots, as in arrowroot, turnip, parsnip, and carrot. In all these, and in many other cases, the habit first set up by nature has been sedulously encouraged and increased by man's deliberate selection. What man thus consciously effects in a few generations, the survival of the fittest has unconsciously effected through many long previous ages of native development.

OUR UNBIDDEN GUESTS.

BY DR. ANDREW WILSON, F.R.S.E.

THE fact that in most animals there may reside, as "guests," within unconscious or unwilling "hosts," certain other animal forms, is, of course, widely known. These animal "guests" form the "parasites" of the natural historian. But, although the fact of their existence is known, the general history of even the commonest parasites is a matter concerning which the general public are, as a rule, lamentably ignorant. I say "lamentably," and I mean what I say. A vast amount of disease, and that of a preventible nature, is caused by the carelessness of man in the preparation of his food. This carelessness is, in its turn, founded upon gross ignorance, for there are not a few persons who believe that parasites come, like Dogberry's reading and writing, by nature, and that they are part and parcel of an animal's constitution. That this opinion is very far removed from the true state of matters can easily be shown. It is perfectly provable that animals were not created with the parasites infesting them as we find them to-day. Common sense forbids such a supposition, and the organised common sense we call "science" shows us that the reverse is the case. All parasites are acquired, and not original "guests." This alone is provable by the facts of parasite-development. There is a bag-like parasite called *Sacculina*, for instance, which attaches itself to the bodies of hermit crabs. Now, sac-like though this parasite is, and destitute as it is of all the ordinary belongings of animal life, it yet begins its existence as a little free-swimming animal, exactly resembling a water-flea. The first stages in a sacculina's development are, in short, like the beginnings of the development of some shrimps, of barnacles, of water-fleas, and of crabs themselves, though in a less marked degree. Only after becoming degraded in structure, does the sacculina become the "guest" of the crab. The mere facts that sacculina is at first as free-living as a fish, and that it afterwards settles down on the crab, testify, if we read nature's story aright, that "once upon a time" the sacculina race was not a parasitic one. Whether or not the sacculina stage itself was the beginning of the attached existence, we do not know. It is most probable that the bag-like body we term a "sacculina" was the result of the adoption of the lower and rooted way of life. But apart from all other considerations, the main facts that a young sacculina is always free, and that it begins life under a similar guise even to some of the shrimp race, shows that its parasitic life has been acquired, and is by no means an original condition.

Now the same rule holds good of all "parasites." The development of most of them shows us the lingering remnants of a once-free life. But there are other proofs at hand of this assertion. There are degrees and stages in the perfection of the parasitic state. There exist animals which are mere "lodgers," so to speak—who "dine out," but who repose within the anatomical establishment of a "host." This is the case with certain little fishes, which choose the very "jaws of the lion" as a dwelling-place, since they appear to live in the interior of certain big tropical sea-anemones. These fishes may be seen to swim in and out of the anemone's mouth, and they may be enclosed within the anemone's body when that animal contracts itself, and yet swim free and unharmed out of the mouth when these flower-like animals once more resume their normal and expanded state. Here, then, there is mere "association;" but it is in some such association that the beginnings of pure parasitism have originated. Suppose the case of an animal which, at first merely "lodger," took to feeding upon the tit-bits secured by its host for home consumption. The "lodger," in such a case, would practically become a "boarder" as well. But nature has a law as fixed as the edicts of the Medes and Persians, called the "law of disuse." This law enacts that whatever structures or organs of living beings are not normally used, will waste and tend to disappear. It is the operation of this law which has caused the two outer toes of our horse to grow "small by degrees and beautifully less," until they now appear as the "splint bones" on each side of the single toe upon which the horse walks. And applying this law to the case of the animal lodger, we see how an animal which does not require to move about when resident within another animal will lose its organs of motion. If it obtains fluid food, already digested, the probabilities are that its digestive system will become rudimentary. Not requiring eyes or other sense-organs, these will disappear; and thus we see represented a kind of zoological backsliding, which reduces the parasite to the elementary and degraded condition we, as a rule, discover in the races of animal "guests."

The histories of some of the most common parasites are fraught with instruction, not to speak of the curiosity that invests them. Take, for instance, the history of the fluke (*Fasciola hepatica*), found in the bile-ducts of the liver of the sheep and ox. It is the presence of this parasite that makes sheep fall into a decline, known to veterinarians as the "rot." A fluke is a little, flattened, oval body, about 1 in. or $\frac{3}{4}$ in. in length, and about $\frac{1}{2}$ in. in breadth. It possesses a nervous system, a set of water-vessels, two suckers, a branched digestive system, and an egg-producing apparatus. It has no organs of motion, but it is by no means a very degraded being after all. Its development is very curious. The eggs, liberated from the animal "host," get scattered abroad. Many—as in the case of all parasites—must perish, but a proportion finding their way into water, enter the body of the water-snail, where they develop into curious little tailed beings called *Cercariæ;* and there are sundry other forms assumed by the fluke in the days of its youth, but which need not be mentioned here. Sooner or later, however, these *Cercariæ* escape into the water or into the meadows; and it is believed that from the damp meadows, or from the water itself, the sheep obtain these little beings. Once within a sheep's stomach, each *Cercaria* seems to waken up to its ultimate destiny. It drops its tail, and bores its way through the tissues of the sheep towards the liver, where it soon appears as the young fluke, which will develop eggs that will repeat its own curious history. The most notable fact, however, of this development is that if a sheep swallowed the *egg* of the fluke, no development would ensue. The egg requires to pass through its water-snail stage, ere the sheep can obtain the new fluke.

It is much the same with the tapeworm tribe as with the fluke. The common tapeworm of man (*Tænia Solium*) consists of a very minute "head," attaching itself by suckers and hooks to man's intestines; of a slender "neck," and of hundreds of "joints." Each "joint" is really a semi-independent *animal;* and the tapeworm is therefore a *compound* animal, and presents us with a *colony* of similar beings. A large tapeworm may measure 20 or 30 ft.; and new joints are continually being "budded" out from the head and neck. Hence the physician can never be sure that he has cured a case of tapeworm until he has seen the head and neck of the animal. If a man swallowed the *egg* of a tapeworm, he would not be infested thereby. The young worm has to pass its early life in the body of another warm-blooded animal; and in the case of a common tapeworm, it is "the gintleman that pays the rint," which acts the part of nurse or first host. Man, in other words, obtains his common tapeworm guest from the pig. When this animal swallows the egg of a tapeworm, the young worm bursts through the egg-case and bores its way to the pig's *muscles.* If the porker is affected by numerous embryos, that is, if it has swallowed a large number of eggs, it will become feverish and ill, and it will then be said to have developed "measles." The "measles" of the pig are the visitations of young tapeworms. In the muscles of the pig, then, these young worms rest. *J'y suis; j'y reste,* is decidedly the motto of the young worm. It developes a little head and neck, and it also, by way of a tail, produces a little bladder or bag. Before naturalists knew its true nature, it was regarded as a special kind of parasite, and was named a "cystic worm."

If the pig dies a natural death and is respectably interred, or if the pig should live long enough, these youthful tapeworms will respectively perish, or will degenerate and disappear from the tissues of the aged porker. But assuming that the usual Nemesis of the pig race overtakes the animal, then, in the form of pork, it will gladden the heart of certain members of the human race. Now, let us suppose that a man eats a portion of the "measly pork." Let us further suppose that the pork has been imperfectly cooked; then comes the "tide of fortune" to the young worms. For when the young worm has been eaten by the man, the bladder-tail drops off. Each little head and neck finding itself in the human stomach, recognises its lawful *habitat.* Each attaches itself to the lining membrane of the human intestines, and each by a process of budding produces joint after joint, until man is presented with his matured "guest."

If we tabulate matters thus, the history of the tapeworm will become clear:—

1st Epoch.	Stage 1.	The egg derived from parent tapeworm of man.	Passed in the pig as host.
	„ 2.	Swallowed by the pig; developing.	
	„ 3.	The "Resting Larva," or cystic worm, in the pig's muscles, and forming "measly" pork.	
2nd Epoch.	„ 4.	Swallowed by man.	Passed in man as the host.
	„ 5.	Development of the head and neck, and attachment to man's intestine.	
	„ 6.	The production by budding of the adult worm.	

As a last piece of parasite biography, we may glance at the history of a form which now and then attracts the notice of even Imperial Parliament itself. This form is the famous *Trichina,* which acquires an unenviable notoriety, in that it may, unlike the tapeworm race, cause the death of its "host." Each trichina is a minute worm, coiled, in its immature condition, within a little sack or bag, which in numbers may be found again in the muscles of the pig. Where the pig gets its trichinæ from is hardly certain, but rats are believed to be the sources of supply for the pig race. In the muscles of the pig each trichina is, as already remarked, in an imperfect and youthful condition. If the pig lives long enough, the trichinæ will disappear from its muscles, or will degenerate to become mere specks of lime. But should a man eat a portion of the trichina-infected pork, the youthful worms will undergo, in his digestive system, a rapid and extraordinary development. The trichinæ will develop enormous numbers of young; and the young brood will now naturally seek the muscles of man for a habitation, as their parents before them sought those of the pig. Then ensues the tug of war for the afflicted human. The pain caused by the boring of these microscopic worms from stomach to muscles is intense. It is this pain and attendant symptoms that constitute the disease known as trichiniasis. If the patient's strength holds out, he is safe whenever the young trichina-brood enter the muscles. There they rest, and remain to degenerate—unless, indeed, cannibal instincts were represented in the human race; in which case the cannibal would experience a few of the tortures and troubles which are said proverbially to afflict the just and unjust alike.

The great lesson to be learned, from our survey of parasites, is care in the choice and increased care in the cooking of our food. It should be remembered that the germs of these parasites are killed by a sufficiently long exposure to heat. Hence, while underdone meat may have its charms, it has likewise its grave dangers. Pork, in any and every fashion, should at all times be thoroughly cooked. In this latter case, the parasitic horde may not merely be destroyed, but may even contribute in a microscopic way, to human nutrition.

THE FIRST DAFFODIL.

After watching it closely for four or five days, I have just found the first daffodil of the season wide open this morning, with a big humble-bee buried deep in its capacious throat, already rifling its little store of nectar, and dusting his body and legs with pollen which he will promptly carry away to fertilise one of its pretty sisters in some neighbouring garden. Though I have watched it like a child, I could not resist the childish temptation of picking it, and I have got it here before me now for dissection, poor thing, with my little pocket-knife, though it does not need much of a magnifying power to see all that need be seen of its structural arrangements. It is only a common wild English daffodil: the "daffy-down-dilly who came up to town in a yellow petticoat and a green gown," as the old nursery rhyme has it; and it has been simply transplanted hither from the meadow beyond the bourne; but it is as gay and bright a blossom as one could wish to see, for all that, besides being full of genuine scientific interest for those who care to look at it aright. Let me cut it straight down through the middle, so, and then you will understand better what it is driving at.

You see, the flower consists of a single amalgamated tube, with six lobes or points, and in between them, projecting from its centre, is a large circular crown, broadly tubular in shape, and brightly yellow, like the rest of the blossom, in colour. It is well to begin at the beginning; and so we may first ask why it is six-lobed? The answer is, because it is one of the monocotyledonous plants. That is a very long and technical word—I am half afraid our English-speaking editor will cut it ruthlessly out—and, indeed, I wish it were shorter and simpler; but at present, unhappily, I know of no other that will efficiently supply its place. Let me try to explain it. Many years ago, when flowering plants first appeared upon the earth, they began to diverge into two principal divisions, from one or other of which all our existing flowering kinds (except only the cone-bearing pine family) are ultimately descended. One of these primitive groups had two seed-leaves in each seed, the other had one. There are a great many other differences between the two tribes, but these are the most constant; and it is to the last tribe that the daffodil belongs. Now, so far as the flower is concerned (and it is with that part of the plant alone that I am going to deal to-day), the widest original difference between the two great divisions was this—the plants with two seed-leaves had their parts arranged in whorls of five, while the plants with one seed-leaf had them arranged in whorls of three. Thus the typical flower of the first class has five sepals, five petals, five stamens, and so forth; while the typical flower of the second class has only three of each. In the course of time, however, this original difference has become greatly masked; for many flowers of the first kind have lost one or two of their petals or stamens, by coalescence or otherwise; while many flowers of the second class have doubled their numbers in one part or another. Nevertheless, in most cases, we can even now trace, in some way or other, the steps which connect the existing form with its primitive ancestor; and it is still true that the two types are broadly marked off from one another, as the five-rayed and the three-rayed forms respectively.

Now, the daffodil is a very advanced and highly-modified development of the three-rayed type. The artificial family to which it belongs in the present somewhat irrational arrangement of flowers is that of the amaryllis kind; but we shall understand it better if we look first at its near neighbours of another family, the iris and crocus group. These plants in some of their modifications, such as the common yellow flag, are very simply three-fold in their ground-plan. There are three seed-cells to the pistil in the centre; then there are three stamens outside them; next, there are three petals; and, last of all, there are three large spreading sepals in the outermost whorl. But in the crocus, the three petals and three sepals are indistinguishable, and have coalesced into a single tube, so that the flower seems to have a united corolla of six lobes. Now, in the amaryllis family, to which the daffodil belongs, we get the same sort of tendency carried a little further. Instead of having only one row of three stamens, the members of this group have two rows, thus making a total of six—for, though no mathematician, I will fearlessly venture upon so much arithmetic as that. In the simpler amaryllids, such as the snowdrop, the confusion goes no further than this single step; and we get, first, a three-celled pistil in the centre; next, six stamens in two rows outside it; then three small green-veined petals; and last of all, three large pure white sepals. Here the original three-fold symmetry is hardly at all masked by the occurrence of a double set of stamens; while the petals and sepals are quite separate down to their very base, without any sign of union or coalescence. I don't say they never have been united; indeed, I have certain grave doubts of my own upon that head, connected with what botanists call their inferior ovary; but I'm not going to mention that point to-day, lest I should tell you too much about them all at once, and so spin out my paper to an unconscionable length. For the present, it must suffice to notice that we still possess amaryllid flowers in which the primitive arrangement by threes is even now distinctly visible.

The daffodil, however, has got beyond this early stage, and has undergone so very much modification that its primitive aspect is almost entirely masked by its acquired traits. When I slice across its ovary, or embryo fruit, it is true, I can see that it still consists of three cells, produced by the union of the three originally separate pieces; but with this exception, all its parts now appear to be in sixes rather than in threes. There are six pollen-bearing stamens, produced by doubling the original three; and there are six lobes to the corolla, produced by the coalescence of the three petals with the three sepals, so as to form a single united tube. The object of this coalescence is easy enough to understand. As in the harebell, the daisy, and so many other flowers, it has been effected by the selective agency of humble-bees and other insects, like the one whom I found buried so deeply in its throat this morning. The tubular form, with its stamens hanging out from the side, ensures the fertilisation of the flower much better than the system of open petals; and so it has been brought about by the fact that any variation in that direction was unconsciously favoured by the insects, while variations the other way were universally neglected. But while many other plants have hit upon this same device of coalescence, few have carried it so far as the daffodil. In the first place, the tube in the five-rayed flowers is formed out of the petals alone; but in the three-rayed flowers, the petals are too few in number to make a sufficiently wide tube, and so the sepals or calyx-pieces are joined with them in producing the desired result. Thus we can trace a gradual progress from flowers like the iris and snowdrop, where the sepals are distinctly different from the petals, through flowers like the wild hyacinth, lilies, snowflake, and flowering rush, where all six pieces are equal and similar, to flowers like the crocus, meadow saffron, and daffodil, where the six pieces are united together into a long tube. But, furthermore, and in the second place, the daffodils and the others of the narcissus kind have done more than the mere ordinary tubular blossoms, inasmuch as they have produced a singular outgrowth in the shape of the crown or cup, which forms, as it were, a vestibule to the tube, and thus still better ensures the proper fertilisation of the flower. In some of the pink tribe (amongst the five-rayed flowers) we get a scale or parapet on each petal in somewhat the same way; but in the daffodil and its allies the crown is united and circular, like the tube, though one can still trace six wavy lobes or sinuosities on its edge. In some exotic members of the narcissus group the crown is very small and rudimentary, and is brilliantly coloured with red or orange, so that it seems rather to act as a honey-guide for the bees than as an additional aid to fertilisation; but in the wild English daffodil it has reached a very high state of development, and occupies at least half the entire length of the blossom.

One word more as to its colour. The daffodil is a pale yellow, and it apparently depends mainly for impregnation upon the visits of diurnal insects. Hence it is quite scentless, for its large size and brilliant colour suffice to attract quite enough visitors, without any necessity for the extra allurement of sweet perfume. But many of the southern species, like the jonquils of our flower gardens, have pure white petals, and possess a very powerful jasmine odour. Such white, strong-scented flowers always depend, in part at least, upon night-flying moths, which are largely attracted by perfume; and, of course, no colour can be so well perceived in the dusk of evening as a pure glossy white. Hence the difference in hue between the two kinds. At the same time, the southern varieties are also fertilised by day-flying bees, and for these the frill of the crown is prettily fringed with brilliant orange. Each insect selects the plant that suits it best, and their joint selection has thus produced the snowy petals and exquisitely-coloured cup of the garden jonquil.

STRANGE SEA MONSTERS.

BY RICHARD A. PROCTOR.

THE sea-serpent has long been regarded by most persons as simply a gigantic fraud. Either the object which appeared like a sea-serpent was something altogether different—a floating tree entangled in sea-weed, the serpentine outline of distant hills half lost under a scudding haze, a row of leaping porpoises, or, if a single living creature at all, then one of a known species, seen under unusual and deceptive conditions—or else the circumstantial accounts which could not be thus explained away were concoctions of falsehood. Yet, as the naturalist Gosse long since pointed out, in his curious essay on "The Great Unknown," it is altogether unlikely that men know all the forms of animals which exist in the ocean, and the antecedent probability againt the theory of the existence of creatures such as the great sea-serpent has been described to be is not sufficient to outweigh the evidence which has been given respecting such creatures. No one who has read the account given by the officers and men of the *Dœdalus*, for instance, can for a moment suppose that they were deceived in any one of the ways ingeniously imagined; we *must* assume that they all told untruths before we can reject the belief that some as yet unknown sea creature was seen by them. That creature may quite possibly not have been a serpent properly so called; the picture drawn by one of the midshipmen may have been incorrect in details (as Professor Owen insisted it must have been): but, unless the whole affair was a fraud, a sea animal was seen which had all the appearance of a gigantic serpent. And the idea of fraud in such matters is not nearly so reasonable as many seem to imagine. Travellers are sometimes said to tell marvellous stories; but it is a noteworthy fact that, in nine cases out of ten, the marvellous stories of travellers have been confirmed. Men ridiculed the tale, brought back by those who had sailed far to the South, that the sun there moves from right to left, instead of from left to right, as you face his mid-day place; but we now know that those travellers told the truth. The first account of the giraffe was laughed to scorn, and it was satisfactorily proved that no such creature could possibly exist. The gorilla would have been jeered out of existence but for the fortunate arrival of a skeleton of his at an early stage of our acquaintance with that prepossessing cousin of ours. Monstrous cuttle-fish were thought to be monstrous lies, till the *Alecton*, in 1861, came upon one, and captured its tail, whose weight of forty pounds led naturalists to estimate the entire weight of the creature at four thousand pounds, or nearly a couple of tons. In 1873, again, two fishermen encountered a gigantic cuttle in Conception Bay, Newfoundland, whose arms were about thirty-five feet in length (the fishermen cut off from one arm a piece twenty-five feet long), whilst its body was estimated at sixty feet in length and five feet in diameter—so that the Devil-fish of Victor Hugo's famous story was a mere baby cuttle by comparison with the Newfoundland monster. The mermaid, again, has been satisfactorily identified with the manatee, or "woman-fish," as the Portuguese call it, which assumes, says Captain Scoresby, "such positions that the human appearance is very closely imitated."

As for stories of sea-serpents, naturalists have been far less disposed to be incredulous than the general public. Dr. Andrew Wilson, for instance, after speaking of the recorded observations in much such terms as I have used above, says:—"We may, then, affirm safely that there are many verified pieces of evidence on record of strange marine forms having been met with, which evidences, judged according to ordinary and common-sense rules, go to prove that certain hitherto undescribed marine organisms do certainly exist in the sea-depths." As to the support which natural history can give to the above proposition, "zoologists can but admit," he proceeds, "the correctness of the observation. Certain organisms, and especially those of the marine kind (*e.g.* certain whales) are known to be of exceedingly rare occurrence. Our knowledge of marine reptilia is confessedly very small; and, best of all, there is no counter-objection or feasible argument which the naturalist can offer by way of denying the above proposition. He would be forced to admit the existence of purely marine genera of snakes which possess compressed tails, adapted for swimming, and other points of organisation admittedly suited for a purely aquatic existence. If, therefore, we admit the possibility—nay, even the reasonable probability—that gigantic members of these water-snakes may occasionally be developed, we should state a powerful case for the assumed and probable existence of a natural 'sea-serpent.' We confess we do not well see how such a chain of probabilities can be readily set aside, supported as they are in the possibility of their occurrence by zoological science, and in the actual details of the case by evidence as trustworthy in many cases as that received in our courts of law."

We now have evidence actually taken in a court of law, though the sea-serpent has not yet appeared either as plaintiff or defendant in any legal case. Our readers have already, no doubt, seen all the details of the evidence given by the captain, officers, and several of the crew of the barque *Pauline*, under affidavit, at the Liverpool Police-court. It is manifest, to begin with, that unless these five persons were possessed by a singular taste for unnecessary perjury, we have to deal with a story which cannot relate to floating trees, distant hills, porpoises swimming in Indian file, or the like. A large sperm whale was seen, gripped round the body with two turns of what appeared to be a huge serpent, whose head and tail appeared to have a length beyond the coils of about thirty feet, its girth being apparently about eight or nine feet. For about a quarter of an hour a fierce struggle took place between the serpent and its victim, at the end of which the whale was mastered, and suddenly dragged head first into the depths of the sea. (The account says "to the bottom," but we may be permitted to question whether the bottom was visible.) As the usual length of the cachalot, or sperm whale, is about seventy feet and the girth about fifty, the creature which achieved this decisive victory must have been a rather large animal, and would prove an "awkward customer" (in the old fighting slang), if it chose to attack a small ship. It would seem to have had some idea of the sort, for five days after the capture of the whale, a similar serpent was seen, about two hundred yards from the *Pauline,* "shooting itself along the surface head and neck being out of the water several feet." "A few moments later it was seen elevated some sixty feet perpendicularly in the air," and then, having probably satisfied itself that the ship was neither its natural enemy nor appropriate food, the creature retired. The captain's idea would, indeed, seem to be that the serpent mistook the ship for another serpent of its own kind; but this would seem about as likely as that a horse should mistake a traction-engine for a filly.

Singularly enough we receive almost simultaneously with this curious story another, authenticated in a similar way, and relating to an animal equally marvellous, though of a different kind. Soon after the British steam-ship *Nestor* anchored at Shanghai, in October, 1878, John K. Webster, the captain, and James Anderson, the ship's surgeon, appeared before Mr. Donald Spence, Acting Law Secretary to the British Supreme Court, and made affidavit to the following effect:—"On September 11, at 10.30 a.m., fifteen miles north-west of North Sand Lighthouse, in the Malacca Straits, the weather being fine and the sea smooth, the captain saw an object which had been pointed out by the third officer as 'a shoal!' Surprised at finding a shoal in such a well-known track, I watched the object, and found that it was in motion, keeping up the same speed with the ship, and retaining about the same distance as first seen. The shape of the creature I would compare to that of a gigantic frog. The head, of a pale yellowish colour, was about twelve feet in length, and six feet of the crown was above the water. I tried in vain to make out the eyes and mouth; the mouth may, however, have been below water. The head was immediately connected with the body, without any indication of a neck. The body was about forty-five or fifty feet long, and of an oval shape, perfectly smooth, but there may have been a slight ridge along the spine. The back rose some five feet above the surface. An immense tail, fully one hundred and fifty feet in length, rose a few inches above the water. This tail I saw distinctly from its junction with the body to its extremity; it seemed cylindrical, with a very slight taper, and I estimate its diameter at four feet. The body and tail were marked with alternate bands of stripes, black and pale yellow in colour. The stripes were distinct to the very extremity of the tail. I cannot say whether the tail terminated in a fin or not. The creature possessed no fins or paddles so far as we could perceive. I cannot say if it had legs. It appeared to progress by means of an undulatory motion of the tail in a vertical plane (that is, up and down)." The amiable instincts which characterise the human race suggested to the captain "the idea of running the creature down," but the risk of breaking the screw-blades prevented him from thus welcoming our new acquaintance. Mr. Anderson, the surgeon, confirmed the captain's account in all essential respects. He regarded the creature as an enormous marine salamander. "It was apparently of a gelatinous (that is, flabby) substance. Though keeping up with us, at the rate of nearly ten knots an hour, its movements seemed lethargic. I saw no eyes or fins, and am certain that the creature did not blow or spout in the manner of a whale. I should not compare it for a moment to a snake. The only creatures it could be compared with are the newt or frog tribe." The animal, however, may possibly belong to some class related to the skate. An enormous creature of the skate tribe, without spines, and with small eyes, would present an appearance closely corresponding to the description given by Captain Webster. The mouth and gills of the skate are on the ventral or under surface, and the back-fins on the tail, and often very small. But a skate having a total length of two hundred feet would be as great a novelty in zoology as a monstrous marine salamander.

When we remember how few fish or other inhabitants of the sea are ever seen compared with the countless millions which exist, that not one specimen of some tribes will be seen for many years in succession, and that some tribes are only known to exist because a single specimen or even a single skeleton has been obtained, we may well believe that in the sea, as in heaven and earth, there are more things "than are known in our philosophy."

THE ORIGIN OF BUTTERCUPS.

BY GRANT ALLEN.

HERE in my hand I hold a solitary little golden buttercup, picked this morning in an autumn meadow, but still as bright and sturdy as though it had grown up in warmer days beneath the sunny skies of June. Common and familiar as it is, the buttercup is yet a very interesting flower from the point of view of its origin and evolution. Not that it is a highly-evolved or very singular blossom, with a long and intricate history at its back, like some of the orchids and snapdragons, whose complexity almost defies explanation; on the contrary, the importance of the buttercup in the eyes of the historical botanist is mainly due to the extreme simplicity of its typical arrangement. It is a very early type of plant, which has scarcely undergone any alteration from the form it must have acquired already many millions of years ago. There are other flowers of the same family, such as the larkspur, the columbine, and the monkshood, which still bear obvious traces of being derived from an ancestor exactly like the buttercup, but which have diverged widely from the original stock in their curious, irregular flowers, sometimes spurred, sometimes hooded, and sometimes so altered from the primitive radial shape as to be scarcely recognisable. What makes our buttercup so interesting, on the other hand, is the fact that it represents an early stage in the history of these more highly-developed forms. In order to understand *them* we must first understand *it*. This buttercup, in short, is one of the most central members of the family to which it belongs; while some of its congeners have diverged in one direction and some in another, it has still kept unaltered for us the primitive lineaments of the common ancestor from which all alike have ultimately sprung.

Buttercups, as everybody knows, are tall meadow weeds, and the one which I hold in my hand belongs to the tallest species of all, which we know *par excellence* as *the* buttercup; for we have in England alone no less than some sixteen representatives of the entire genus. Let us look a little closely into its structure, and see what hints we can gather from its existing shape as to its past history and evolution.

First of all there are the leaves. These, one notices at once, are raised on long stalks, and deeply divided into several segments. Sometimes there are only three divisions to each leaf, sometimes five, and sometimes seven; the reason why they thus run in uneven numbers being, of course, that there is always a single terminal leaflet, together with one, two, or three lateral leaflets on either side of it. Again, each of these segments is itself further divided into three toothed lobes. Now, such a complex leaf as this shows by its very nature that it must be the product of considerable previous development. All very early leaves are quite simple and rounded; it is only by slow steps that a leaf thus gets broken up into many divided segments. In this respect, then, the meadow buttercup cannot be regarded as the simplest member of its class. There are some other buttercups, such as the ivy-leaved crowfoot, which creeps along the mud of ditches, or the lesser celandine, which springs in the meadows in early April, whose leaves are entire and undivided. In the lesser celandine they are almost circular, and in the ivy-leaved crowfoot they are slightly angular; but both these plants, having plenty of room to spread in the unoccupied fields of spring or the unappropriated ditches, have never felt the necessity for subdivision into minute segments. They have free access to the air and the sunlight, and so they can assimilate to their hearts' content the carbon of which their tissues are built up. It is otherwise, however, when similar plants push out into new situations, less fully supplied with carbonic acid or with sunshine. For example, there is the water-crowfoot, a mere divergent variety of the ivy-leaved species, which has taken to growing in ponds or rivers. Here it cannot obtain the materials for growth so readily as on its native mud-banks; and it has been compelled, accordingly, to split up its submerged leaves into long, thin, hair-like filaments; but when it reaches the surface, its foliage spreads out once more into the broad ancestral blades of the ivy-leaved crowfoot. It is just the same with the true buttercups. They have taken to growing in the open meadows, where the competition for vegetable food-stuffs is keen, and the struggle for existence very bitter. Hence they have been compelled to divide their leaves into many finger-like segments; and only those which have succeeded in doing so have managed to hold their own in the struggle, and so to hand down their peculiarities to future generations. As a rule, just in proportion as vegetation is thick and matted, do the plants of which it is composed tend to develop minutely divided and attenuated foliage.

It is the flower, however, that most people think of as the essential part of a buttercup, and it is by means of the flower that all the higher plants are usually classified. Now, the blossom of the buttercup is almost an ideally simple typical specimen. It consists of three parts or series of organs, from within outward. First comes a little central boss or cushion, supporting several carpels or unripe fruitlets. Each of these carpels contains a single embryo seed. Outside these comes a row of many stamens, which are the organs for producing the yellow dust which we call pollen. Now, no carpel can mature into a fruit containing ripe seed until it has been impregnated by pollen from a stamen; and these two sets of organs are, therefore, the only really essential parts of the whole flower. But in common language, what we mean by a flower is not these little central knobs and tassels, but rather the bright-coloured petals outside, which in the buttercup are five in number and golden yellow in colour. What, then, is the use to the plant of these expanded and very strikingly-coloured organs?

A flower is at bottom merely a device for producing seed. But in order that the seed may prove capable of germinating, the ovules in its carpels must necessarily be fertilised by pollen. Now, all the earliest flowers consisted merely of stamens and carpels; they had no petals at all. But, as Mr. Darwin has shown, flowers which are fertilised by pollen from a neighbouring plant produce more seed and healthier seedlings than those which are fertilised by the produce of their own stamens. Hence, any modification which promoted such cross-fertilisation would benefit the plants in which it occurred by giving them an advantage over their rivals in the struggle for existence. Now, there are two ways in which flowers have thus acquired special adaptations for fertilising one another. Some of them have developed hanging stamens which shake out their pollen to the wind, and such flowers are also provided with feathery collecting surfaces to the carpels, so as to catch the stray grains which may happen to be wafted to them from their neighbours by the breeze. Plants of this type never possess bright-coloured petals. A second class, on the other hand, have learned to utilise the winged insects which visit their blossoms in search of food. These welcome little pilferers, in passing from head to head, carry the pollen of one plant to the carpels of another, and so assist the flower in effecting the desired cross-fertilisation. This class, to which the buttercup belongs, has usually developed various inducements of food, scent, and colour, in order to attract the fertilising insects. Those flowers which best succeeded in alluring their little winged guests would naturally hold their own against all less highly-endowed competitors, and would hand on their own constitution to their descendants. In this way insect-fertilised plants have acquired the bright petals and sweet scents which chiefly make them noticeable to our human senses. A brief examination of the buttercup blossom will show us the use which they subserve, and the way in which they act in the simplest forms of insect-fertilised flowers.

Pull out one of the golden petals from the outside of the head, and you will see at its base a small hollow spot, covered by a tiny concave scale. That spot is the nectary, and it contains a single drop of pure honey. The honey is put there to entice bees and other insects; it is the wage offered them by the plant in return for the service which they perform for it in fertilising its seeds. The golden hue of the petals, again, acts as an advertisement for the honey; the bees know that such bright hues are never found in any flowers except those which specially lay themselves out to bid for their favour. When a bee sees the brilliant colour, he flies straight towards the blossom and settles on the little boss of carpels in the centre. Here he sips the honey for his own behoof and at the same time dusts himself with pollen on behalf of the flower; for, as soon as the blossom opens, the stamens discharge their precious burden, beginning from the outside and slowly ripening towards the centre. At this early stage, however, the carpels are not yet mature for impregnation, and so they avoid being fertilised from the pollen of their own stamens. If the bee flies away to another buttercup which happens to be still in the same stage of development, he only collects more pollen about his head and thighs; but if he alights on a somewhat older buttercup, he finds its stamens withered and its carpels fully mature for impregnation. Some of the pollen is then sure to fall on the sensitive surface of the carpels. Thus, while he seeks honey for himself, he unconsciously affords his host all the advantages of cross-fertilisation; and it is because he does so that the flower has been enabled to develop its complicated arrangement of petals and nectaries for his delectation.

The buttercup, then, with its five separate simple petals, its many stamens, and its central one-seeded carpels, may be regarded as a good example of the earliest type of insect-fertilised flowers. In some other plants, such as the harebell and the primrose, the separate petals have coalesced into a single tubular corolla; while in others, again, they have assumed various fantastic shapes; but all of them are ultimately derived from flowers like the buttercup, which thus contains in itself all the essential elements of a perfect insect-fertilised plant.

FOUND LINKS.

BY DR. ANDREW WILSON, F.R.S.E., F.L.S.

As the question of "Missing Links" has excited a considerable amount of attention, a few papers on the general aspects of the beings that link together distinct groups of animals, may prove interesting and instructive to reflective minds. It is very necessary that in the first place we should remember the special form which the rational demand for such "links" should take. There exists no necessity or demand whatever for any theoretical link, either between man and any existing ape, or between man and any extinct ape. Such a demand is simply the outcome of an ignorance both of natural history at large, and of evolution also; and, as often as not, such ignorance is of the most prejudiced type. That which the evolutionist and naturalist desire to know, is the nature of the forms which, on the theory of "development," must have connected the human *root-stock* with the pre-human *root*. The connexion, or "link," cannot be sought in the existing world. It must be obtained, if ever it comes to light at all, from the world of fossil life, and from the stores of life-relics which the geologist is year by year adding to our stores of knowledge. It is true that nature is not bound to furnish us with "links" because we see a logical necessity for their existence. But all analogy leads us to expect that such "links" once existed; and I wish now to describe certain interesting examples of such *intermediate forms*, as they are called, culled from varied groups of the animal world. In a word, if I am able to show that we possess at present in the world around us certain animals which undoubtedly connect distinct groups, I may claim the strong support of such examples in favour of the idea that "links" that are now "missing" where we desire their presence, once did exist.

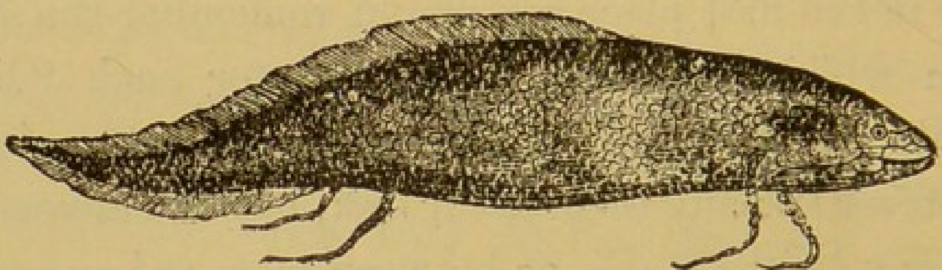


Fig. 1.—*Lepidosiren annectens*, or Mud-fish, showing the limb-like fins.

One of the most curious groups of fishes is that named by geologists the *Dipnoi*. This name means "double-breathers," and the significance of the name will become apparent later on. Of this order of fishes there are two chief examples. The *Lepidosirens* (Fig. 1), or "mud-fishes," found in the rivers Amazon and Gambia, form the first of these examples; whilst a curious fish, occurring in Australian waters, and known as the *Ceratodus*, or "Barramunda," represents the second type. This latter fish is the "Jeevine" or "Teebine" of the Australian natives. Now, in looking at either of those fishes, the observer would never for a moment suppose that they presented any features out of the common. Yet a very slight acquaintance with natural history lore proves the singular nature of their position in the fish-class. Every one knows that fishes breathe by gills; that they are cold-blooded; that their "limbs" are represented by certain of their fins (the "paired" fins); and that their bodies are covered with scales. If we add to these facts, the declaration that fishes possess a heart consisting of only two chambers, we shall have nearly completed our definition of the fish-type; and we might add, lastly, that the nostrils in fishes are typically closed pockets, and do not, as in higher animals, open backwards into the mouth.

It is necessary for our present purpose to point out that most fishes possess a singular sac or bag, lying just beneath the spine, and called the *swimming-bladder*, *air-bladder*, or *sound*. From the "sound" of the sturgeon we obtain isinglass; and in a herring, for example, the "sound" may be seen as a silvery, glistening bag, which is removable along with the other organs of the fish when it is "gutted." This bag contains gas, and its use is that of serving to alter the specific gravity of the fish—that is, to render (by compression or expansion of the gas) the body of the fish heavier or lighter than the surrounding water. It thus enables its possessor to readily rise or sink in the medium in which it lives. The air-bladders of all fishes, as Dr. Günther tells us, at first open into their digestive systems by means of a tube or duct. But in many fishes this tube disappears, leaving the air-bladder a closed sac (as in the cod); or the duct may persist, and place the sound in communication with the digestive tract, as in the sturgeon or herring. Again, the air-bladder may be a simple and single sac; or it may be variously divided, and its interior may be smooth or may be divided into cells. We shall presently see that in the mud-fishes and the "Jeevine," this structure assumes a form and function for which its variations in common fishes in some measure prepare us. Turning now to the last-named fishes (*Lepidosiren* and *Ceratodus*), we discover that their fish-characters exist on the very surface of things. Their blood is cold; their bodies are scaly; they have fins and fin-rays; and above all, they possess gills existing in the sides of the neck, and in which, so long as they swim in the water, their blood is purified. But here the fish-characters end. Another aspect of the mud-fishes and the barramunda reveals characters which startle us as being not those of fishes, but those of frogs; and frogs, toads, and newts form, as every one knows, the second higher class of vertebrates, that of the *Amphibia*.

Firstly, then, the *Lepidosiren* possesses a heart, which is not that of a fish, but modelled on the type of the frog or reptile heart. Instead of being two-chambered, it is three-chambered; and no other fish save itself possesses such an advance on the ordinary type of fish-heart. But, secondly, their "paired fins," which represent in all fishes the "limbs" of higher animals, resemble—in the mud-fishes at least—rudimentary limbs. Then the nostrils, thirdly, open into the mouth—a character agreeing with frogs and all higher vertebrates, but possessed by one other fish-group only—the low hag-fishes, which are poor relations of the lampreys. These characters, then, are the characters of frogs, and not of fishes. But a far more interesting likeness to the frogs and higher vertebrates yet remains for notice. The "air-bladder" of the mud-fish and of the "Jeevine" alters wonderfully, both in form and function, from its nature in other fishes. It becomes divided in two, and it opens into their throat by a windpipe, at the top of which is a "glottis," corresponding to part of our own organ of voice. Furthermore, it is divided internally into cells—in a word, the air-bladder of the mud-fish and its neighbour has become a lung. But this wonderful transformation is not quite ended with the recital of the altered structure of the air-bladder in these fishes. A lung is an organ which not merely receives blood in an *impure state*, but which, as in ourselves, returns that blood *pure* to the heart for recirculation through the body. If, therefore, the "lung" of the fish is to be accounted a true "lung," we should be able to show that it performs the functions and discharges the duties of an organ of breathing.

Now the life of these fishes exhibits exactly the peculiarities which demand the exercise of an air-breathing organ like a lung. The mud-fishes inhabit their native rivers during the wet season; but when the dry season approaches, they bury themselves in the mud, and lie there, baked as in a kind of mud-pie, until the return of the persistent rains. During this land-existence, their "lungs" come into play. So long as they live in their native waters, they breathe by their gills like ordinary fishes; but, ensconced in the mud, they breathe air directly from the atmosphere, like ourselves. The air-bladder purifies the blood, which the heart pumps into its vessels, and from the "lungs" the purified blood is returned to the heart. The fish is thus truly a "double-breather"; it exhibits in itself the combination of the frog and the fish.

Dr. Günther tells us that whilst the mud-fishes remain in the "torpid state of existence, the clay-balls containing them are frequently dug out, and, if the capsules are not broken, the fishes imbedded in them can be transported to Europe, and released by being immersed in slightly tepid water." The "Jeevine," with its similar "lung," is said to leave the Australian rivers at night, and to waddle its way to the marshes and swamps, there to feed upon the vegetable matter that forms its staple food. In the nocturnal journeyings of the fish we can readily perceive the utility of the "lung."

It may lastly be remarked that other fishes are known to leave the water and to exist for a time on land. The climbing perch of India, and the *Ophiocephali,* also of India, illustrate such fishes; but in these forms the breathing in air is contrived in a different fashion from that process in the mud-fishes, and has no connexion with any "lung."

Let us now reflect that a frog itself begins life as a fish. The "tadpole" has gills and a fish-heart, whilst it has no lungs. Ultimately it acquires lungs and loses gills and tail as its mature shape is attained. Summing up these plain facts of zoology, I think it is not difficult to see that in the mud-fishes and "Jeevine" we find a "link" between the lower water-living fishes and the air-breathing frogs. If we suppose that a form like the mud-fish could rid itself of its gills when it became adult, and that it could throw off the scales of the fish, and develop the limbs of the frog, we might figure to ourselves the ascent of the frog-type from the fish-type. There is nothing more wonderful or impossible in this idea than in the veritable fact that every frog is at first a fish, then a tailed newt, and only ultimately becomes the amphibian. Anyhow, one fact seems clear enough, that fishes and frogs—two utterly distinct classes — are "linked" by the mud-fishes and "Jeevine"; and this single fact in itself supports powerfully, in a rational view of matters, the theory that the air-breathing tribes of animals sprang originally from water-living forms. We shall see in future papers that "links" even of stranger kind unite classes of animals as dissimilar as the fishes and the frogs.

PART II.—FROGS AND TADPOLES.

Having in my previous paper tried to show that the mud-fishes were veritable links between the fish-class and the frog-class, we may now turn to the history of the latter group itself, by way of showing how, within its own limits, gaps and gulfs have been bridged in nature's own way. The history of a frog is in itself an interesting study. It begins life as a tadpole, and lives, as most readers know, a perfectly fish-like existence. It is fish-like in form; its heart is two-chambered, and thus resembles that of the fish, and it breathes at first by outside gills. By-and-bye a broad fold grows over the gills, and ultimately covers them; whilst internal gills grow from the gill-arches. Meanwhile, the tadpole has been cropping the water-weeds by means of the horny jaws with which it is provided, and has been digesting its food within the long and spiral intestines which is the right and heritage of the vegetable feeder. Soon, however, the hind legs, which in the frogs and toads are the first to appear, are developed; and these are in turn succeeded by the front limbs. Lungs begin also to grow, as all lungs do, namely, in the form of two sacs or bags from the hinder or lower wall of the gullet. At this stage, the likeness of the frog to the fish has disappeared, and it closely resembles one of the common tailed "efts" or newts, which are familiar denizens of our ponds and pools. If it had retained its outside gills after its legs had become developed, the young frog would have exactly resembled that curious creature, the *Proteus*—found only in underground caves in Central Europe—or the curious Axolotl of North America. But the ways of frog-development do not permit it to remain in the guise and likeness of its eft-cousins. Whilst its lungs have been undergoing development, the heart has been approaching that of the frog-type, which possesses a three-chambered heart, as already observed. Then, as development is completed, the tail shrivels. Growing "small by degrees," it is represented in the adult frog by a mere rudiment; and, as the obliteration of the tail takes place, the young frog leaves the water and assumes the habits of a land-existence; breathing by lungs alone in its adult state, and exchanging, moreover, the vegetarian tastes of its infancy, for an insect dietary in after-life.

Now, the history of a frog is beset with questions of interest for the earnest mind that studies even its superficial features. Why, firstly, should a frog pass through these changes at all? is a very pertinent inquiry; and if this be capable of being answered, why, secondly, should its development run in the lines sketched out? If we start with the idea that animals and plants were simply "created" as we find them—and that view of matters is, of course, not yet displaced in unscientific circles—then, so far as I can see, no explanation whatever of the frog's development can be offered. "It is so, because it is so"—

such is the logical dead-wall that awaits the student who turns to the "special creation" theory for an explanation. There is no accounting for a supernatural creative fiat; we cannot give reasons for a "special creation;" in a word, we must, on this theory of nature, simply accept the fact of the frog's existence, and have done with it. But there exists the alternative idea of *evolution* and *descent*. What if it be admitted that one species or group of animals arises by natural variation and descent from another group? What if in the frog's development we are led to see a panorama—a moving picture, of the descent of its race? The reasonableness of evolution may thus, I think, become very apparent; contrariwise, I know of no other rational explanation of the frog's tadpole-stage, and its subsequent development.

What evolution, then, says is this: the frog is, at first, a fish-like, gill-breathing tadpole, with a fish-heart, because its earliest ancestor was a fish; and it is interesting to note that the young of some well-known fishes (*e.g.*, dog-fishes) breathe by outside gills. I have a beautiful specimen of two of these young fishes with their outside gills in my museum. Furthermore, the resemblances of the tadpole to the type of some primitive fish do not end with its outside aspect. Mr. F. M. Balfour says the anatomy of the tadpole points to its relations with the living lampreys, which, as every naturalist admits, must be fishes of a very ancient type. But, secondly, the tailed tadpole becomes four-legged, and it thus resembles, as we have seen, a newt or eft. The reason of the newt-stage is evident if we assume that the frog-stage was attained through a newt-stage. Abbreviate the tail of the newt, elongate its hind legs, and with a few other modifications, we find the higher frog to be represented. For the frog, let it be remembered, is the highest type of its class; and the evolutionist's contention is that it has ascended to that place and dignity by successively rising from fish to newt, and from newt to frog. The reasons for the "metamorphosis" of the frog are clear enough, on the principle that *development repeats descent*—not always clearly, it is true, and with much modification, but still plainly enough to reveal the ways of the "becoming" of the animal world.

If it is asked, Why do not all animals show their descent as clearly as does the frog? I reply, because their development has been modified. But it is none the less true that in the development of all animals we see glimpses of the lines of their genealogy. The great difference between a frog's development (or that of an insect or crustacean which also undergoes "metamorphosis") and that of, say, a fish which hatches directly from the egg, consists simply in the fact that the frog's development is mostly passed outside the egg, whilst the fish developes within the egg.

But it is interesting to note that the frog in itself thus serves to link together groups of its own class. Thus its own development—not to speak of that of the newts themselves—teaches us that the newts have arisen from the fish-stock, and that they represent a lower phase of amphibian life than do the frogs and toads with their shortened tails. Indeed, the study of the frog itself not merely proves to us its own evolution, but demonstrates an orderly sequence in the descent of its class—a sequence wherein the newt-type followed the fish, and wherein the frog-type, in turn, was evolved from the newt.

That some such explanation—or, at least, an explanation based on similar grounds—is the only feasible method of explaining the metamorphosis of a frog, may be stoutly maintained against all comers. Evolutionists may differ regarding the exact lines along which the descent proceeded. They do not differ regarding the main facts at issue, namely, that fishes are linked to frogs in more ways than one, and that the history of the frog-race, rightly viewed, is really a connecting-thread on which the various forms of living and extinct members of its class may be strung. In my next paper, I shall endeavour to trace the "links" which bind birds to reptiles.

PART III.—BIRDS AND REPTILES.

There are no two classes of animals between which exists a greater dissimilarity than birds and reptiles. The active organisation of the one and the sluggish ways of the other, the warm blood of the former and the cold blood of the latter, are points in the popular natural history of the two groups which technical zoology has but emphasised in its turn. Yet the scientific examination of these beings reveals bonds of connexion between them, all unsuspected by the ordinary reader, and demonstrates further, in the most suggestive fashion, that the likeness to be presently alluded to must possess some origin and meaning. That origin, evolution maintains, is "descent" from a common stock; the meaning is that seen throughout all similar series of likenesses, namely, the natural result of the laws of animal development. In the case of birds and reptiles, the same considerations appeal to us which I have already indicated as existent in the details of frog-development. Either the likenesses science discovers between apparently distinct groups of animals are explicable, or they are not explicable. If the former, then science declares, with unanimous voice, that the like nesses are due to common descent, as the unlikenesses are due to the variations and modifications produced during the evolution of the race. If, on the other hand, the likenesses are inexplicable—as I hold them to be on any other theory save that of evolution—then must mankind fold their hands in the acknowledgment of an ignorance that might legitimately, by its avowal, close the door to astronomical research, to geological work, and to scientific investigation of every kind.

I am led to make these remarks because several correspondents of *Knowledge* have remarked to the editor, that because likenesses can be proved to exist between two different groups of animals in their young state, they do not understand why the evolutionist should lay such stress upon these facts as proving his contentions. One correspondent, for instance, says that he cannot admit that because one thing is like another, the two things must stand in the relation of parent and offspring. I reply, likeness does not necessarily imply similarity of origin, but, on the other hand, it is one of the proofs of such similarity. If likeness is to be denied its place as a proof of common origin—apart from other and equally powerful proofs known to biologists—what guarantee should we possess that unlikeness means dissimilarity? That the likeness of child to parent is a natural likeness, every one must admit. The reasons are clear enough, and they derive their force from the fact that the latter begets the former. I hold that the likenesses existent—especially in the *early* stages of development—between different groups, are to be judged on the same basis, namely that of *heredity*. A manifest resemblance in the young frog to a fish is, I repeat, inexplicable, equally on scientific principles and on common-sense grounds, unless on the hypothesis that some bond of relationship connects the two. The duty of disproving this idea rests with those who deny evolution. Until we receive a fuller and more likely explanation of such likenesses as those we are at present discussing, we are entitled to hold to the only theory, which, so far as I know, satisfies the requirements of a good hypothesis—these requirements being that *it explains all the facts and is contrary to none.* This end the theory of evolution attains in explaining both the likenesses and the dissimilarities of living nature.

Returning, after this needful digression, to the case of birds and reptiles, let us firstly note the structural points in which these classes agree. To begin with, the skull of both is joined to the spine by one bony process or *condyle.* There are two of these processes in frogs and their neighbours, and a similar number in quadrupeds, including man. Then, secondly, the lower jaw of a reptile agrees with that of a bird in its compound nature. The jaw, instead of being simple and composed of two simple halves (as in quadrupeds), consists in birds and reptiles of from eight to twelve distinct pieces, which are amalgamated to form one bone. Furthermore, whilst the quadruped's lower jaw is joined directly, and of itself, to the skull, that of the bird and reptile is attached to the skull through the medium of a distinct bone, which is named the *quadrate bone.* Curiously enough, this bone in the quadruped is pushed upwards into the middle of the skull in the course of development, and becomes one of the three small bones (*malleus*) of the internal ear. Again, reptiles and birds agree in possessing lungs alone as their breathing organs. No gills are developed (as in frogs and fishes) at any period of reptile or bird-life, although both, like quadrupeds, possess *gill-clefts* in the neck in early life. These "gill-clefts," seen in the early life of man himself, are to be viewed as feeble survivals of the aquatic ancestry from which, according to evolution, all Vertebrate animals have sprung. Furthermore, instead of the ankle-joint (as in man and quadrupeds) being situated between the end of the leg, so to speak, and the beginning of the ankle-bones, this joint in reptiles and birds exists in the middle of the ankle-bones themselves. This curious feature will be further alluded to later on.

The technical naturalist would enumerate other points of agreement between birds and reptiles, but sufficient has been said to show the close affinities which lie just beneath the surface of their organisation. Their differences, however, are also of pronounced type. The causes to which in the far-back past the evolutionist conceives the likeness between these animals to be due, have operated, through variation, at a less remote period, to produce the divergent lines of development. Thus we discover that birds are warm-blooded, whilst reptiles possess cold blood; the bird's feathers are unknown in the reptile-world; and the perfect heart and circulation of the bird—similar to that of man—are also unrepresented in reptiles. Crocodiles, which possess a four-chambered heart, like birds and quadrupeds, nevertheless exhibit the same imperfect and "mixed" circulation seen equally in frogs and reptiles. The lungs of birds are of "open" structure, and part of the air inspired passes through the lungs to fill certain "air sacs" in the bird's body, and also fills the interior of the bones in most birds. Such a distribution of air in the bird's body is evidently adapted for the exigencies of flight. On the whole, then, with certain well-marked likenesses—which, be it observed, evolution accounts for on the idea of a common origin—the classes of birds and reptiles are demarcated from one another by certain highly-distinctive characters.

The dissimilarities on the hypothesis of evolution are due to variation and modification; but, if this idea be correct, can we show the stages through which the variation had led these two groups? In other words, have the "links" which should hypothetically connect them, any existence whatever? Such an inquiry would have been answered in the negative only a few years ago; but, thanks to recent research, we are now enabled, satisfactorily enough, to bridge the gulf between birds and reptiles, and in a measure to reconstruct the pedigree of these curious races.

To render my remarks clear, it may be well at this stage to show in a tabular form the relative positions of the rock-formations with which we shall have to deal. Placed in the order in which they occur in the earth's crust, the rocks in question lie thus:—

Tertiary Rocks.	Recent. Pliocene. Miocene. Eocene.
Secondary Rocks.	Chalk. Oolite. Trias.

The meaning of this table becomes clear, if it be borne in mind that the rocks as here noted are divided into the older Secondaries and the newer Tertiaries. The Eocene in turn is the oldest (or lowest) series of the Tertiary rocks, as the Trias is the oldest of the Secondary rocks.

The fossil remains of birds are few and far between, and this for the reason pointed out by Lyell—namely, that the body of a bird falling into water, prior to its entombment in the deposits which form the rocks of the future, would float, and would afford a likely object of prey to other animals; thus escaping the chances of preservation. For long, fossil birds were regarded as limited to the Tertiary rocks; but we now know of their existence in the Chalk, or Cretaceous period; and we have also obtained fossil specimens from the rocks immediately preceding the Chalk in time, namely the Oolitic or Jurassic Period.

It is almost needless to remark that the bird-remains of the Tertiary rocks, as a rule, resemble closely the birds of our own day. In this light they only testify to the age of some of our existing groups of birds, and do not directly support the theory of evolution, whilst, of course, they do not in any way negative it. But in the deposits of the London clay of Sheppey, belonging to the Eocene (Tertiary) period of geology, the remains of a bird, belonging apparently to the swimmers, were discovered. This form was named *Odontopteryx* by Professor Owen, and its remarkable jaw-armature at once attracted the notice of naturalists. No existing bird has teeth; and no bird possesses any structures approaching teeth in function—save, perhaps, such birds as the Mergansers, in which the horny margin of the jaw is cut into a series of projections, adapted for retaining a secure hold of the finny prey on which these birds subsist. But in the *Odontopteryx*, the jaws were beset with strong bony processes, which, though resembling teeth in appearance, nevertheless are mere projections of bone—for, as most readers know, teeth are not of bony nature, but possess a special and distinct structure of their own. Nevertheless, the fact of this extinct bird of the Eocene rocks possessing toothed projections of its jaws, serves to link it, in the opinion of naturalists, to the reptile hosts; for teeth are as stable and characteristic possessions of the reptile class as their absence is a natural feature of existing birds.

Backwards in time, and in the course of the geological æons, we find the Cretaceous or Chalk rocks. To the naturalist these deposits have yielded a rich and suggestive harvest of bird fossils, which, in their approximations to the reptiles, certainly serve as "found links" in more ways than one. In the Chalk rocks of North America we discover the remains of "toothed birds," whose teeth in every respect agree with the structures of that name, and are not mere bony projections, as in the old swimmer of the London clay. The curious *Hesperornis* (*see* p. 60) and its neighbours the *Ichthyornis* and *Apatornis*, thanks to the exertions of Professor Marsh, appear before us as veritable links, connecting the birds and reptiles in respect of their teeth, as well as in other features of their economy. Hesperornis stood at least five feet high, and in respect of its bony framework exhibits a close alliance with the grebes of our own day. But, strange to say, Hesperornis wants one marked peculiarity of other birds (save the ostrich group), namely, the prominent "keel" or bony ridge on the breast-bone, to which the wing-muscles of birds are attached. The wings were certainly of rudimentary character, but this is a feature we see exemplified in the auks and penguins of our own day; and it is probable that the tail of this great diver of the chalk seas was unusually mobile, and adapted possibly to serve as a rudder. The reptile characters crop out, however, most clearly in the teeth of this bird. There were no teeth in the front of the upper jaw, and presumably this region was covered with a horny beak. The teeth themselves are curved structures; but they are set in a common groove, and not lodged each in a socket, as is commonly the case in higher animals. In living reptiles themselves, it may be added, the teeth, save in crocodiles, are not implanted in sockets. Thus, in serpents and lizards the teeth are simply united by bony union to the bones which bear them; but certain extinct lizards had socket-fastened teeth, and the giant fossil reptiles (*Ichthyosaurus*, &c.) of the Lias, Oolite, and Chalk, possessed teeth which likewise arose from sockets in the jaws. In so far as Hesperornis is concerned, it removes the bird-class, on the face of things, a step nearer to the reptile hosts. Formerly, part of the naturalist's definition of a bird was included in the declaration that teeth were wanting. Now, the definition requires stretching, to include a character which is shared in by certain reptiles, just as others, represented by tortoises and turtles, imitate the toothless condition of existing birds.

But the Ichthyornis of the Chalk is even a more remarkable bird-fossil than Hesperornis. For the teeth of the former are implanted in distinct sockets, whilst its breastbone had a keel, and its wings are of large size, and indicate the possession of bird-habits, united to structures of reptilian kind. But more peculiar still, as a departure from bird-characters was the nature of its vertebræ or the joints of the spine; for Ichthyornis possessed vertebræ, which, like those of the fishes and of extinct reptiles, were hollow at either end. Such a feature must naturally be made much of in estimating the relationship of this old bird to the reptilian hosts. The size of Ichthyornis was that of a pigeon.

Preceding these birds in time comes the *Archæopteryx* of the Upper Oolite deposits of Solenhofen, in Bavaria. Here the reptile-characters increase in number as becomes the older nature of their possessor. A recently-procured specimen of this bird enabled a zoological authority to declare that it was certainly not wholly a bird, and as certainly not wholly reptile in its nature, but a strict link between these classes. For, firstly, it has the tail of a lizard, that is, the tail is long and jointed, and has no plough-share bone, as in other birds (Fig. 2, B, *b*). Secondly, the bones of its palm were not joined together as in all other birds, whilst at least two of its fingers appear to have been provided with claws, a feature of exact reptilian nature.

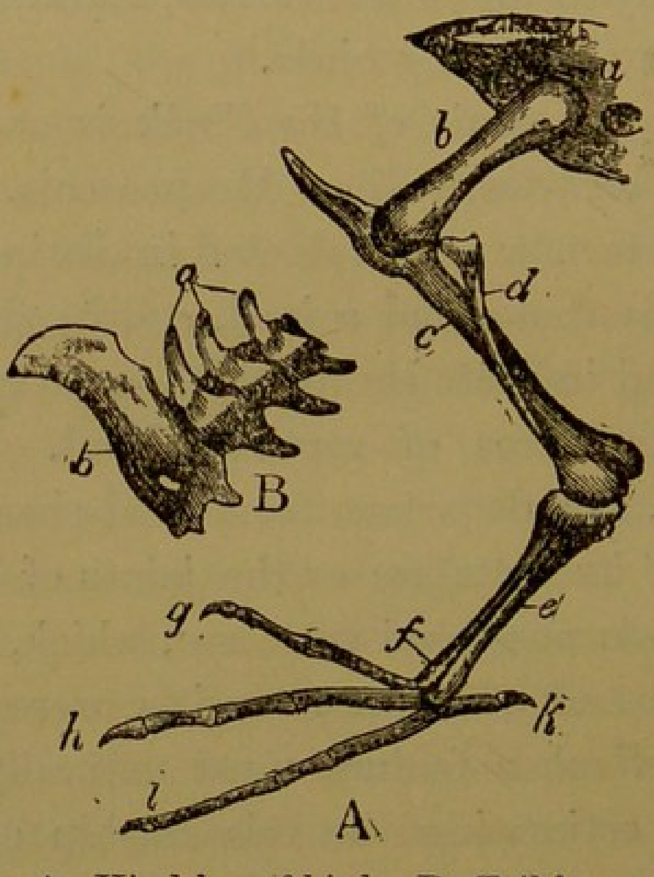


Fig. 2.—A. Hind leg of bird ; B. Tail bones of bird.

Then it likewise has been ascertained, by the discovery of the recent specimen already referred to, that this old bird of the Oolite possessed teeth. Judged fairly, then, Archæopteryx is, at the very least, as much a reptile as a bird. Its shoulder and fore-limb (or wing) are decidedly those of a reptile, whilst its hind limbs are bird-like in nature. The facts that such a race of animals once existed, and that they lived at a period when, presumably, the bird-race was undergoing its evolution from the reptilian confines, may, in the eyes of any unprejudiced thinker, serve as clear evidences that the common origin of birds and reptiles is matter, not of speculation, but of scientific demonstration.

I have shown, thus, cursorily, the evidences supporting the contention that if, standing within the bird-class, we look for reptilian features within its limits, we are not disappointed in our search. But on the reptilian side of things there are also evidences to be found of the community of type from which the birds and reptiles of to-day have sprung. It takes but a slight acquaintance with zoology to discover that the curious lizard, *Hatteria* (or *Sphenodon*), of New Zealand, as befits the curious history of its native country, brings us face to face with characters of abnormal kind, from the reptilian view of matters, at least. For this lizard has ribs which are decidedly those of bird-type, and, moreover, it has the same hollow-ended vertebræ seen in the fossil-bird Ichthyornis. In other points of its structure as well, Hatteria seems to represent a primitive type of reptile, presumably indicating that stage in the evolution of the two classes wherein certain characters of the bird had already begun to be developed in the common ancestors of these groups.

The flying reptiles (*Pterodactyls*) (Fig. 3) of the Lias, Oolite, and Chalk, teach us that as the pure reptile thus acquired powers of flight, the development of flight in the bird-stock, which was evolved from the reptile, or conjointly with it, need cause us no surprise.

The Pterodactyls possessed the outermost finger (seen in the illustration) enormously elongated, and adapted to form the chief support of a wing-membrane

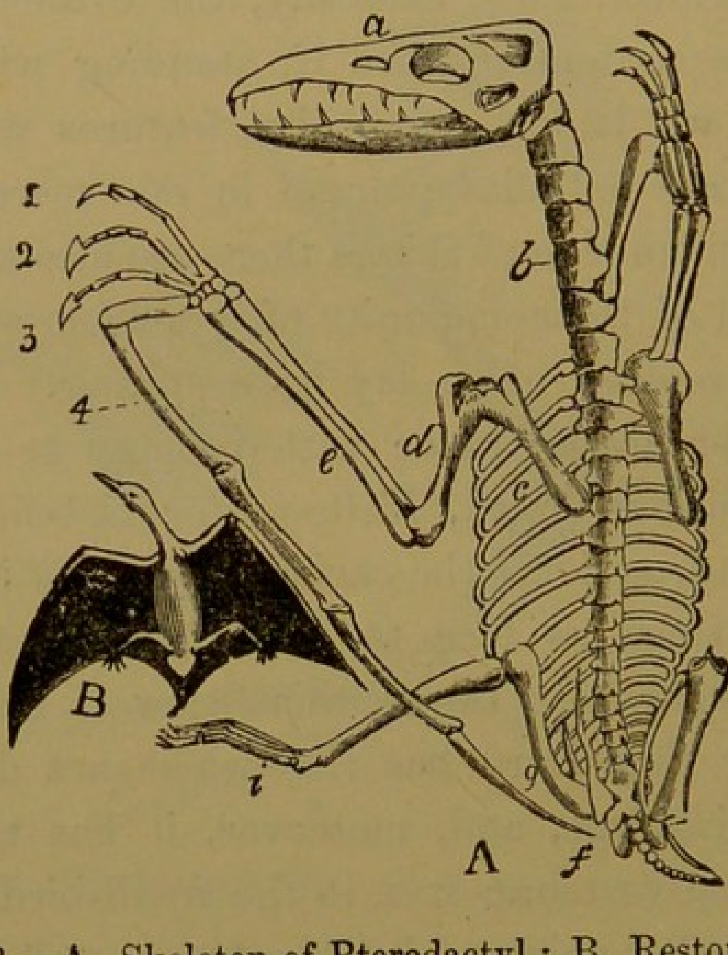


Fig. 3.—A. Skeleton of Pterodactyl ; B. Restoration of Pterodactyl.

which extended along the sides of the body and between the hind limbs and tail also, as shown in B, Fig. 3. It may be added that these reptiles had a keel on the breastbone like most living and extinct birds, and whilst in some species the teeth were developed, in others the jaws appear to have been toothless, and to have been sheathed in horn like those of birds. But these reptiles are not "links." They stand, not between birds and reptiles, but at the end of their own side-branch of the great tree of animal life. Still, from the reptile-side, it may lastly be shown that the "found links" connecting them with birds—it may be, of course, in different lines from those indicated by Archæopteryx and its neighbours—

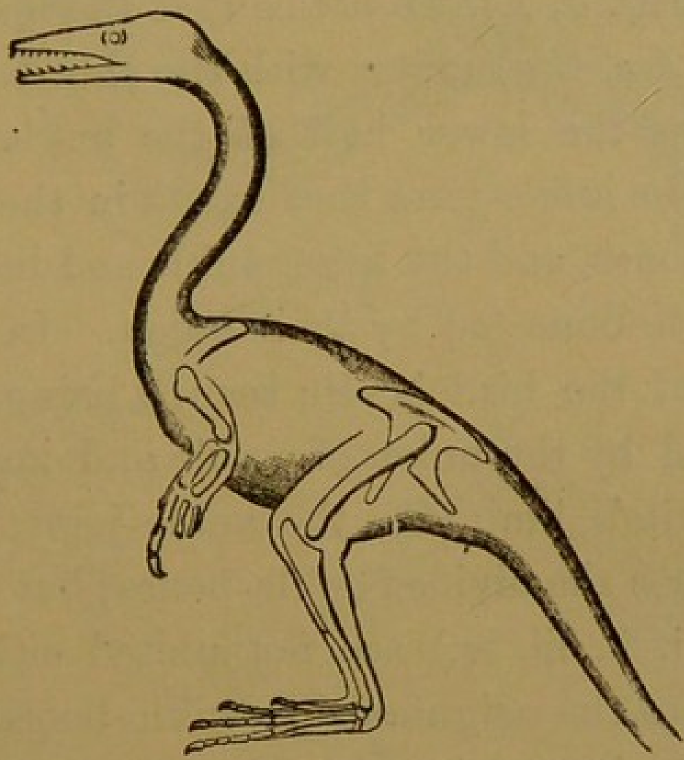


Fig. 4.—Compsognathus (restored in outline).

already find a place in the geological museum. In those curious reptiles, of which *Compsognathus* (Fig. 4) is the best known example, the characters of birds and reptiles were united in a literally surprising degree. Imagine a reptile possessing a swan-like neck, with toothed and bird-like jaws; suppose, further, that this animal had very rudimentary front limbs, and that it walked on its two hind limbs like a bird, and we may conceive that this Compsognathus, had it been feathered, would have at least appeared to resemble a bird much more nearly than a reptile. But a still stronger piece of evidence in favour of its bird-relationship awaits the naturalist when he discovers that the hind limbs of these curious reptiles are, in respect of structure, midway and between those of birds and reptiles. If we examine the hind limb of a bird (Fig. 5, A), we notice that the upper half of the ankle (*A s*, *C a*) unites with the shin-bone, or leg (T); and as the lower half of the ankle joins the instep (1), the ankle-joint thus exists in the middle of the ankle-bones, and the lower ankle and instep-bones form a single bone (*m*) by their union. In Fig. 2 the hind limb of the bird is also seen, *e* being the single bone formed by the union of ankle and instep-bones. In the reptile's limb (C), the ankle-joint, as a rule, opens between the divided ankle-bones; but the instep-bones (C; i. ii. iii. iv.) are not united either to one another, or to the neighbouring ankle-bones. Now it is extremely interesting to discover that the hind limb of Compsognathus and its allies (B) is exactly intermediate between birds and reptiles. Here, the leg bones resemble those of birds in shape. The chief ankle-bone (*A s*) exactly corresponds with that of a bird; and, as in birds, this bone becomes united to the lower end of the leg. But lastly, as if to show the intermediate nature of the limb, the instep-bone (I—iv.) remains free, and the leg of Compsognathus is thus practically halfway between that of the bird and reptile. Thus, as in birds, the upper part of the ankle is united to the leg; but, unlike birds and like reptiles, the Compsognathus had the lower part

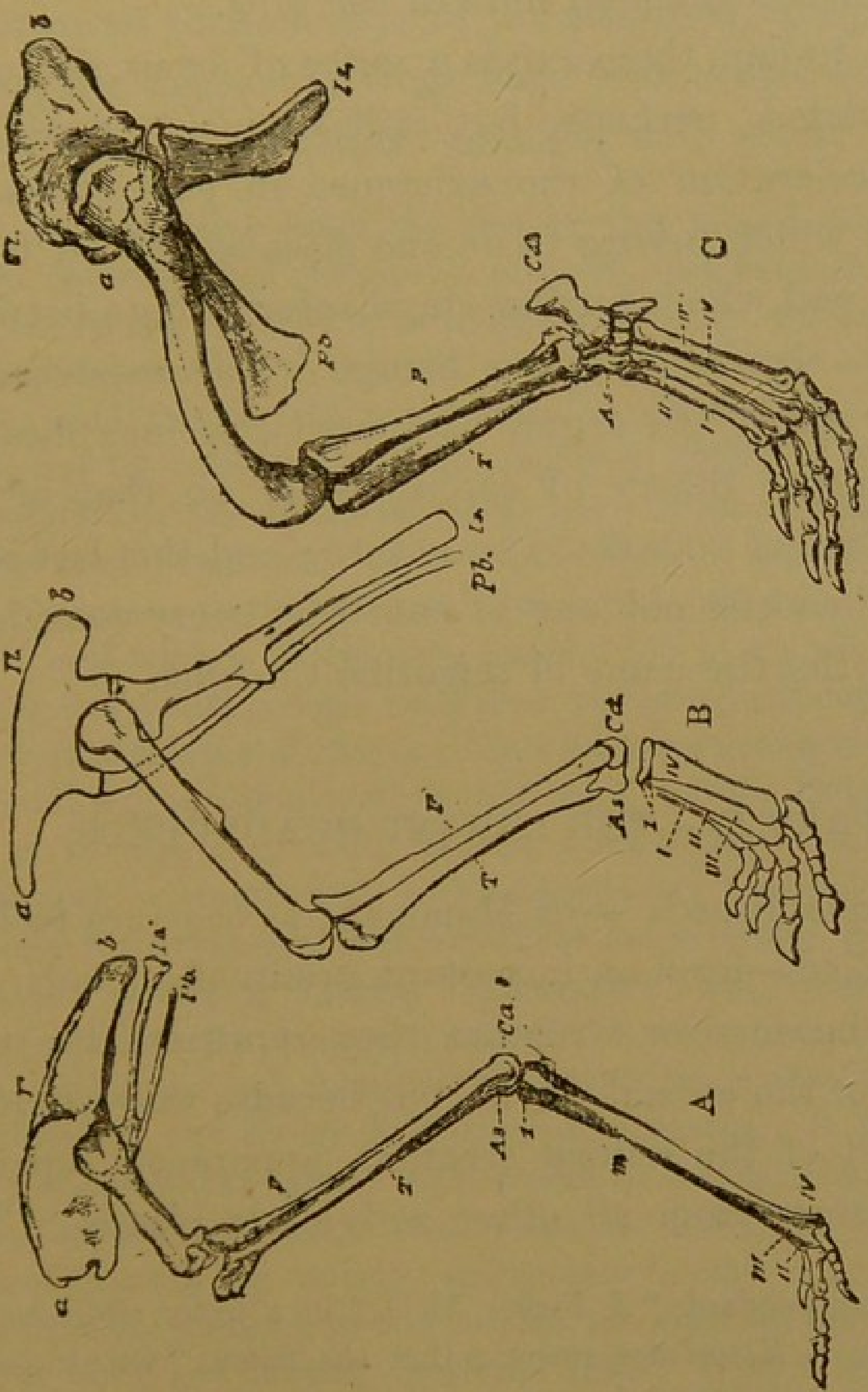


Fig. 5.—Limbs of Bird, Crocodile, and Compsognathus

of the ankle free, and not united with the instep. In a word, the hind limb of this old reptile resembles the condition of the limb in the chick before hatching, and it may thus represent that stage in the evolution of the bird-type wherein the type of limb common to the primitive stock was being gradually modified into the more consolidated limb of the bird.

Thus to-day, there exists a series of forms, detached and isolated, perhaps, but still eloquent enough in their declaration of the existence in past epochs of animals which belong to no one class as defined by us to-day, and which further stand intermediate between existent classes of living beings. The existence of these "links," to argue backwards, is inexplicable, save on the theory of evolution, or on that of the production of "freaks" by nature; and this last idea, I apprehend, is put out of court, by every consideration worthy the name of scientific thought.

PART IV.—THE LOWEST QUADRUPEDS.

The quadrupeds[1]—or Mammals, as they are technically called—form an important group of animals, not merely because in structure they represent the perfection of the animal world, but because they stand at the head of the animal creation, apparently separate and distinct from all other and lower classes. The

[1] A correspondent, "J. Fisher, M.D.," in a letter addressed to the Editor of *Knowledge*, remarks that the names "Quadrupeds" and "Mammals," used by me as synonymous terms (and, I may add, in strict accordance with natural history usage), are apt to convey what he is pleased to call an "erroneous impression." He remarks that the whale is a "Mammal," but not a "Quadruped" —meaning, of course, that a whale has not four legs. Dr. Fisher

distinctive nature of the quadrupeds, in fact, has been tacitly acknowledged in zoology in the systems of classification, which themselves are mere expressions of the various relationships of the classified beings. For, whilst the fishes and frogs have been united to form a province of Vertebrate animals, and whilst reptiles

may, perhaps, have heard the remark that a good deal in this world depends upon one's point of view; and his point of view happens in this case not to be mine. I carefully explained that I used the terms "Quadruped" and "Mammal," as convertible names, and this for the reason that in zoology—as, indeed, in every-day life—the names are so employed. Has Dr. Fisher ever heard of a frog (one of his examples) being called a "Quadruped," in the same breath with an ox? And does he not know that a whale possesses all the essential characters of quadruped-life which he himself rejoices in the possession of? As to a whale not possessing four limbs, perhaps Dr. Fisher, not being a zoologist, is not aware that in some whales (*e.g.* the whalebone genus, or *Balæna*,) there are actual representatives, not merely of the haunch-bones, but of the thighs as well. Hence, a whale may claim to be a quadruped, even although its hind-limbs are rudimentary. Dr. Fisher's somewhat querulous objections are overruled by the fact, that, as I started by defining "Quadrupeds" and "Mammals" as being one and the same, the scientific meaning (and, as I maintain, the popular meaning also) of these terms is not likely to be mistaken by any reader of ordinary intelligence. It is true, as Dr. Fisher remarks, that in many mammals the clavicles, or collar-bones, are wanting, just as these bones are absent in some members of an order (*e.g.* rodents) and present in others; or, as is the case with the guinea-pigs and rabbits, the clavicles may be wanting at birth, and become developed later. What I indicated in my paper was the typical condition of the quadruped shoulder. If Dr. Fisher maintains that it is more typical for a quadruped to want collar-bones than to possess them, that is his affair. He is not likely to find any comparative anatomist to agree with him.

and birds have also been arranged in one chief group by reason of their affinities, the quadrupeds have been made to form a province by themselves. The hairy nature of the body-covering, the nourishment of the young by means of milk, the fact that the young are born alive, and many other characters well known in popular zoology, attest the distinctive nature of the highest group of animals.

But whilst these statements cannot be questioned, it must not be imagined that the quadrupeds are thereby entirely separated from all other animals. On the contrary, they possess their own affinities with lower forms, such as evolution pre-supposes, and such, indeed, as that theory of nature demands. The lowest mammals, to begin with, are by no means like the higher quadrupeds; and it is in the lowest confines of the class, as we shall presently see, that the approach to lower animals is made. The warmth of blood so characteristic of quadrupeds has already made its appearance in the birds, and although the exact origin of the mammals is yet a matter of doubt, it seems pretty clear that the root-stock of the class to which man himself belongs, may be sought for in some common territory whence, from a half-bird type, the lowest quadrupeds arose, or whence the mammals on the one side, and birds and reptiles on the other, have independently arisen. Such a conclusion seems to be that at present supported by facts as they stand; and although further research may modify this view, there will still exist the demand for the links that bind the quadrupeds to their lower Vertebrate neighbours.

There can exist, at least, no doubt of the remarkable likeness which the lowest quadrupeds present to the bird and reptile groups. To understand thoroughly the zoological aspects of the matter, I may remind the reader that the class of mammals is very sharply split into two main divisions. These, to avoid technicalities, we may term Higher and Lower Mammals. The former group includes forms ranging from man downwards through the apes, bats, rodents, and hoofed quadrupeds, to the whales, sloths, anteaters, and their

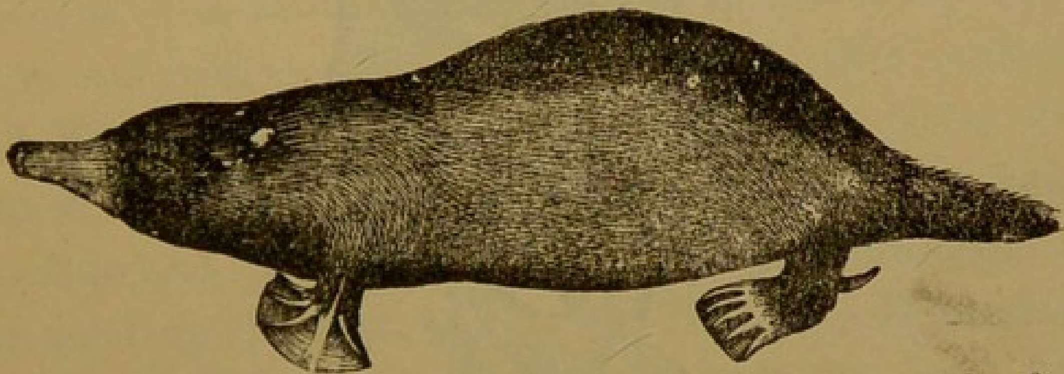


Fig. 6.—**Ornithorhynchus**, or "Duck-billed Water-mole of Australia" (showing the "bill" and webbed feet).

kith and kin. These animals are distinguished by the higher brain-structure and by the general possession of all the typical characters of quadrupeds. The Lower Mammals are the Ornithorhynchus, or "Duck-billed Water-mole" of Australia (Fig. 6), and its neighbours the Echidnas or "Porcupine Ant-eaters" of Australia; these two genera forming the lowest order (*Monotremata*) of all. A little above them, but still shut off from the higher ranks of the class, are the kangaroos, wombats, phalangers, &c.—in a word, the whole of the *native* population of Australia (along with the New World opossums), forming the order of *Marsupialia*, or that of the "pouched" quadrupeds. In Fig. 7 is represented the *pelvis* or haunch-bones of a kangaroo. At *a, a,* the *marsupial bones*, or those supporting the well-known pouch, are seen. These bones are only found in the Marsupials and Mono-

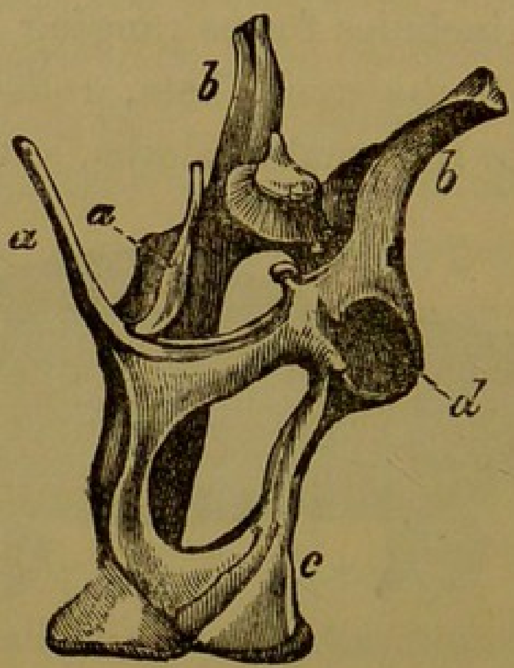


Fig. 7.—Haunch-bones of Kangaroo : *a, a,* marsupial bones ; *d*, socket for thigh-bone.

tremes, and whilst in most of the former they support a pouch, they are never associated with that structure in the Monotremes.

Now, it is in the Monotremes—represented by the *Ornithorhynchus* (Fig. 6) and the *Echidnas*—that the characters linking quadruped life to lower life are most typically seen. It may be well to strengthen our position at the outset, by reminding the reader that in the early life of *all* quadrupeds, without exception, there are to be perceived evidences of their connexion with lower forms of life. Thus, every Vertebrate, at an early stage of its development, exhibits certain clefts or openings in the sides of the neck, known as branchial clefts, and which are bounded by folds called branchial arches. These, in fishes, come to bear the gills, but in reptiles, birds, and quadrupeds, they simply disappear—useless rudiments of structures, once necessary in the life of aquatic quadruped-ancestors, and still retained in the developments of to-day by the law of inheritance. Thus, in the development of a rabbit, the biologist sees three pairs of branchial arches behind the mouth of the embryo, and four branchial clefts. Three of the clefts disappear, and the fourth, by the modification to which development has been subjected in the evolution of the quadruped tribes, is converted into the Eustachian tube and other structures belonging to the ear. The presence of "branchial clefts" in the developing mammal would alone suffice to show its evolution from lower life. Denying that probability, which to the biologist is a fact, there is no explanation whatever of the cause or existence of these vanishing structures in the history of the quadruped race.

Concentrating our attention on the Monotremes themselves, however, we may speedily discover numerous links which unite them with lower life, and specially with the bird-type. There, firstly, exists in these quadrupeds what Huxley has called "a striking feature" of reptiles, of birds, and of the frog-class as well, in the structure of the shoulder. In the shoulder of an ordinary quadruped, and of a kangaroo and its marsupial race as well, there are but two distinct bones. One of these is the shoulder-blade, or *scapula*, the other being the collar-bone, or *clavicle.* In the shoulder of a bird (Fig. 8) there are three distinct

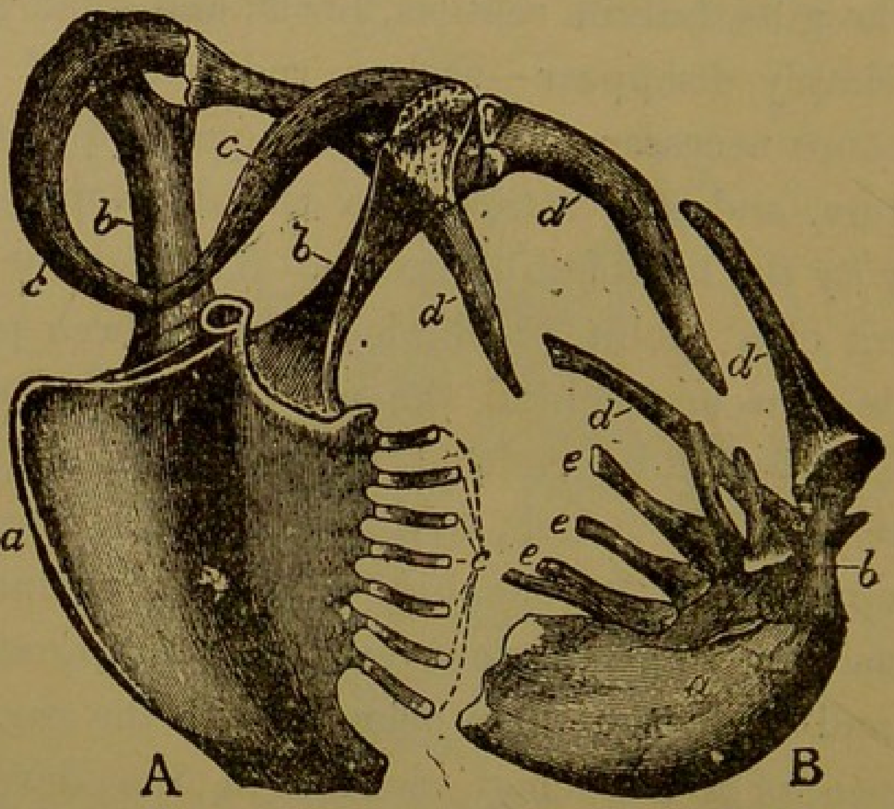


Fig. 8.—Shoulder-bones of (A) an Eagle, and (B) an Ostrich.

elements, the *scapula* (Fig. 8, *d*) *clavicle* (*c*), and the *coracoid bone* (*b*, *b*). This last in quadrupeds, a mere process of the shoulder-blade, forms, as shown in Figure 8, the chief support of the wing in birds, and arises directly from the breastbone (*a*). Now, it is a remarkable fact that the Ornithorhynchus and Echidna, alone of all quadrupeds, possess a distinct *coracoid bone,* which, as in birds and reptiles, springs from the breastbone. Again, there is another bone, called the *epicoracoid*, which is found in reptiles, and which exists likewise in the Ornithorhynchus and Echidna. In the bird, again, as everybody knows, the two collar-bones unite to form the "merry-thought," or *furculum* (Fig. 8, *c*). In these lowest quadrupeds the collar-bones (Fig. 9, *cc*) are joined by a T-shaped

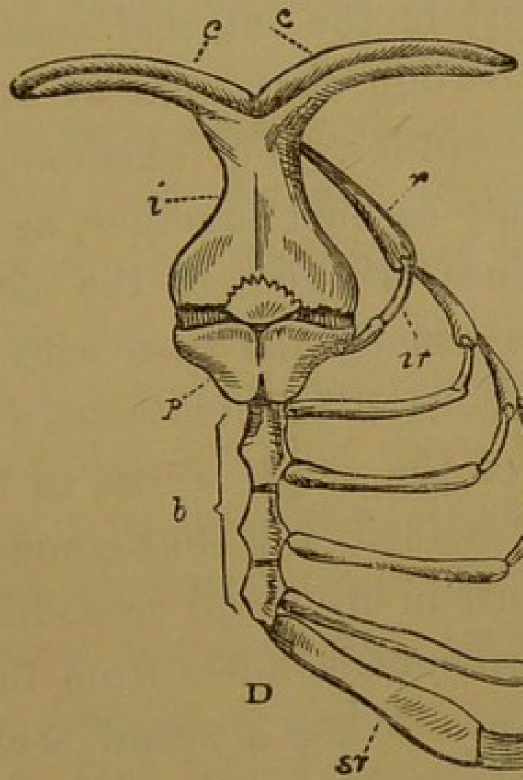


Fig. 9.—Shoulder-bones of Ornithorhynchus : *c*, *c*, clavicles ; *i*, interclavicle ; *b*, breast-bone ; *sr*, sternal or breast-bone ribs, as in birds.

bone, called the *interclavicle* (Fig. 9, *i*), unknown in any other mammals ; and here, again, we find a character which is decidedly reptile-like and bird-like, and which is not seen in other mammals. Professor Flower tells us that the shoulder-girdle of these quadrupeds "differs widely in many points from that of any other mammal, and far more resembles that of the Lizards."

The jaws of the Ornithorhynchus are prolonged to form a flattened horny bill (Fig. 6), on the upper aspect of which the nostrils are seen. It is the possession of this bill which has given origin to the name "duck-billed," applied to this animal. The Echidna possesses no such structure, but has simply a flexible snout.

There also exist in the internal anatomy of these curious animals certain characters which relate them to the birds and reptiles. For example, the bones of the head are firmly ossified together, as in birds, and the *sutures*, or lines of union of the skull-bones, do not persist, as is usually the case with quadrupeds, whilst the hollow of the haunch-bones (Fig. 7, *d*), in which the head of the thigh works to form the hip-joint, is not fully ossified, and thus comes to resemble the similar structure in birds and crocodiles. The ears of these lower quadrupeds differ from those of other mammals in not possessing a spiral arrangement of that part of the organ named the *cochlea*. As in very many reptiles, the upper, or front, or neck-ribs of these quadrupeds long remain as separate bones; and the same remark holds good of the curious little pivot (*odontoid process*) on which the head turns. This pivot in quadrupeds is firmly joined to the second bone of the neck; but in the Monotremes, as in reptiles, it remains separate and distinct till a very late period—if, indeed, it becomes ossified at all.

The internal anatomy likewise reveals characters of bird and reptile life which can only be alluded to here.

The arrangements of the internal organs in many respects present the closest likeness to the anatomy of birds and reptiles, and this is particularly the case with those structures in the quadrupeds which represent the egg-producing organs of the bird and reptile. Even the typical mammalian characters are but feebly represented in these lowest quadrupeds. We know that the young, although born alive, as in quadruped life at large, are provided with a horny knob on the upper jaw, such as is seen in the young bird; and no teats exist in the milk-glands of these forms, a feature represented in all other members of their class.

Summing up the inferences to be drawn from our brief study of the lowest quadrupeds, we may legitimately hold, firstly, that they are of essentially lower structure than other mammals; secondly, that all the points in which they evince this inferiority ally them, at the same time, to birds and reptiles; and thirdly, that the only feasible explanation of the differences in question is that which regards them as arising from the nearer relationship—the result of heredity and descent—which these lowest quadrupeds present to birds and reptiles.

In a concluding paper, I shall strive to show the nature of the links which unite the Vertebrate animals to their lower and Invertebrate neighbours.

PART V.—LINKS BETWEEN BACK-BONED AND BONELESS ANIMALS.

In the present paper I purpose to give an outline of the means whereby the zoologist has been enabled to supply "links" between the *Vertebrate*, or "back-boned" animals, and the *Invertebrate*, or "boneless" animals. Ever since the time of Lamarck, the distinction between the highest, or *Vertebrated* animals (fishes, frogs, reptiles, birds, and mammals or quadrupeds) and the *Invertebrate* groups, has been recognised as one of very clear nature. And modern zoology, dealing merely with the structure of the animals in question, fully recognises the apparent gap which intervenes between the great array of boneless animals—such as worms, insects, shell-fish, &c.—and the "backboned" group. But, as in many other cases, a closer examination of the lowest Vertebrate group seems to demonstrate that the gulf between the highest animals and their Invertebrate neighbours is by no means so wide or impassable as, at first sight, it appears to be. The lowest fish and Vertebrate is the *Amphioxus*, or Lancelet (Fig. 10). This is a little clear-bodied fish—formerly regarded as a kind of slug—found inhabiting sand-banks in various quarters of the world. It attains a length of an inch or two, and is pointed at each end. It has a kind of back and tail fin, but possesses none of the "paired" fins, which, existent in most other fishes, represent the limbs of higher animals. The mouth (*o*) is an oval slit, and is fringed with gristly filaments. The lancelet has no brain, heart, bones, skull, ears, or kidneys. It is the only vertebrate which wants a heart, and it is likewise the only vertebrate in which the blood is colourless. Along the back runs the only representative of the skeleton—namely, a soft rod-like body, called the *notochord* (*n*). This struc-

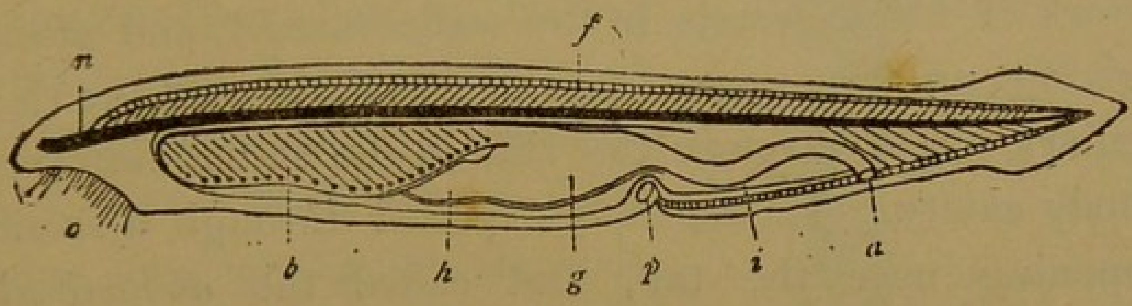


Fig. 10.—The Lancelet (*Amphioxus lanceolatus*), enlarged to twice its natural size. (*o* Mouth ; *b* Enlarged pharynx ; *g* Stomach ; *h* Sac representing the liver ; *i* Intestine ; *a* Anus ; *n* Notochord ; *f* Rudiments of fin-rays ; *p* Abdominal pore.)

ture, by the way, is found in the early development of every vertebrate animal, being replaced in all, save a few fishes, as time passes, by the spine itself. Above this rod lies the nervous cord of the lancelet. The mouth opens into a very wide throat or *pharynx* (*b*), whose walls are perforated with slits that open into the cavity of the body. The walls of this great throat are richly set with the microscopic processes called *cilia*, which, by their incessant waving, circulate the water admitted to the cavity. The throat leads into a simple stomach (*g*), and this, in turn, leads into the intestine (*i*). A liver (*h*) of the most rudimentary description also exists. The blood, in the absence of a heart, is circulated by the contractions of the blood-vessels, and it is interesting to note that the arrangement seen in all vertebrates, whereby a portion of the venous or impure blood is sent to the liver for the manufacture of bile, is represented even in this curious fish. When the lancelet breathes, water is received into the throat, passes over the network of blood-vessels in the walls thereof, and after giving up its oxygen to the blood, is sent by the ciliary action through the slits in the throat into the body cavity. Thence it is expelled through a small opening near the tail, and called the *abdominal pore* (*p*).

The lancelet differs from every other vertebrate animal in the absence of a heart, skull, brain, and kidneys, and in the colourless blood; in the peculiar and rudimentary liver; and in a digestive system, which, like the throat, is also lined with *cilia*. But that it *is* a vertebrate is proved by the presence of the *notochord* (*n*), already remarked as being developed in the early life of every vertebrate animal. The supply of venous blood to the liver is also a vertebrate character; whilst its development, studied from the egg onwards, no less clearly shows its right and title to be regarded as a true vertebrate.

Passing now to a very different group of animals, we find the *Tunicates, Ascidians,* or "Sea Squirts" (Fig. 11), to present us with certain highly interesting features for remark. These animals are usually regarded as poor relations of the shell-fish or *Molluscs;* and they exist both in a fixed and free state. The fixed sea squirts are tolerably common, and are found attached to shells and other objects dredged from deep water. Each sea squirt is a clear leathery bag, an inch or two in length. Like the old "wine-skin" it has two necks or openings (*d, i*). One leads into a white throat or *pharynx* (A), the walls of which are richly ciliated, and which are perforated by numerous openings, whilst the whole throat, like that of the lancelet, is richly supplied with blood-vessels. The other opening is a door of exit. It leads from a sac or bag, called the *atrium,* into which the water used in breathing is wafted from the throat. Thus, when a sea squirt breathes, the water is inhaled by the mouth-opening, aerates the blood contained in the vessels of the throat, and is then sent into the atrium, whence

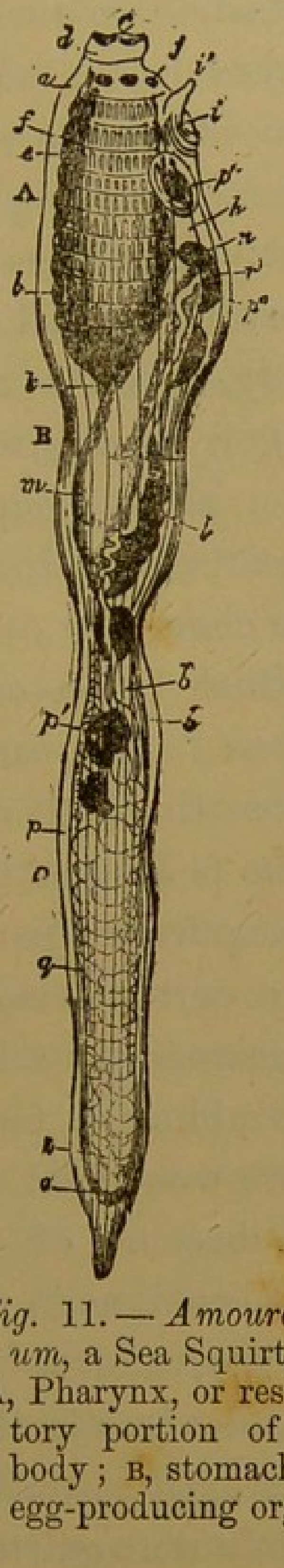


Fig. 11.—*Amouroucium,* a Sea Squirt. (A, Pharynx, or respiratory portion of the body; B, stomach; C, egg-producing organ.)

it is discharged into the outer world. The sea squirt's stomach (B) opens from the throat, and its intestine in turn opens into the atrium. A heart (*l*) exists in the shape of a curious tube, which propels the blood for so many beats in one direction, and then, reversing its action, sends that fluid for so many pulsations in the opposite direction. A single nervous mass lies between the two openings of the body, and the other wall of the body itself consists largely of a material called *cellulose*, which is a common plant compound. The animal in such a case manufactures the substance of the plant, and imitates the chemistry of the latter organism.

Such is an outline of the rooted and fixed "sea squirt." Its earlier history, however, is still more interesting. It developes from the egg in exactly the same fashion as the lancelet. The early stages of the sea squirt run parallel with those of that fish. Finally, at a certain stage, the young sea squirt makes its appearance as a free-swimming active body, somewhat resembling a tadpole, and possessing a long tail. More wonderful still, the resemblance to the lancelet has become of a closer character. A *notochord* is developed, as in the lancelet and young of other Vertebrata, and a nervous system appears above the *notochord*, as in the lowest fish. So, also, the characteristic throat, with its clefts, is formed. Now, whilst certain sea squirts appear to remain in this tadpole-stage, most of the species begin sooner or later to retrogress and to backslide in development. The young sea squirt fixes itself to some object by the suckers with which its head extremity is provided. The tail begins to shrivel, whilst the body enlarges and the throat increases in size. Then the *atrium* and the leathery skin are formed, and finally the animal becomes the bag-like organism with which we started. As a sea squirt, pure and simple, the animal loses all, or nearly all, the characters by which it was related to the lancelet; and but for the knowledge of what it *was*, we should therefore hardly know what a sea squirt (or indeed, any other animal) really *is*.

What, now, are the legitimate inferences to be drawn from the facts above detailed, and which, it may be remarked, are the common details of modern zoological instruction? Firstly, that, whilst the lancelet is the lowest Vertebrate, it shows its affinities to other vertebrates clearly enough in the possession of a *notochord* and of the other characters already detailed. Secondly, that the sea squirts are the only animals which present any likeness to the lancelet, and through it to other vertebrates—man included. Thirdly, that this likeness is so real and so close in all respects that the affinities of the two groups cannot be doubted. The likeness is seen not only in the possession of a *notochord*—found in no other Invertebrated animals—but in the curious throat with its gill-slits, and in the nervous axis placed above the *notochord*. Again, the likeness in the earliest stages of development is still more startling; the egg of the lancelet and that of the sea squirt develop in precisely similar fashion.

Fourthly, if these likenesses be admitted it logically follows that they must be susceptible of explanation. The only feasible and rational account of the resemblances in question, is that which, through the aid of the theory of evolution, attributes the likeness to a common origin or descent, as it attributes the differences to modification and adaptation to special ways of life. If this explanation be admitted, it follows, fifthly, that the entire vertebrate series, from the lancelet to man, has been evolved from a root-stock represented to-day by the sea squirt's larva. The Tunicata, in this view, are the far-back progenitors of the vertebrate tribes.

One has heard frequent allusions to the so-called "base origin" of man as attributed by evolution to the sea squirt larva, and this usually from persons unacquainted with the marvellous details of parallel development in sea squirts and in the lancelet. But such persons forget that, traced back to its ultimate beginnings, the human germ itself is a mere speck of protoplasm about the $\frac{1}{120}$th of an inch in diameter, and indistinguishable in any fashion from the egg of lancelet or of sea squirt. Moreover, at a certain stage in man's early history, the developing germ resembles tolerably closely that of sea squirt and lancelet, as, later on, it has characters common to all quadrupeds, and only as an ultimate phase exhibits the special features of the human type. In a word, the hard facts of development exist, whether we like them or no; and they alone are wise who can reflect, calmly and placidly and philosophically, that these facts in no wise detract from man's place in nature; but, rightly viewed, only the more ennoble the humanity that, from such humble beginnings, has attained to the highest twig on the tree of life. Mr. Darwin's own words will bear quoting here:—"The most ancient progenitors in the kingdom of the Vertebrata at which we are able to obtain an obscure glance, apparently consisted of a group of marine animals, resembling the larvæ of existing Ascidians. These animals probably gave rise to a group of fishes as lowly organised as the lancelet; and from these the Ganoids, and other fishes, like the Lepidosiren, must have been developed. From such fish, a very small advance would carry us on to the Amphibians." Mr. Darwin's words are again worth quoting, when, in speaking of the origin of man, he remarks that "it is only our natural prejudice, and that arrogance which made our forefathers declare that they were descended from demi-gods, which leads us to demur to this conclusion (that of man's descent from lower forms). But the time will before long come, when it will be thought wonderful that naturalists, who were well acquainted with the comparative structure and development of man and other mammals, should have believed that each was the work of a separate act of creation." And, finally, concerning the often-assumed degradation of vertebrate ancestry, the late distinguished author of the "Origin of Species" has a noble passage wherein he gives the death-blow to all arrogance of heart and mind respecting the origin of the highest forms:—"Thus we have given to man a pedigree of prodigious length, but not, it may be said, of noble quality. The world, it has often been remarked, appears as if it had long been preparing for the advent of man; and this, in one sense, is strictly true, for he owes his birth to a long line of progenitors. If any single link in this chain had never existed, man would not have been exactly what he now is. Unless we wilfully close our eyes, we may, with our present knowledge, approximately recognise our parentage; nor need we feel ashamed of it. The most humble organism is something higher than the inorganic dust under our feet; and no one with an unbiassed mind can study any living creature, however humble, without being struck with enthusiasm at its marvellous structure and properties."

PART VI.—SUMMARY.

I PURPOSE in this concluding article to direct attention to the very interesting, and at the same time astonishing, facts in favour of evolution which recent researches amongst extinct and fossil *Mammalia* (or Quadrupeds) have brought to light. The quadruped class presents us with a large and varied array of animal forms; and it is therefore needful that at the outset we should endeavour to gain some plain ideas respecting the arrangement of the class into "orders." These latter are the subordinate groups into which every "class" of animals is primarily divided. To begin with, the quadrupeds themselves, as a class, are capable of being divided into two distinct series. Of these, the first, as mentioned in a previous paper, contains the kangaroos, wombats, opossums, and their neighbours, along with the *Ornithorhynchus*, or duck-billed water-mole of Australia, and its near neighbour, the *Echidna*. These animals form collectively a division which may be named that of "Lower Mammals," inasmuch as, in respect of many points in their anatomy, they exhibit a decided inferiority to our common quadrupeds, and to the other members of the class. All other quadrupeds may be named "Higher Mammals," since they exhibit among themselves an agreement in structure which places them above the kangaroos and their kith and kin. Tabulating the great class of quadrupeds, we find that the following arrangement gives a brief sketch at once of the characters of the various "orders," and their chief representatives.

Order the first is called the *Monotremata*. It includes the Ornithorhynchus and Echidna, both denizens of the Australian region. These animals exhibit bird-like characters, as has been shown in a previous paper. They possess "marsupial bones," like the kangaroo races; and in many respects present us with a peculiar and special, but still low type of quadrupeds. The second order is that of the *Marsupialia*. These are the kangaroos, wombats, phalengers, and opossums; the latter alone being found outside the bounds of the Australian province.

Here the bird-characters have disappeared, although the included animals are of low structure as compared with such forms as the dogs, horses, seals, &c., of higher orders. The "Marsupials," as the name implies, usually possess a "pouch," supported on the "marsupial bones" that rise from the front of the haunch (see *a a*, Fig. 7, p. 136). Even if the "pouch itself be wanting (as in some opossums), the bones supporting it are developed.

The Higher Mammals introduce us to order the third, that of the *Cetacea*, or Whales. A fish-like body, one fully-developed pair of limbs (the fore limbs) assisting in the shape of swimming-paddles, a horizontal tail-fin, and nostrils forming "blow-holes," are the characters of which the whales, dolphins, porpoises, and the like are characterised. The fourth order is that of the *Sirenia*, represented by two genera of animals—the Manatees, or Sea Cows, and Dugongs—long classified with the whales. Here the body is again fish-like, and the fore limbs, which are alone developed, form swimming-paddles; but the nostrils do not form "blow-holes," and the skin is sparsely covered with bristles. The *Edentata*, or Ant-eaters, Armadillos, Sloths, and Pangolins, constitute the fifth order, whose head-quarters exist in South America. There is only a single set of teeth in these animals, and the teeth are further destitute of distinct roots, whilst they want enamel. Scales or bony plates, as in the Armadillos, often cover the body.

An order of immense extent, that of the *Ungulata*, or "hoofed" quadrupeds, forms the sixth division. Here the largely-developed nails, called "hoofs," are met with, and all four limbs are always developed. The rhinoceroses, horses, pigs, ruminant animals (sheep, deer, oxen, camels, &c.), hippopotamus, &c., represent this group. The seventh division is that of the elephants (*Proboscidea*), the characters of these animals requiring no special mention. The hyrax, or "coney" of Scripture, represents the eighth group, and resembles the rodents or "gnawers" in some respects, whilst it is also allied to the rhinoceroses, if the form and structure of the molar or grinding teeth are considered. The *Carnivora*, or lions, tigers, wolves, dogs, bears, seals and walrus succeed, as order the ninth; and the *Rodents*, or gnawers, with chisel-shaped front teeth, growing from permanent pulps, and represented by the rats, mice, beavers, squirrels, porcupines, &c., form the tenth division. The bats, or *Cheiroptera*, with an elongated hand of four fingers (and a short thumb), adapted to support a flying-membrane, form the eleventh group. The *Insectivora* are the twelfth order, and present us with the moles, shrews, and hedgehogs as types. The *Primates* (including the *Quadrumana*, or monkeys, and *Bimana*, or man) bring us at once to the concluding order, and to the height of animal development.

Now, as regards the past history of the Mammalia, there exists abundance of evidence to show that many extinct quadrupeds stand in relation to these existing orders in the light of "intermediate forms" or "links." The recent researches of Professor Marsh amongst the American fossil mammals have been fraught with literally surprising results in this latter direction. Prior, however, to Marsh's discoveries, there were not wanting facts which pointed to the conclusion that the demands of evolution for links between the existing orders of quadrupeds would not be made in vain. Take, for example, the single order of the Whales. No more circumscribed and apparently distinct group of animals exists, yet their relationship to other orders of quadrupeds is no mere matter of conjecture, but one of proof. There is a fossil whale known as *Zeuglodon*, found in Tertiary deposits, and so named from the peculiar double-nature of the molar teeth. Whales with such teeth are unknown to-day, and when the affinities of Zeuglodon are examined, they are seen to point to a clear connexion with the Seals and Walruses, belonging, as we have seen, to the *Carnivora*. It would thus seem as if the natural idea that the Seals and Whales were near relations was founded on fact; and fossil whales certainly tend to bridge over the gulf betwixt the two groups. But this case, powerfully as it argues in favour of the connected series of animals which evolution requires, is by no means solitary. We have long known, for example, of the *Anoplotherium*, an extinct quadruped, which presents in itself a curious mixture of the characters of Pigs and Ruminant animals, *i. e.*, those that "chew the cud," and comparative anatomists will tell us that the pigs and hippopotamus group themselves show, in many respects, an approximation to the Ruminants. Or to take yet another example from Cuvierian times, we find in the *Palæotherium* an animal which links the Tapirs to the Horses, and which shows a combination of characters that amply satisfies the evolutionist of its "intermediate" nature.

But the more recent discoveries of Marsh throw the foregoing cases into the shade in respect of the mass of material which that indefatigable palæontologist has accumulated. Thus we have been forced to constitute a whole series of new orders for the reception of the forms Professor Marsh has unearthed. What, for instance, shall we say of the extinct *Dinoceras* and its neighbours? These huge elephantine animals united in themselves the characters of Elephants, and of odd-toed "hoofed" quadrupeds. With limb-bones like those of Elephants, Dinoceras possessed teeth that exhibited a combination of the characters of carnivorous animals with those of "hoofed" forms. More extraordinary still were the *Tillodonts* from the Eocene rocks of the United States. Here are combined the features of hoofed quadrupeds (*Ungulata*), *Carnivorous* animals, and *Rodents*. With a skull like that of a Bear, *Tillotherium* possessed front teeth exactly resembling those of the Rodents, or "Gnawers," and which appear to have combined to grow throughout the life of the animal, whilst the grinding-teeth were those of a hoofed animal. So, also, another group of extinct animals, of which *Toxodon* is the chief, presents us with a combination of characters mingling those of the "Hoofed" forms with those of Rodents and Edentates—such as the Sloths, Ant-eaters, &c.

As a final example of the curious "links" between existing forms, which may be found amongst the treasures disclosed by scientific inquiry, the curious "Flying Lemurs" (*Galeopithecus*) may be mentioned. These animals are found in the Eastern Archipelago, and resemble squirrels in appearance. A curious fold of skin stretches from the sides of the neck to the fore limbs, and between hind limbs and tail. The body is thus fringed, as it were, by a broad fold of skin, and although, unlike the bats, the flying lemurs do not possess true powers of flight, the skin-folds serve as a kind of parachute, supporting these animals in the air, as they take their flying leaps from tree to tree. In their internal anatomy, these animals exhibit transitional features, and on the whole may be regarded as linking the Insectivora with the higher group of the Primates in which Man and Apes are included. Whilst it seems tolerably clear that the Bats themselves are merely Insectivorous animals which have undergone the modifications fitting them for true flight.

Such is a brief and meagre outline of the result of an incursion into the province of geology as that science relates itself to the past history of living forms. In concluding the series of papers on "Found Links," I may perhaps be permitted to add that the design of these articles will have been fully served, if they may in any way stimulate the personal inquiries of my readers into the great study of modern times, namely, that of ascertaining how the universe of life has been modified and evolved. Such a study is fraught with profit in more ways than one. The search after evidence in favour of or against Evolution necessitates an amount of inquiry which is certain to strew the observer's pathway with curious facts concerning every department of life science. Furthermore, the main question at issue is one which in reality underlies all our conceptions of life, and of the order of nature. It is the question which the best and wisest of mankind have ever asked and inquired of themselves—the How, Why, and Whence of this world and its belongings. Happy indeed are they who, in the spirit of earnest truth-seekers, are permitted to engage in the work of discovering new facts and phases of the wondrous story of creation, which Nature is ever inviting us to peruse.

INTELLIGENCE IN ANIMALS.

BY R. A. PROCTOR.

Few of the questions raised in Darwin's "Descent of Man" are at once more difficult to deal with satisfactorily, or more important in their bearing on the subject of that volume, than the question how far animals possess mental powers akin to those of man, It is somewhat singular, we may remark in passing, that Darwin and Huxley, whose views in some respects are so similar, and who are regarded by the general public as standing side by side in their advocacy of the theory of the relationship of man to the lower animals, should seem to uphold almost exactly opposite opinions respecting the cerebral qualities of animals,—one maintaining that in some cases animals reason, while the other (if we rightly apprehend what Huxley has said about animal automatism) will scarcely allow that animals even possess consciousness.

We propose here to consider some cases in which animals have seemed to reason. The importance of the subject will be recognised if we remember Darwin's admission that, had no organic being except man possessed any mental power, or if man's powers had been of a wholly different nature from those of the lower animals, we should never have been able to convince ourselves that our high faculties had been gradually developed. Darwin expresses his belief that there is no fundamental difference of this kind. "We must also admit," he says, "that there is a much wider interval in mental power between one of the lowest fishes, as a lamprey or a lancelet, and one of the higher apes, than between an ape and a man; yet this immense interval is filled up by numberless gradations." But this has not been so generally admitted, despite the evidence advanced by Darwin, as might have been expected. The feeling is still commonly entertained that a distinction exists between the mental qualities of the cleverest ape and the dullest and stupidest savage, which is utterly unlike any that exists among animals. In this essay we shall have to consider cases in which rats, cats, dogs, &c.,—animals all inferior in mental faculties, though not all in equal degree, to the more intelligent apes,—have acted in ways which seem to imply reasoning. We shall treat these cases rather from the point of view of an opponent of Darwin's thesis above quoted than of a supporter, endeavouring in every case to find explanations not involving the exercise of reasoning faculties. But we must admit at the outset, that we find ourselves led to precisely the conclusion he has indicated.

In the first place, we must recall to our reader's recollection those instances which have been selected by Darwin as so satisfactory, that in his opinion any one not convinced by them would not be convinced by anything that he could add.

Rengger states, says Darwin, "that when he first gave eggs to his monkeys, they smashed them, and thus lost much of their contents; afterwards they gently hit one end against some hard body, and picked off the bits of shell with their fingers. After cutting themselves only once with any sharp tool, they would not touch it again, or would handle it with the greatest care. Lumps of sugar were often given them wrapped up in paper, and Rengger sometimes put a live wasp in the paper, so that in hastily unfolding it they got stung" (the tenderness of some of these students of science towards animals is quite touching). "After this had once happened, they always first held the packet to their ears, to detect any movement within." These were not monkeys of the higher orders, but American monkeys, none of which are so near man in cerebral development as the orang, the champanzee, the gibbon, or the gorilla. The next cases relate to the dog, and are important, first, because two independent observers give evidence in the same direction; and secondly, because the action of the dogs can hardly be explained as resulting from the modification of an instinct. "Mr. Colquhoun winged two wild ducks, which fell on the opposite side of a stream; his retriever tried to bring over both at once, but could not succeed; she then, though never before known to ruffle a feather, deliberately killed one, brought over the other, and returned for the dead bird. Colonel Hutchinson relates that two partridges were shot at once, one being killed, the other wounded; the latter ran away, and was caught by the retriever, who on his return came across the dead bird. 'She stopped, evidently greatly puzzled, and after one or two trials, finding she could not take it up without permitting the escape of the winged bird, she considered a moment, then deliberately murdered it' (the winged bird), 'by giving it a severe crunch, and afterwards brought away both together. This was the only known instance of her having wilfully injured any game.'

"Here," proceeds Darwin, "we have reasoning, though not quite perfect, for the retriever might have brought the wounded bird first, and then returned for the dead one, as in the case of the two wild ducks." If the dog had followed the wiser course, it would not have been quite so clear as in the actual case that he had reasoned, though the pause for consideration after an attempt to take both together, would have gone far to suggest that explanation. But the action of the dog in killing the bird seems quite decisive, because such an act was entirely opposed to the instincts of the breed, and to the training which retrievers receive.

To these cases Darwin adds the statement that "the mulateers in South America say, 'I will not give you the mule whose step is the easiest,' but *la mas racional*—the one that reasons best"; on which Humboldt has remarked, "this popular expression, dictated by long experience, combats the system of animated machines better, perhaps, than all the arguments of speculative philosophy." Here, although Darwin only quotes Humboldt, he manifestly expresses his own view, and we find him opposed in a very definite manner to the theory of Kepler, afterwards supported by Descartes, and recently advocated by Huxley and others, that animals are automata, not possessing consciousness (or at any rate that this theory is admissible).

The next case to be considered is one which was described a year or two since in *Nature*. It was not one which in reality demonstrated, or even strongly suggested, the exercise of reasoning faculties by animals. We quote it, however, because it illustrates well the mistakes into which want of care may lead the student of our subject. During the cold weather of a recent winter the writer of the letter in question put bread on the window-sills of his drawing-room for the benefit of the birds. These, finding food there, were constantly fluttering about the windows. "One day a large water-rat was seen on the window-sill, helping himself to the bread. In order to reach the window he had to climb to a height of about 13 ft.; this he did by the help of a shrub trained against the wall. Neither instinct nor experience," proceeds the correspondent of *Nature*, "will easily account for his conduct, since he never found food there before. If neither experience nor instinct, what, save reason, led him? His action seems to have been the result of no small observation and reasoning. He seems to have said to himself: I observe the birds are thronging the window all day; they would not be there for naught; it may be they find there something to eat; if so, perhaps I, too, might find there something I should like. I shall try." The way in which this story is told singularly illustrates the difficulty which we, as speaking animals, find in understanding how a process of reasoning can be carried on without the imagined use of words. Probably few men whose mental powers have been well trained carry on a process of pure ratiocination, without clothing with words the thoughts successively suggested to their minds. It almost seems to a mind thus accustomed to reason with a verbal accompaniment (audible to the mind's ear only) that any mental process not thus accompanied must be to some degree instinctive, and any actions resulting from such a process automatic. But it is certain that even the most intellectual sometimes act in a manner which, if noticed in an animal, would suggest the exercise of reasoning power, not only without putting their thoughts into mental language, but without, in reality, noting what they are doing. However, the point to be specially noticed about the above story is that the narrator overlooks the most obvious, and probably the true, explanation of the rat's behaviour. The rat could not see the food, but most probably he could smell it. If so, his adventuring up the wall to get it was not the result of reasoning, or, at least, not necessarily so, for that was the shortest path to the much-needed food. Possibly the birds themselves may have been an attraction to him. Certainly the case is not one which compels us to believe that water-rats reason.

This objection was so well urged, in company with other points necessary to be considered in such inquiries, by a German writer, Herr H. T. Finck, that we quote his remarks almost in full. "Before we ascribe to a rat such complicated reasoning powers," Herr Finck remarks, "it is necessary to ask if there is no other simpler way of accounting for the phenomena. I think there is. It is well-known that different species of animals vary greatly in the acuteness of their senses. To man, sight is the most important sense, and the same is true of many other animals and most birds. The cat is a representative of another smaller class of animals, whose most perfect organ of sense is the ear; while the dog lives in a field of sensitives, the most important of which are contributed by the sense of smell." This point, as dogs afford many of the most striking illustrations of reasoning, or of what looks like reasoning, in animals, must be carefully remembered. Few are aware, we believe, how imperfect a sense is sight with all dogs, as compared with our own sense of sight. We believe that there could not be cited a single instance tending to show that a dog has been able to see as well as a very short-sighted man would, while in the great majority of cases, it can be shown by a few easily-tried experiments that dogs scarcely see at all in the true sense of the word. Our sense of smell is probably not more completely inferior to the same sense with dogs, than is their sense of sight to ours. To return, however, to Herr Finck. After pointing out that the rat belongs to the class of animals who are guided by the sense of smell, he says, "It is evident, therefore, that the water-rat in question was led to the window-sill by his nose, which in his case was a more trustworthy guide than his eyes would have been. I do not wish to deny, by any means, that animals have reasoning powers. On the contrary, I am convinced that human and brute intellect differ only in degree, not in kind. But what we have to guard against is not to ascribe [he obviously means the reverse, that we are to guard against ascribing] to animals reasoning powers of a higher type than is consistent with the development of their brain, especially when the actions which seem to postulate such powers can be readily accounted for by simply bearing in mind the extraordinary acuteness of one or more of their senses. We are altogether too prone to judge the intellectual life of animals by the human standard—to imagine that the eye is everywhere, as with us, the leading source of knowledge. The neglect of the important *rôle* which the sense of smell plays in animal life has been particularly fruitful of errors in philosophical speculation. It has, among other things, helped to give a longer basis of life to the old theory of instinct, regarded as a mysterious power of nature." In passing, we may remark that at the very beginning of our own life the sense of smell is stronger and more useful than the sense of sight; as though during those first few days, before the eyes acquire power to recognise objects or to do much more than to distinguish light from darkness, we belonged, for the time being, to that inferior class of animals with whom the predominant sense is that of smell. In that part, also, of their lives, human beings seem so far to resemble the lower animals that their actions appear to be governed by instinct solely. In reality, probably, a sense of smell much keener then than during the subsequent years, which alone we can remember, governs the actions in the same way, though not so obviously, as sight governs them in most of the actions of later years.

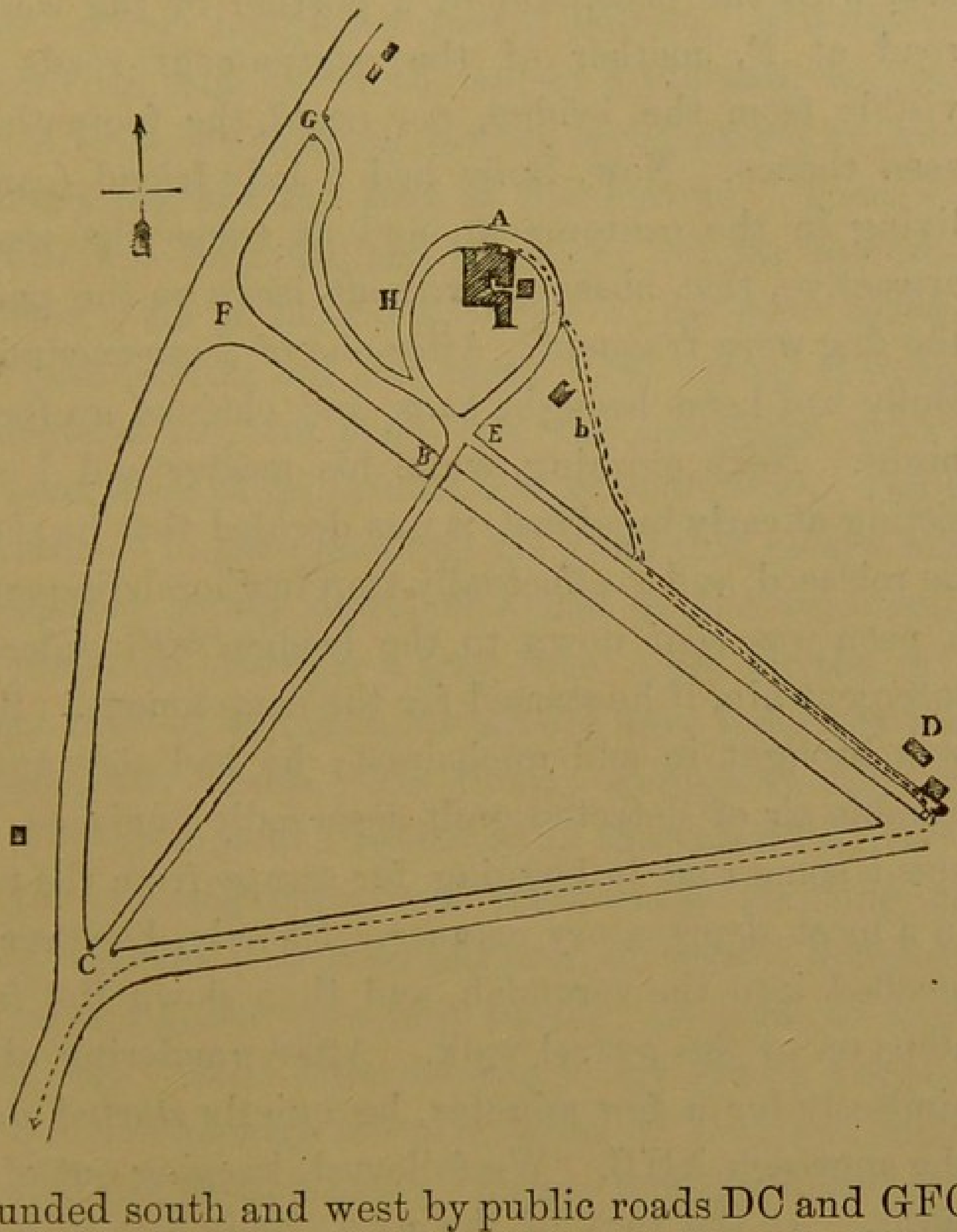
The next case cited also relates to the apparent exercise of reasoning faculties by rats, and is interesting, because probably their action was guided by the sense of hearing, rather than by that of smell. "Some years ago," says the narrator, "a plumber told me that he had, on several occasions, been called in to examine into the cause of leakage of water-pipes under the flooring of houses, and had found that the rats had gnawed a hole in the leaden pipe to obtain water, and that great numbers of them had made it a common drinking-place, as evidenced by the quantity of dung lying about. The plumber brought me a piece of leaden pipe, about three quarters of an inch in diameter, and one-eighth of an inch in thickness, penetrated in two places, taken by himself from a house on Haverstock-hill. There are the marks of the incisors on the lead as clear as an engraving; and a few hairs and two or three of the rat's whiskers have been pinched into the metal in the act of gnawing it. This crucial proof of brute intelligence—for a rat will not drink foul water—interested me so much that I ventured to send an account of it to Dr. Charles Darwin, asking his opinion on the means by which the rats ascertained the presence of water in the pipe. To this he replied: 'I cannot doubt about animals reasoning in a practical fashion. The case of the rats is very curious. Do they not hear the water trickling?'" This explanation would go far, it would seem, to do away with the idea that the rats in this case had reasoned, seeing that if they recognised the presence of water by the sense of hearing, their action in biting their way through to what they wanted would correspond precisely with what we have been taught (erroneously, in all probability, but that is a detail) to regard as instinctive. The narrator, however, did not read Dr. Darwin's reply in this sense. "It may be conceded," he says, "that this explanation is the most probable, and if it be the true one, we have an example of an animal using his senses to obtain the data for a process of reasoning leading to conclusions about which he is so certain that he will go to the trouble of cutting through a considerable thickness of lead. Obviously man could do *no more* under the same conditions." If the rats had shown in their boring operations some special aptitude for securing most conveniently, with the least possible overflow, the water they required, this would be a just inference. But as we know no more than that, having found, probably by the sense of hearing, that water was present in the pipe, they bored their way through to reach it, we have in reality no more proof of reasoning power than is afforded by the familiar action of mice biting their way through the wooden or card casings of boxes of edibles they like, of whose presence within such boxes the sense of smell has convinced them.

This objection is well put by Mr. Henslow in a letter discussing this particular case, and Dr. Darwin's comments thereon, only, as it seems to us, he carries the objection rather further than it will fairly go, extending it to cases to which we think it can hardly be applied. "It has always seemed to me," he says, "that brute reasoning is always *practical*, but never *abstract*" (but he tries to show that there is very little reasoning at all in the matter). "They do wonderful things, suggested by the objective fact before them; but, I think, never go beyond it. Thus, a dog left in a room alone, rang the bell to fetch the servant. Had not the dog been taught to ring the bell (which, on inquiry, proved to have been the case), it would have been abstract reasoning; but it was only practical. The Arctic fox—too wary to be shot, like the first, who took a bait tied to a string, which was attached to the trigger of a gun—would dive under the snow and so pull the bait down below the line of fire. This is purely practical reasoning; but had the fox pulled the string first out of the line of fire, *in order* to discharge the gun, and *then* to get the bait, that would have been abstract reasoning, which he could not attain to." This, however, is assuming more than can be proved; the fox, in the case referred to, did not act in the way which would have implied abstract reasoning; we do not know that no fox has ever done so, still less that, failing a simpler way of attaining his object, no fox could so reason. Albeit, we believe there are very few cases in which a line of reason involving so many steps as that suggested by Mr. Henslow has been followed by an animal. Mr. Henslow makes a good point in noting how like the practical reasoning of animals is the reasoning of young folk. "A boy the other day," he says, "found the straps of his skates frozen. The fact only suggested *cutting* them. Not one of his schoolfellows reflected upon the abstract fact that the ice would melt if he sat upon his foot a few minutes. Hence brutes and boys are exactly alike in that nothing occurs to either beyond what the immediate fact before them may suggest. The one kind I call purely *practical* reasoning, which both have; the other abstract, which brutes *never* acquire; but the boy *will* as his intelligence develops."

Certainly the next case cited in the correspondence suggests practical rather than abstract reasoning. "In Central Park, one very hot day, my attention," writes Mr. James J. Furniss, of New York, "was drawn to the conduct of an elephant which had been placed in an inclosure in the open air. On the ground was a large heap of newly-mown grass, which the sagacious animal was taking up by the trunkful, and laying carefully upon his sun-heated back. He continued the operation until his back was *completely thatched,* when he remained quiet, apparently enjoying the result of his ingenuity. It seems to me that *instinct* should have prompted the elephant to eat the grass, and that it was reason which caused him to use it for the purpose of diminishing the effect of the sun's says." Undoubtedly, had hunger been the prevailing sensation at the time, instinct would have caused the elephant to eat the grass. But, as he was probably much troubled by the heat, it was not more wonderful that he should throw grass on to his back, than it would have been if, had there been any shadow, he should have withdrawn under it. Doubtless, however, the true explanation is that the elephant reasoned in a practical way. The effect of the grass as a protection from the heat was obvious to his senses, so he continued to add more and more grass to his covering until he felt comfortable. If the use of the grass for food occurred to him at all, it would have appeared obvious enough that even if all the grass were used for shelter, it would be none the less suitable for food when hunger began to be troublesome.

Passing over several cases which seem to carry the matter no further than those already cited, we come next to a case which appears to us one of the most striking ever recorded. The writer, Mr. E. H. Pringle, remarks that it is an instance of sagacity which finally sets at rest any doubts he had ever entertained that the difference between human and animal intelligence is one of degree only. We can see no way in which the story can be explained without assuming the exercise of something more than that mere practical reasoning which probably underlies all the so-called instinctive actions of animals :—

Mr. J. W. Cherry, of the Madras Forest Service, is owner of a dog, a bull-terrier, called "Bully." (This breed is notoriously not the most intelligent of the canine tribe, so that the behaviour of Bully appears all the more striking.) "We lived," says Mr. Pringle, "in the bungalow A,[1] the compound of which was



bounded south and west by public roads DC and GFC, both leading to the cantonment of Bangalore in the direction C. There were three gates into the com-

[1] The figure presents all the features essential to a correct understanding of Mr. Pringle's narrative.

pound at C, D, and G, the main approach to the bungalow leading over a bridge B that spanned a public road FD. The compound was filled with trees and shrubs, and bordered by dense lantana hedges, so that with the exception of a portion of the western road at F, neither of the cantonment roads was visible from the bridge, nor could the footpaths be seen thence. Now, Bully had a lady friend (canine) living in the cantonment, and at times she was so attractive, that absences without leave on the part of the dog were frequent. After one of these excursions, Bully had been brought back and chained up for the night. Next morning, while his master and I were sitting at early breakfast, it was decided that he should be released, and to effectually stop further delinquency, a peon was sent down to the bridge with orders to intercept him if he started for the cantonment. Bully was brought in and unchained; he had that unmistakable air of detected guilt deservedly punished, and spent some time in begging for scraps from the table in a most deprecatory manner. Shortly, however, he strolled into the verandah, and then down the front steps on to the gravel walk. After wandering about aimlessly for a few minutes, he quietly started down the approach AHB. We followed, keeping out of his sight. At the turn of the road, Bully met with the unexpected apparition of the peon standing on the bridge. In a moment, though not a word was spoken by the man, the dog turned and came straight back to the room, whither we had in the meantime slipped back unobserved, and re-entered it, wagging his tail violently, and looking exceedingly sheepish. He now lay down, and closed his eyes. The cocked ears showed that sleep was mere pretence, and he soon rose again, went into the front garden, and hunted for buried bones—purely imaginary ones, I believe. His search gradully led him down the hill by a footpath leading from A to G, we keeping him in sight, as before, and he finally reached the road at the bottom. There all disguise was dropped, and he started off for the cantonment. As he neared the spot F, the peon espied him, and shouted out his name. He turned at once, climbed the hill, and came into the bungalow, where the same farce of repentance was gone through. Bully now seemed to have made up his mind that escape was impossible; he lay down on a mat in the verandah, and remained there for a long time. But for the persistent cock of the ears, we should have imagined the animal really asleep. Mr. Cherry eventually went to his office-room, and I remained in the verandah, reading the morning paper and occasionally glancing at Bully. He lay very still, but once or twice I detected him opening his eyes and raising his head to look round him. Each time he caught my eye he wagged his tail vehemently for a moment or two, and then resorted to his sham sleep. It may have been for half-an-hour or thereabouts that this state of things continued. I then became interested in an article in the paper, and when I next looked up, Bully was gone. I called Mr. Cherry, and the house was searched for

Bully. The peon was sent for and interrogated; he had not seen the dog. As a last resource, inquiry was made of the horse-keepers down at the stables, D. The reply was 'Yes; the dog has passed through the gate, D, some time before.' Taking advantage of my occupation, and the absence of his master, Bully had left the house and taken his way to the cantonment by the only path by which he could have escaped unnoticed by the peon—that shown by the dotted line."

It seems to us quite impossible to account for the dog's action, as above narrated, without attributing to him the exercise of reasoning powers, not merely in selecting the route by which he finally escaped, but in the manœuvres by which he endeavoured to assure those who were watching him that he had given up all hope of escaping. Doubtless, if he had reasoned more perfectly, he would even have allowed his ears to seem asleep, instead of leaving them cocked. But very few of us human beings simulate sleep without some such error, by which any observant person would be enabled to detect the trick. Either the muscles of the face are not perfectly relaxed; or the hands or feet are left in a constrained attitude; or the position of the body generally is unlike that which a sleeping person would assume; or else the breathing is unnaturally restrained. And again, though Bully was too demonstrative in his contrition, and afterwards in his attempts to hide the consciousness of failure, it was not for want of reasoning power. Few of us know how to act such parts as he tried to play, with perfect correctness; nor do those who know suceed always in acting such parts as they could wish. Probably Bully was as sensible as the onlookers that he was not quite successful in his acting. It is obvious, however, that he directed his efforts as carefully to the end he wished to obtain as a human being of average reasoning powers and skill in counterfeiting sleep, &c., could have done.

Wigan, in his "Duality of the Mind," says that he once offered an apple to an elephant, letting the apple drop at the moment the elephant was about to seize it, so that it rolled out of its reach. The elephant waited a moment to see if Wigan would pick it up, and being disappointed in this expectation, set himself to blow violently against the opposite wall, and the recoil forced the apple to his feet. This may be regarded as a case of practical, rather than of abstract reasoning. Yet, as Wigan remarks, it was a trick which no one could have taught the animal, and "it must have arisen from a process of reflection perfectly similar to that which takes place in the human mind" under similar conditions. We have, indeed, he justly remarks, "examples of human minds not even capable of the degree of thought possessed in this instance by the elephant, yet performing, by a sort of automacy (*sic*) all the ordinary functions necessary to their occupation. In some of the mechanical processes in our great manufactories, where the minute subdivision of labour reduces the art of each individual almost to the very ultimate elements of muscular motion, I think that I have seen individuals incapable of a similar process."

In the following instance, from the same work, we have ingenuity combined with, and suggested by, indignation: "A large grey spider established himself in a recess formed by a shed and a projection of the house, and taking his long line diagonally from the corner of the house to the eaves of a small building which was at the bottom of the recess, he then filled up the triangular space with a well-defined circular web. I had noticed with admiration during the day his wonderful skill, the accuracy of his lines, and the equality of the spaces, and observed how carefully he pushed down his line, and fastened it securely with his two hind feet to each radius in succession. When he had finished about two-thirds of his concentric circles, or rather of his helix, he went to the centre and swallowed a quantity of white tenacious mucus, which he had deposited there at the commencement, having apparently spun himself out; he then proceeded to complete his work, which having accomplished, and thus reduced himself to very small dimensions, he hung himself up by the hind legs, and I presume went to sleep. The slightest touch of a fly was, however, sufficient to make him start out, and having wrapped up a few of them in his toils and well stocked his larder, he again betook himself to repose. In the meantime, one of the smaller spiders, considering that the diagonal line of his neighbour was strong enough to bear two webs, began to attach his lines to it, and having done so in four or five places, proceeded to spin his own web. My older friend tolerated the intrusion very patiently, and acquiesced in the use his neighbour was making of the "party wall," though against *spider law*. By-and-by the newcomer, having partly fitted up his own trap, and finding that no flies came into it, observing, I presume, the ample supply of food in his neighbour's premises, advanced along one of his own lines, seemingly for the purpose of open burglary. My old friend had tolerated much, but this was a degree of impudence for which he was not prepared, and which he determined to punish forthwith. He proceeded to the centre of his web, and giving the whole framework a violent shake, hoped to shake the intruder down upon the ground. He did no more, however, than turn him round on the line, where he hung very patiently till the shaking ceased, and then resumed his march towards his neighbour's territory. Again and again, and with increasing violence, did the large spider shake his web—it was all in vain; there was the enemy advancing, and though so small as to be easily overpowered, should he reach the mainland, the insult of the attempt was intolerable. On looking round, my elder friend saw that, during the violent shakes, he had broken two or three of his own short lines, and he left his opponent and set himself to work to mend them. Having completed the task to his perfect satisfaction, he returned to the burglar. The latter, when he came near, saw at once that he had been rash in provoking such an enemy, and hurried back to his own web. When his opponent saw him on his thin line in his retreat, he again set himself to his shaking fit, and made the most violent efforts to throw him down; it was all in vain, however, and he got safe home. After a moment's consideration, the other seemed to think that so audacious an attempt ought to be condignly punished, and he determined to retort the invasion. The thin lines of his diminutive antagonist, however, did not afford a sufficient support for his heavy bulk, and as he advanced, he carefully spun a strengthener upon the other's tenuous cord. It was now the little one's turn to shake off the intruder, and twice did he break the thin part of the line, and leave his enemy dangling. At last, the latter gave up the attempt, and went back to the centre of his own web, *after carefully detaching every one of the lines* which his neighbour had had the impudence to fasten to his long diagonal."

In this case we seem to recognise on both sides reasoning which approaches at times the abstract. In the calculation of means to an end, and change of plan in consequence of unexpected obstacles, there is practical reasoning. As Wigan well says, "Had the human race spun webs, and dared one another to single combat, they could not well have shown more judgment and skill in the attack and defence." The strengthening of the lines to bear the shaking, and doubling the smaller spider's lines while using them as lines of advance, belonged also to the order of practical reasoning, though of a rather advanced kind. But there was abstract reasoning, it seems to us, or a near approach to it, in the conduct of the smaller spider, first of all in considering, as it were, how far he might trespass on the patience of an enemy whom he recognised as his superior, and again in the conduct of the larger in deciding when the time had come to give his small enemy a lesson, and in retreating finally without persisting, as if reflecting that his purpose was as well achieved as though he had actually driven the smaller spider from his web. His removing the lines which had supported the smaller web, though he had previously allowed them to remain, looks very much like a result of abstract reasoning.

We find illustrated by such instances the remark of Dr. Prichard, that among insects, if we take the different tribes collectively, manifestations of all the psychical qualities which we observe in mammifers and birds (regarding as a whole the properties divided among different departments), may be recognised in the most strict analogy. Attention, memory, the faculty of combining means to attain ends, cunning, the desire of revenge, care of offspring, and all the other psychical qualities which have been traced in the former class of animals (mammifers) are likewise to be observed in the latter as typical or characteristic phenomena—sometimes in one combination, sometimes in another; or, in different groups, sometimes strongly, sometimes more feebly expressed.

Let us next examine a few cases in which animals have done things which they have seen done by the persons with whom they live, and more or less obviously with the object of obtaining the result which they had observed to follow from such actions. For this would seem, if the animal can be clearly shown to have had such a purpose, to be distinctly the result of reasoning. Monkeys may or may not reason when they imitate actions which, when performed by themselves, are of no advantage to them, or are even mischievous. Indeed, it is not improbable that they suppose their human fellow-creatures would not perform such actions except for a useful purpose, though what that purpose may be they may have no conception. But whatever opinion we may form on this point, we can have, it would seem, no room for rejecting the belief that an animal has reasoned who performs an act demonstrably for the purpose of producing a certain effect, such as he has observed to follow when human beings have so acted. Now in some of the cases which follow, this does seem to be most clearly made out.

A writer in *Nature* gives the following case:—" My sister, who lives just opposite to my own house, possesses a cat (now about thirteen years old), whose intelligence is very remarkable. He has a habit of making use of the knocker of a side door, which is just within his reach as he stands on his hind legs, whenever he desires admission. A single knock is tried in the first instance; but if this is not answered promptly, it is followed by what is known as the 'postman's knock'; if this is not successful, trial is then made of a scientific 'rat-tat' that would not disgrace a west-end footman. I should say that 'Minnie' holds the knocker in his paw as we should hold it in our fingers, and not by simply tipping it up. How far this practice involves 'abstract reasoning,' I will not say, but something like an approach to it is suggested, for he was never taught to knock at the door, and adopted the habit some three years ago, evidently to gain admittance, very often to the annoyance of my sister's family, who have occasionally been disturbed in this way at unseemly hours." The rest of the letter has no bearing on the subject we are upon, but it is too amusing to be omitted. "I should be sorry," says the writer, "in thus referring to the sagacity of poor pussy (who is now also somewhat feeble), to reflect upon him by noticing some other of his peculiarities, one of which is his fondness for a little brandy-and-water, and other alcoholic stimulants." It would be, perhaps, to inquire somewhat too curiously to ask whether this story shows that the fondness for stimulants is associated with an advance in reasoning power, or whether, perhaps, Minnie's brain was aroused to abnormal activity by the tippling in which alone (we may assume) he was indulged by his mistress. The point established by the story is that in some cases—at any rate, as in animals so low in cerebral development as cats—the consequences of a certain action are observed and remembered, the action being repeated by the animal when he wants those particular consequences to follow.

This cannot be explained by any theory of mere instinct.

In the last story, the cat was an old one, and though this does not modify the conclusion to be deduced from the animal's behaviour, yet it in some degree diminishes our estimate of the activity of Minnie's reasoning power. In the following case, a young cat showed equal intelligence :—" I may mention a case," says the writer, " of a kitten about half-grown, having mental reflection of some sort. I was sitting in one of the rooms at a house where I was stopping in Somersetshire, and hearing a knock at the front door, was told not to heed it, as it was only this kitten asking admittance. Not believing it, I watched for myself, and very soon saw this kitten jump on to the door, hang on by one leg, and put the other fore paw right through the knocker and rap twice. The knocker was an ordinary shaped one, fixed in the centre of the door half way up; the top part of the door was glazed. I saw this performance dozens of times afterwards, and often used to put the kitten outside to see it done. It was never known to knock when any one stood in the garden, but if one went indoors and shut it outside, in a few minutes came the usual knock. A sister kitten to this one was never known to knock, but sat on the doorstep and entered when the door was opened, and in nine cases out of ten the knock was successful. The kitten was never taught in any way; it would knock at both front and back door."

In the following case, the object of an animal's action in such cases was tested by an experiment, but the evidence is less satisfactory in one respect than that afforded by the two previous cases, the animal having been taught the action: "A small English terrier belonging to a friend," says the narrator of the story, "has been taught to ring for the servant. To try if the dog knew *why* it rang the bell, he was told to do so while the girl was in the room. The little fellow looked up in the most intelligent manner at the person giving the order (his master or mistress, I forget which), then at the servant, and refused to obey, although the order was repeated more than once. The servant left the room, and a few minutes afterwards the dog rang the bell immediately on being told to do so." Here it is to be noticed that the dog did not ring the bell (as, in each of the preceding stories, the cat knocked at the door) to get some end of his own accomplished. He rang to save his master or mistress trouble. And the fact that he had been taught to ring for this purpose, although making the act itself less obviously a sign of reasoning power than the cat's action in knocking at the door, makes his refusal to ring when told to do so a more manifest evidence of reasoning than it would otherwise have been. If the dog rang for the servant because of some advantage he always gained from the servant's coming, it would have been natural enough that he should refrain from ringing when the servant was in the room. But his refusing to do what he had been taught to do, at the risk of offending his master or mistress by such refusal, makes it absolutely certain that he had clearly recognised the object which was to be attained by ringing the bell.

It may be objected that in cases such as those we considered last, the animal has merely imitated an action which it has seen performed by others, and has subsequently learned to associate the action with its ordinary consequence. Apart from the consideration, however, that although in any single case such an interpretation might possibly be correct, it would be most improbable that it should explain all cases in which cats or dogs have used knockers or rung bells in the usual way: cases may be cited in which animals have devised a way of their own for producing such signals. Thus Mr. E. L. Layard, of the British consulate, Noumea, relates the following case in which a cat acted in a way which can hardly be explained, save by assuming that she reasoned:—"Many years ago," he says, "we lived in Cambridge, in Emmanuel House, at the back of Emmanuel College. The premises were partly cut off from the road by a high wall; the body of the house stood back some little distance. A high trellis, dividing off the garden, ran from the entrance door to the wall, in which was another door, or grate. A portion of the house, a gable, faced the trellis. . . . . We were, after some time of residence, extremely troubled by runaway rings, generally most prevalent at night, and in rainy, bad, or cold weather, which was a great annoyance to the servant girls, who had to cross the space between the house and the wall to open the outer door in the latter, and were thus exposed to wet and cold." The annoyance became so great, that Mr. Layard and a cousin watched behind the trees on "Jesus piece," armed with stout ash saplings, wherewith to administer a sound thrashing to the ringer, whomsoever he might be. But though the rings continued, no one pulled the handle. Hence the theory of ghosts was naturally suggested, but Mr. Layard, having brains, rejected that interpretation. At length chance cleared up the mystery. "Being ill," he says, "I was confined to the wing facing the trellis, and one miserable, blowing, wet day, gazing disconsolately out of the window, espied my favourite cat — a singularly intelligent animal, much petted—coming along the path, wet, draggle-tailed, and miserable. Pussy marched up to the house-door, sniffed at it, pushed it, mewed, but, finding it fairly shut, clambered up to the top of the trellis, some eight or ten feet from the ground, reached a paw over the edge, scratched till she found the bell-wire which ran along the upper rail from the wall to the house, caught hold of it, gave it a hearty pull, then jumped down, and waited demurely at the door. Out came the maid; in rushed puss. The former, after gazing vaguely up and down the street, returned, muttering 'blessings,' no doubt, on the ghost, to be confronted by me in the hall. 'Well, Lydia, I have at last found out who rings the bell.' 'Lard, master, ye haven't, surely'—she was broad Zumerzetsheer.

'I have, come and see. Look out of the breakfast-room window, but don't show yourself.' Meanwhile I went into the drawing-room, where Mrs. Puss was busy drying herself before the fire. Catching her up, I popped her outside of the door and ran round to my post of observation. Puss tried the door, and mewed, thinking, probably, some one must be near, and, after waiting two or three minutes in vain, again sprang up the trellis, and renewed her attack on the bell-wire, of course, to be immediately admitted by the delighted maid, who this time did *not* cross the yard, nor ever again, I fear sometimes to the inconvenience of visitors, if puss was waiting for admission."

In this case it is possible that the cat may have only discovered by accident that the bell-wire could be reached in the way described. This is Mr. Layard's explanation. He considers that puss, in clambering up the trellis to the house-top, accidentally moved the wire and caused the bell to ring. It seems at least as likely that she noticed the wire moving when the bell was rung, and afterwards deliberately moved it to produce the desired effect. But in either case, it is clear that neither instinct nor mere imitative faculty can explain the cat's action in this case. In passing, I may remark that the imitative faculty, which some regard as a mere automatic quality, seems to me far better explained as the result of reasoning, though, of course, the reasoning is not of a very high order; an animal seeing a man perform some action, infers that some advantage is to be gained by the action, and repeats it in the expectation that some good result will follow, though without knowing what this may be. However, in the present case there was no imitation, nor certainly could any instinct have been in question. Mr. Layard mentions other cases, of which the same may be said. "I have known dogs shake a door violently," he says, "to attract attention and be let in. A dear old spaniel of ours at the Cape used to rattle the empty bucket if he was thirsty, and then come and look in our faces. My horse will come up from his pasture to the pump in the yard, and whinny till some one gives him water. . . . . Surely all this is abstract reasoning," he proceeds. "These things are not taught them, and they do not do all of them even by imitation. I don't go to the pump and whinny if I want drink! nor rattle a bucket! No! they come by a process of mental reasoning, and I am convinced all animals have it to a certain degree, more or less."

There have been cases which have afforded opportunity of noting the behaviour of an animal when first some new experience has occurred to it, and (as it would seem) new ideas have been suggested. Such cases are of extreme importance in determining whether animals really reason or not; because it must be admitted that in some instances where animals have appeared to reason, the action noted may possibly have originated, in the first instance, by accident, and have been continued subsequently as a mere habit. It is rather unfortunate that the only animals which we can observe under favourable conditions—domestic animals, and those which, though not domestic, affect the neighbourhood of houses—are not those whose cerebral development is of the highest order among animals. If monkeys were commonly domesticated (which would, for other reasons, be by no means desirable), we should probably have a number of far more striking and convincing instances of animal reasoning than we at present possess, for nearly all monkeys are far higher in cerebral development than the most sagacious dogs, while horses, cats, rats, &c., are lower than dogs in this respect. Still if we remember that whatever evidence we obtain from the behaviour of dogs and cats must be regarded as suggesting, for this very reason, a powerful argument *à fortiori* as to the reasoning faculties of monkeys, and especially of the higher orders of simians, we may be well satisfied with such instances as have been adduced above. The following case, showing how a cat reasoned out the meaning of a phenomenon brought for the first time under its notice, seems to afford decisive evidence of the capacity of animals to deal with cases when neither instinct, habit, nor imitative faculty can afford them any assistance:—A household cat was observed to enter a bedroom which was being cleaned at spring-time: a looking-glass stood on the floor, and Tom, on entering, found himself confronted by an image which he naturally supposed to be another cat, an intruder on his domains. He made hostile demonstrations, which were presently followed up by a rush at his opponent, who, nothing loth, seemed to rush also at him. Finding an apparent obstacle to his vengeance, Tom ran round behind the glass, where he found no enemy; so he came again to the front. Here he again found his foe, on whom he again made an onslaught, only to be similarly foiled. He repeated this two or three times, applying manifestly the inductive method to the problem before him. The result of these experiments was to suggest the theory that the cat in the looking-glass, if actually existent, was unlike those specimens of the feline race with whom Tom's experience had hitherto made him acquainted. These repeated failures must have a meaning, Tom seems to have reasoned. Either he was the victim of some illusion, or the cat behind the glass was of altogether exceptional activity. But, however active that cat may be, Tom proceeded to reason, he cannot be on the further side and yet not on the further side at the same moment of time. If, then, I look at him and see him to all appearance on the further side, while at the same time I feel for him there with my paws and find him not there, then the cat in the glass must be a mere fraud. No sooner was this *experimentum crucis* devised by the clever cat than it was put into execution. Tom deliberately walked up to the looking-glass, keeping his eyes fixed on the image; then, when near enough to the edge, he reached out carefully with his paw behind the glass for the supposed intruder, whilst with his head twisted round to the front he assured himself of the persistence of the reflection. He also must have recognised, what the narrator seems to have overlooked—that the looking-glass was not, as it seemed, transparent, for the paw with which he was feeling about for the other cat was not visible, though the supposed intruder remained in view all the time. The apparent presence of the feline foe, though the feeling paw could not be seen, satisfied Tom fully. "The result of his experiment," says the narrator, "satisfied the cat that he had been the victim of delusion, and never afterwards would he condescend to notice mere reflections, though the trap was more than once laid for him." It would, by the way, have been worth while to try whether a looking-glass without a frame deceived him after he had discovered the meaning of an ordinary mirror, or whether a cat placed on the other side of a transparent framed glass would be at first mistaken for a mere reflection—his conduct in either case being carefully watched. A cat which had shown such excellent capacity for reasoning was worth experimenting on.

Whether we suppose that the cat of the preceding narrative judged of the position of his supposed foe solely by sight, or may partly have been influenced by the sense of sound (very slightly, in any case), it must be admitted that he showed a fitness for original research which some amongst ourselves might be found wanting in, if we may judge from their actions in certain cases. But it is an interesting question how far an animal may really be deceived by the image of another animal, or of some object in which the animal observer takes interest. There are stories of birds pecking at painted fruit, and the like, of which some are unquestionably apocryphal. When we remember, too, that some savages fail utterly to understand the meaning of pictures,[1] even of the most familiar objects, we may well doubt whether animals can possibly mistake a painted figure for a real object. Yet there are some stories which seem to show that animals certainly recognise pictures of persons, animals, or objects familiar to them. It would almost seem as though such cases could only be explained as depending on the exercise of a certain amount of reasoning power, the animal inferring that, because a certain picture presents details of shape and colour corresponding to those belonging to a familiar object, the picture is in some way connected with that object, although other senses, as of sight, smell, hearing, &c., must serve perfectly to prevent any possibility of actual deception. A letter in *Nature*, by one who remarks that "his own observations lead him to suppose that dogs very rarely take notice of a painting or any representation on the flat," seems to me especially interesting, as illustrating how the sense of sight may for a moment deceive an animal which usually trusts chiefly to other senses. "I only know of one instance," he says. "A bull-terrier of mine was lying asleep upon a chair in the house of a friend, and was suddenly aroused by some noise. On opening

[1] There are some illustrations of this in my little book called "The Flowers of the Sky," in the article relating to "Fancied Figures among the Stars."

his eyes, the dog caught sight of a portrait of a gentleman on the wall not far from him, upon which the light was shining strongly. He growled, and for some little time kept his eyes fixed upon the portrait, but shortly satisfying himself that there was no danger to be apprehended, he resumed his nap. I have often," proceeds the narrator, "endeavoured since to induce him to pay some attention to portraits and pictures, but without success, though sometimes he will bark at his own reflection in a looking-glass. He knows it to be his own image that he sees, for he very soon tires of barking and looking."

In the case last considered, we see that a dog, belonging to a species not distinguished for keenness of scent, was not long deceived by a picture, even under circumstances favouring the deception—as his previous sleep, the position of rest from which he saw the figure, and the strong light shining upon it. As this was the only instance known to one who was familiar with the ways of dogs, the negative evidence respecting the recognition of pictures by animals is rather strong. However, there have been cases where animals, if not actually deceived by a picture, seem certainly to have understood what it was intended to represent. The following case seems to me full of interest. It is related by Mr. Chas. W. Peach, of Edinburgh. He remarks, first, that in certain publications dogs are said never to have recognised a painted likeness. "During my residence in Cornwall," he goes on to say, "I had a most intelligent and faithful dog for fifteen years. I had him when a month old. His mother was a beautiful liver-coloured spaniel, rather large; his father, a black Newfoundland; my dog took after him in colour and shape. In 1843, a young and self-taught artist asked me to allow him to paint my likeness in oil colours, and I consented. His studio was in the next town, three miles distant, and, as often as required, I went over. I, however, did not take my dog with me. It was done in 'kitcat' size, and he succeeded so well in the likeness and artistic work, that, when exhibited at the annual meeting of the Polytechnic Society at Falmouth, a medal was awarded for it; and, as well, it was highly commended. The artist was so grateful that he presented me with the painting, and I still have it. When it was brought to my house, my old dog was present with the family at the 'unveiling'; nothing was said to him nor invitation given him to notice it. We saw that his gaze was steadily fixed on it, and he soon became excited, and whined, and tried to lick and scratch it, and was so much taken up with it, that we—although so well knowing his intelligence—were all quite surprised; in fact, could scarcely believe that he should know it was my likeness. We, however, had sufficient proof after it was hung up in our parlour. The room was rather low, and under the picture stood a chair; the door was left open without any thought about the dog; he, however, soon found it out, when a low whining and scratching was heard by the family, and on search being made, he was [found to be] in the chair trying to get at the picture. After this I put it up higher, so as to prevent its being injured by him. This did not prevent him from paying attention to it, for whenever I was away from home, whether for a long or short time—sometimes for several days—he spent most of his time gazing on it, and as it appeared to give him comfort, the door was always left open for him. When I was long away he made a low whining, as if to draw attention to it. This lasted for years, in fact so long as he lived and was able to see it. I have never kept a dog since he died; I dare not, his loss so much affected me."

A similar anecdote is related of a painting by the elder Phillips. "Many years ago," says the lady who narrates the tale, "my husband had his portrait taken by T. Phillips, sen., R.A., and subsequently went to India, leaving the portrait in London to be finished and framed. When it was sent home, about two years after it was taken, it was placed on the floor against the sofa, preparatory to being hung on the wall. We had then a very handsome, large, black-and-tan setter, which was a great pet in the house. As soon as the dog came into the room, he recognised his master, though he had not seen him for two years, and went up to the picture and licked the face. When this anecdote was told to Phillips, he said it was the highest compliment that had ever been paid to him."

We have seen how a bull-dog, the least intelligent, perhaps, of all dogs, behaved in presence of a portrait. We have now to consider the behaviour, under similar circumstances, of the British mastiff, a more intelligent animal than the bull-dog, though not regarded as standing by any means first among dogs in this respect. The particular mastiff in question is one to whom I had the pleasure of being introduced some five years since, Dr. Huggins's dog Kepler. He is worthy of a brief biographical sketch. He was a son (that is, Kepler was) of the celebrated Turk, and was born about the year 1871. "He stands," wrote Mrs. Huggins of him, towards the close of 1876, a few months before his lamented decease, "thirty inches high, and is lion colour on the body; his face, the tips of his ears, and the tip of his tail, are marked with black. In disposition he is usually exceedingly affectionate and gentle, though he can be otherwise. Probably he thinks [though here I must confess that, strongly though Mrs. Huggins's opinion would support my case, I cannot altogether agree with her] that the words of George Herbert may apply to dogs as well as to men, and so reasons that—

> He is a fool who cannot be angry,
> But he is a wise *dog* who will not.

He has a clear idea of his duty in life. As Mr. Carlyle would say, 'he has found his work to do,' and considers it to be—to borrow the expression of an old writer—'to kepe his mastre and his maistirs hous.' To this end he is continually on the watch, barking in quite different ways as different comers approach· He has a bark of welcome for those he loves; of courtesy for mere acquaintances; of inquiry for strangers; of warning against enemies," an approach here, one may say, to language.

Kepler first attracted scientific attention by a peculiarity which, most probably, must be regarded as a result of instinct, or as, at any rate, inherited, since nothing in Kepler's own life explains it as the result of any process of reasoning. "When he," that is Kepler, "was very young," writes Mrs. Huggins, "his master discovered on taking him for a walk one day, that he" (Kepler, not Dr. Huggins) "was very much frightened at the sight of a butcher's shop, and some little time afterwards, when he was out with a servant, the feeling again showed itself, but in a much more marked manner. On this occasion Kepler threw himself upon the ground near the butcher's, exhibiting every appearance of terror, and as no amount of coaxing could induce him to pass the shop, the servant was at last obliged to bring him home again. His master, upon this, wrote to Mr. Nicholls, from whom he had purchased Kepler, asking if he could throw any light upon this strange dislike. Mr. Nicholls replied that it had been strongly marked in Kepler's father and grandfather, and was unusually strong in one of his brothers, so much so, indeed, that he would fly at a butcher, even when dressed in plain clothes. These facts being very striking, Dr. Huggins—Kepler's master—wrote details of them to Mr. Darwin, who was so much interested, considering the circumstances a clear instance of inherited antipathy, that he sent an account of them to *Nature*. The facts attracted much attention at the time, and various theories were put forward to explain them. In connexion with this dislike to butchers shown by Kepler and his relations, it is interesting to notice that a similar antipathy is noted by Jesse to dog-killers, as mentioned both by Lord Bacon ('Sylva Sylvarum'), and Sir Kenelm Digby ('Treatise on the Nature of Bodies'), as having been common among dogs in their times. The passage from Sir Kenelm Digby's Treatise runs thus: 'We daily see that dogs will have an aversion from glovers, that make their ware of dogs' skin; they will bark at and be churlish to them, and not endure to come near them, though they never saw them before.' Dog-killing was an old custom in August." Perhaps, after all, this intense aversion to butchers, dog-killers, and others who may be supposed to bear about them some scent of blood, suggesting to the dog-mind the slaughter of his kindred, may be an effect of reasoning, not, as I have suggested above, of instinct only. A dog may argue that the scent can only be explained in one way, and that the explanation is such as to suggest danger to himself—"*hinc illæ lachrymæ.*"

Kepler's (the mastiff's) claim to be looked upon as a reasoning dog may be regarded by some as being better based, perhaps, on what his master and mistress described as actual mathematical calculations. "Kepler," says the latter, "like his great namesake, is an excellent mathematician. Many distinguished men have been delighted with his performances in this direction. The mode of procedure is this: His master tells him to sit down, and shows him a piece of cake. He is then questioned, and barks his answers. Say he is asked what is the square root of 16 or of 9; he will bark three or four times, as the case may be. Or such a sum as '6+12—3 divided by 5,' he will always answer correctly: more prolonged calculations rather fatigue him. The piece of cake is, of course, the meed of such cleverness. It must not be supposed that in these performances any sign is consciously made by his questioner. None whatever. We explain the performance by supposing that he reads in his master's expression when he has barked rightly: certainly he never takes his eyes from his master's face." A singular performance, and one showing that some dogs possess not only keen vision, but keener powers of perception than most men. It would, however, be a mistake to regard Kepler's performance as illustrating the possession of actual reasoning power by animals. For certainly the calculations he seemed to conduct were conducted in reality by his master.

This intelligent animal showed excellent judgment when a large photograph of one of Landseer's dogs (that is, a photograph of a dog pictured by Landseer) was shown him. He showed his perception of the painter's skill by at once distinctly recognising that the photograph represented a strange dog, of whom, by-the-way, he manifested decided jealousy. Kepler knew the meaning of many words. He recognised clearly when his master was ill, and showed at such time real concern and sympathy. "He was exceedingly kind and unselfish to a little English terrier, called 'Tycho Brahe'"[1] (I quote again from Mrs. Huggins's interesting little sketch; only, as Kepler is dead, I change the tense in these few last sentences from the present to the past), "who often tried him, and to a very unamiable cat, who both formed part of the household in which he dwelt. Altogether, there was in Kepler's every look, and motion, and utterance, a noble and intelligent individuality which endeared him to all who knew him. Much might be learnt from him in many ways; and he was indeed worthy of a large share of an inclusive love—that love which loveth

'All things both great and small.'"

The question whether animals can count in any way, or discriminate, at any rate, between different numbers, is one about which different opinions have been expressed. We cannot consider that the question was answered (affirmatively) by Kepler's achievements, though he seemed to do more than count. On the other hand, the common opinion that a bird, whose nest has been robbed of all the eggs but one, is as well content with that one as with the entire set, is not supported by evidence, and, indeed, seems to have been devised to comfort the consciences of those who

[1] Tycho Brahe (the dog, not the astronomer) was commonly called by Dr. Huggins, Tyko Barky.

like to go birds'-nesting, but might be troubled with regret for the troubles of the parent birds, were it not for this ingenious theory. We all remember the remonstrance of Tom Brown, when East proposed to take all four of the eggs in the nest robbed by Martin, "No, no! leave one, and then she won't care," said Tom. "We boys," says the author, "had an idea that birds couldn't count, and were quite content as long as you left one egg. I hope it is so." However this may be with birds (and, on the whole, I incline to think even penguins, "boobies" though sailors call them, have some idea of the number of their eggs), the following story seems to show that dogs can count their young. "To my friend, Dr. Velasquez Level, a respectable physician of this city," writes M. A. Ernst, of Caracas; "and for several years a resident of the island of Margarita, I am indebted for the following touching instance of the sagacity of a bitch. Her owner, for some reason or other, had destroyed all the female puppies in two successive litters. On her having brought forth a third one, it was found that there were but three male puppies. The bitch, however, was observed to leave her whelps occasionally, and to return some time after. Being followed, she was discovered suckling three female puppies, which she had hidden under some brushwood, undoubtedly with the intention of saving them from the master's cruel hands." This, perhaps, is the most striking of all the cases we have yet considered. It would seem that when the female puppies of the first litter were destroyed, the mother either did not recognise the circumstance that all the male puppies were left, or else regarded it as merely accidental; for otherwise she would probably have tried with the second litter the plan she actually tried with the third. When the female puppies of the second litter were taken, she recognised the rule by which selection had been made. Thus she had up to this point reasoned well and with due caution, not adopting a conclusion until the evidence in its favour had become very strong and convincing. She had also shown a power of counting; for obvious though the result she obtained may seem to one of ourselves, capable of dealing readily with much larger numbers, yet if we conceive a mind so far inferior in matters of calculation to that of a savage (and such savages are known) who can scarce count up to five, and has to run through a process of calculation before he can say how many children he has, as the mind of such a savage is to that of a skilful mathematician, we see that to such a mind the process gone through by the animal in this case would be what a very profound calculation would be to the mathematician. In other words, we here have evidence that the difference between the mind of an animal and the mind of man is but one of degree, and that the animal is not more widely separated from man in this respect, than the lowest among men is from the highest.

EXAMPLES OF ANIMAL INTELLIGENCE.

As the preceding article passed through *Knowledge,* many interesting letters were received. The following are selected from among these :—

It is a common delusion, founded upon imperfect information, that animals guided by instinct do not modify their proceedings by reason, but persevere in a mechanical repetition of the same acts. Probably no creature with a complex nervous system that was observed with sufficient attention, under a variety of conditions, would be found so deficient in intelligence as this theory imagines. At any rate, it completely breaks down when applied to our common birds, and quite fails to explain the kind of facts to be narrated concerning the house martin. A cottage of many gables, situated on the slope of a wide heath, was for many years the favourite resort of this sociable bird, and in one season as many as thirteen nests were established. Now, according to the instinct theory, they ought to have been all alike, but in eleven cases there were obvious differences, some slight in appearance, but probably all-important for the stability of the erection or the comfort of its inhabitants. The simplest nest was quite open at the top, sheltered by projecting eaves, and very roughly finished at the margin. Another variety was built quite up to the woodwork, and had a side entrance left in the rough.

Others had similar side entrances, neatly finished with a rounded border. On a north-western gable, quite on its top corner, repeated efforts had been made to construct a nest which would brave the storm winds, and after several failures and mendings, a sort of buttress was stuck on below, evidently a new idea. On the southern side, a favourite locality was under a projecting window, sufficiently high above the sill of a lower window that no cat could reach it by a jump. In this situation the birds built twin nests—semi-attached houses, and they placed their doorways close to the wall on opposite sides, so that when looking at them, the left abode had its entrance on the extreme left, and the right one on the extreme right. If the entrances had been in any other position, the birds might have jostled in going in and out. The walls of the cottage being rough cast, offered a good foundation, but there is no tenacious clay near, and the martin architects were never quite successful with two of the highest gables, possibly on that account. Mischievous sparrows occasionally stole a nest, but the right birds were generally very comfortable, and reared their broods prosperously. It was, therefore, a matter of surprise that, after coming for many successive years, repairing old nests, and making new ones, they merely looked at the place, and did nothing in the summer of 1881. The weather was unfavourable, the birds arrived late, and prepared houses some way off, perhaps from their offering more sheltered situations. Towards the close of the martin season, the custom of the old birds for many years was to give the young ones some building lessons, and lines of foundation, several feet long, were usually attached to the cottage walls. Some of them served for the commencement of nests in the following season, but most of them seemed merely school exercises. If these acts were all done under blind instinct, there is a kind of blindness much like seeing, and it may be doubted whether the mud huts of the poor Irishmen exhibit much more intelligence than the martin's homes.

HENRY J. SLACK.

It strikes me that human beings might, perhaps, improve their "intelligence" by trying to acquire a curious habit possessed by some animals, especially the dog. I allude to the way they have of saving themselves up, so to speak, when not on duty, which nearly every one must have noticed, and which the following instance will illustrate:—They have, at my father's house, a small black-and-tan terrier, Toby III., who has taken upon himself the duty of escorting all strangers to the door on their leaving the house. On the slightest sign of a departure, Toby, although lying on the sofa snoring and apparently fast asleep, instantly starts up in a fearful state of excitement, and with every appearance of undying fury and hatred, fairly screams the visitor out. In less than a quarter of a minute he is once more comfortably asleep. It would be interesting to know how dogs have acquired this enviable knack of disengaging their attention when not required; perhaps it is partly because they are, unlike "the literary gentleman," not "exposed to much anxiety respecting family matters."

Some time ago a friend brought us a small terrier, under the impression that it was our Toby that had got lost. It was an amiable little creature, and, unlike Toby, willing to make friends with any one. On being noticed it would look up, shake its head, and actually *laugh* with satisfaction. If laughter be a sign of intelligence—and it is an attribute generally supposed to be confined to the most intelligent of all animals, man—our little friend must have been quite an "infant phenomenon." This is the first instance I know about of a dog laughing; but my wife assures me they had a dog which, although bold and courageous, would, on being left in the house alone, cry "real tears," just like a child.

J. H.

The strategic shifts of Colonel Perkins' (Purtons'?) dog, Bully, at Bangalore, remind me of another story connected with Bangalore. The late Rev. William Campbell, who was formerly a missionary there, on visiting Dublin, to advocate the claims of the London Missionary Society, went with some friends to see the Zoological Gardens in that city. While walking through the gardens, their attention was drawn to a particular den by the excitement of a small crowd before it. On approaching the place, they found it was the den of the Indian bear. Bruin was in a bad humour, and sat resolutely on his haunches, with his back to his visitors. Some tried to coax him with buns, others to startle him with shouts, and a few tried to stir him up with walking-sticks and umbrellas. All their efforts were in vain. At last it occurred to Mr. Campbell to address the bear in the language he was accustomed to in his youth, so he shouted "Cuddapah! Cuddapah!" (Get up! Get up!) To the surprise and amusement of the spectators, Bruin immediately turned round with a delighted grin.

CUDDAPAH.

While at the University, taking my medical course, the facts I relate took place. Among other appurtenances to the department of physiological chemistry was a dog with a gastric fistula, which fistula was properly healed around a silver tube having an internal and external flange to keep it in place. The tube was stopped by a closely-fitted cork, except at such times as we needed a supply of gastric juice. The fistula caused the animal no disturbance whatever. He was well and hearty, was fed at and made his home at the medical department.

During the summer vacation, however, when the University was closed, he was transferred to the care of the surgeon, who took him to his house. During his frolics one day he jumped over a fence, striking it, and dislodged the cork in the tube. Ponto soon noticed that his food didn't seem to satisfy him, and that all he drank ran out of his stomach on to the ground. His master having gone away for several days—fishing—he must needs take care of himself, so immediately on eating or drinking anything, he ran to his bed in the carriage-house close by, turned on his back, and remained so for an hour or more, or until he felt satisfied that it would do for him to get up. Coaxing, threatening, and kicking by the domestics about the house, or by those whose attention was called to his actions, were alike unavailing to drive him from his place or from his supine position. Finally, some one who knew for what purposes the dog was used, examined his fistula, and found the cork gone. This being restored, he was soon persuaded to go about as usual, and indicated by his actions that he understood that everything was all right. This incident can be vouched for by many reliable persons. Who will say that dogs—at least one dog—cannot reason?

F. L. Bardeen, M.D.

At one time our family rejoiced in the possession of five cats. One a magnificent black animal, assumed the air and dignity of chief amongst them, and was deferred to on all occasions by the other members of the feline community. One day I detected him in the commission of an outrageous attack on a juvenile member of the fraternity, and at once expressed my disapprobation in a most vigorous manner, chasing the culprit about the room, under chairs and tables, till he suddenly disappeared.

I listened a moment to catch any sound that might betray his whereabouts, and suddenly heard the latch of the kitchen-door fall. I rushed into the kitchen just in time to see Tom slide his forepaw between the door and the jamb, forcing the door open and leaping out into the garden, thence on to the top of a high wall, from which "bad eminence" he regarded me with a placid and unctuous look of injured innocence.

He had opened the door by jumping on to a small shelf near, from whence, by standing up on his hind legs, he could reach the latch and push it up with his forepaw, thus releasing the door, which then swung partially open. The rest, to a cat of "Sweep's" intelligence, was easy. I often afterwards watched him do it. He never succeeded (though he often tried) in opening the door from the outside, because there was nothing sufficiently near the latch on which he could stand while he pressed the thumb-piece of the latch downwards, a proceeding the necessity for which he evidently thoroughly understood, as evidenced by the way in which his attempts to open the door on the outside were made. He would leap up and catch hold of the latch-guard with one paw, while with the other he frantically struck (downwards) at the thumb-piece, continuing his efforts till his strength for the moment failed him, and he dropped to the ground.

He never asked any one to open the door for him. If he wanted to get out, he opened it and went out; if he wanted to come in, he *tried* to open it, and continued trying (the idea of ultimate failure never, apparently, entering his head) till the noise of his successive failures attracted notice and brought help.

We had several times been annoyed by joints of meat having been gnawed, and often found on the floor of the cellar; of course the cat, about three-quarters grown, was rightly blamed as being the delinquent. The maid repeatedly denied having left the cellar door open, but was for some time disbelieved, and I am sorry to say blamed, until one night, going into the kitchen after the family had retired, I found pussy, naught abashed, busily pawing away at the thumb-piece of the latch. I left her for a short time, and on returning found the cellar door open, and pussy busy with the meat. On examination I found the door would immediately swing open on the lever of the latch being pressed. Next day I had a spring put to the latch, and, needless to say, pussy has not troubled since, though it is not for the want of trying. She still lets herself into the kitchen from the garden—the outer door having a similar latch, climbing up the verandah until level with the latch, and pawing away industriously until the door swings open.

John Humphrey.

Correspondents of *Knowledge*, in treating of cats, do not seem to have remarked some acts of intelligence which may be observed daily in the streets of London. At the cry of the cat's-meat man all the cats are in commotion, but all are not excited by the cry of the same man. A dozen men may walk up and down the same street with the tempting morsels, crying "meat, meat!" but only at those houses which they are accustomed to serve will the cats be roused by the call. No sooner does the proper man arrive in the street than every cat he is accustomed to serve rushes frantically to the door, or, if allowed, into the street, running mewing towards him, rubbing against his legs, or sometimes sitting in a begging attitude before him, but never, as far as I have observed, attempting to steal from the open basket.

One day I noticed a cat whose man had either forgotten her portion or had been unable to make her mistress hear, and so had passed on. The cat, however, insisted on being attended to; she ran after him, mewing piteously, and when at last she made him understand, she ran back to the house before him, where by that time the mistress was ready to take the delicacy so much prized by all London cats, however well fed. I have often watched this act of discrimination in our own cat. Tom would sit quietly dozing whilst man after man went by with the familar cry of "Meat, meat!" but presently he would jump up, rush to the window, and remain in a state of great excitement, and soon after a distant cry of "Meat!" might be heard, and we knew that Tom had recognised his own man long before we had heard him. As the cry drew nearer, Tom's excitement increased, and he would almost fly to the door. A singular fact remains to be told. On Saturdays the man would leave two portions, as he did not go his rounds on Sundays. These were often thrown into the area, to which Tom had access. He would always greedily devour the one portion, but never touch the other, although they lay side by side. This cat would also open the latch of the kitchen-door, as observed by several of your correspondents, and would also open the shutters in the drawing-room (closed but not fastened), in order to look out of window. I have, however, been told of a cat who would open not only a latch, but an ordinary drawing-room door, rather loose, by taking the round knob between her paws and twisting it round and round till it opened.

The fact of cats distinguishing between one meat man and another seems to me to disprove the oft-repeated assertion that cats attach themselves only to places, and not to persons; for here we see them able to pick out a certain man by his voice alone, even at a great distance. A. W. Buckland.

During a recent passage over the North Sea, a flock of sea-gulls followed the steamer for many miles. At last I noticed that one of them, a remarkably fine bird, had, by some chance, got an angler's line attached to its wing. The poor thing flew about the rigging, its companions, meanwhile, uttering loud cries. After great cawing, the bird flew quickly towards the ship dashed round one of the ropes several times, and ultimately flew off, leaving the line twisted round the rope. Geo. B. Fraser.

OUR ANCESTORS.

BY GRANT ALLEN.

I.—THE STONE AGE MEN.

THERE are few questions more immediately interesting to Englishmen than the question—who are our ancestors? From what elements and in what proportions are we compounded? May we consider ourselves as all pure Teutons? or are we partly Celts as well? Furthermore, may we even reckon among our immediate ancestry some still earlier and less historical races than either of these? Such questions are full of practical importance to ourselves, and they are also of a sort upon which modern investigations into language and the science of man have cast a strikingly new and unexpected light.

Of course, in considering the origin of Englishmen, we must look at the matter in no petty provincial spirit. We must include roughly in that general name Welshmen, Scotchmen, and Irishmen as well; and if our friends in the north prefer to speak of Britain rather than of England, I am sure I, for my part, will have no objection. There are many learned modern historians, with Mr. Freeman at their head, who will tell us that Englishmen are almost pure-blooded Teutons, of the same original stock as the Germans, the Dutch, and the Danes and Norwegians. But when we come to inquire more fully into their meaning, it turns out that they are speaking only of the native inhabitants of England proper and the Scotch Lowlands, without taking into consideration at all the people of Wales, Ireland, and the Highlands, or the numerous descendants of immigrants from those districts into the south-eastern half of Great Britain. Even in the restricted England itself, these same doughty Teutonic advocates admit that there is a nearly pure Celtic (or pre-Celtic) population in Cornwall, in Cumberland, and in Westmoreland; while the western half of the Lowlands, from Glasgow to the border, is also allowed to be inhabited by a mainly Welsh race. Furthermore, it is pretty generally granted by our stoutest Teutonic champions themselves, that the people of Dorset, Somerset, and Devon, of Lancashire, Cheshire, Shropshire, Herefordshire, and Worcestershire, are all largely mingled with Celtic blood. Thus, in the end, it appears that only the native inhabitants of the Lothians and the Eastern and Southern coast of England are claimed as pure Teutons, even by those who most loudly assert the essentially Teutonic origin of the English people. We may possibly find that this little Teutonic belt or border itself is not without a fair sprinkling of earlier blood.

Perhaps the best way to clear up this question will be to glance briefly at the various races which have inhabited these islands, one after another, and then to inquire how far their descendants still exist in our midst, how large a proportion of our blood they have contributed, and whereabouts their representatives are now mainly to be found. Of course, in such an inquiry we can only arrive at very approximate results, for in our present advanced stage of intermixture, it is almost impossible for any man to say exactly what are the proportions of various races, even in his own person. Each of us is descended from two parents, four grand-parents, eight great-grand-parents, and so forth; so that, unless we could hunt up our pedigrees in every direction for ten generations, involving a knowlege of no less than 1,024 different persons at the tenth stage backward, we could not even say how far we ourselves were descended from Irish, Scotch, Welsh, or English ancestors respectively. As a matter of fact, every one of us is now, probably, a very mixed product indeed of Teutonic, Celtic, and still earlier elements, which we cannot practically unravel; and, perhaps, all we can really do is to point out that here one kind of blood is predominant, there another, and yonder again a third.

The men of the very earliest race that ever lived in England are probably not in any sense our ancestors. They were those black-fellows of the palæolithic or older stone age, whose flint implements and other remains we find buried in the loose earth of the river-drift or under the concreted floors of caves, and who dwelt in Britain while it was yet a part of the main-land, with a cold climate like that of modern Siberia. These people seem to have lived before and between the recurrent cold cycles of the great glacial period; and they were probably all swept away by the last of those long chilly spells, when almost the whole of England was covered by vast sheets of glaciers, like Greenland in our own time. Since their days, Britain has been submerged beneath several hundred feet of sea, raised again, joined to the continent, and once more finally separated from it by the English Channel and the Straits of Dover. Meanwhile, our own original ancestors—the people from whom by long modification we ourselves are at last descended—were probably living away in the warmer south, and there developing the higher physical and intellectual powers by which they were ultimately enabled to overrun the whole northern part of the old world. Accordingly, interesting as these older stone-age savages undoubtedly are—low-browed, fierce-jawed, crouching creatures, inferior even to the existing Australians or Andaman Islanders—they have no proper place in a pedigree of the modern English people. They were the aboriginal inhabitants of Britain; but their blood is probably quite unrepresented among the Englishmen of the present day.

Long after these black-fellows, however, and long after the glaciers of the ice age had cleared off the face of the country, a second race occupied Britain, some of whose descendants almost undoubtedly exist in our midst at the present day. These were the neolithic, or later stone-age, men, who have been identified, with great probability, as a branch of the same isolated Basque or Euskarian race which now lives among the valleys of the Western Pyrenees and the Asturias mountains. They seem to have crossed over into Britain while still it was connected with the Continent by a broad isthmus, or, perhaps, even by a long stretch of land occupying the entire beds of the Channel and the German Ocean. Our knowledge of them is mainly derived from their tombs or barrows —great heaps of earth which they piled up above the bodies of their dead chieftains. From these have been taken their skeletons, their weapons, their domestic utensils, and their ornaments, all the latter objects having been buried with the corpse, for the use of the ghost in the other world. From an examination of these remains, we are able largely to reconstruct the life of the Euskarian people—the earliest inhabitants of Britain whose blood is still largely represented in the existing population.

In stature, the neolithic men were short and thick-set, not often exceeding five feet four inches. In complexion, they were probably white, but swarthy, like the darkest Italians and Spaniards, or even the Moors. Their skulls were very long and narrow; and they form the best distinguishing mark of the race, as well as the best test of its survival at the present day. The neoliths were unacquainted with the use of metal, but they employed weapons and implements of stone, not rudely chipped, like those of the older stone age, but carefully ground and polished. They made pottery, too, and wove cloth; they domesticated pigs and cattle; and they cultivated coarse cereals in the little plots which they cleared out of the forest with their stone hatchets or tomahawks. In general culture, they were about at the same level as the more advanced Polynesian tribes, when they first came into contact with European civilisation. The barrows which they raised over their dead chieftains were long and rather narrow, not round, like those of the later Celtic conquerors. They appear to have lived for the most part in little stockaded villages, each occupying a small clearing in the river valleys, and ruled over by a single chief: and the barrows usually cap the summit of the boundary hills which overlook the little dales. Inside them are long chambered galleries of large, rough-hewn stones; and when these primitive erections are laid bare by the decay or removal of the barrow, they form the so-called "Druidical monuments" of old-fashioned antiquaries, a few of which are Celtic, but the greater part Euskarian.

At some future period I hope to lay before the readers of *Knowledge* a fuller account of these neolithic people and their existing remains. At present, the points to which I wish to call attention are: firstly, the fact of their existence in early days in Britain; and, secondly, the fact that many of their descendants still remain among us to the present day. Nor do I propose in this paper to estimate the numerical strength of the Euskarian element in the population of the British islands as it now stands. It will be best to consider that part of the question at a later point in this series, when we have seen what were the subsequent races which overcame, and in part displaced, the aboriginal Euskarian folk. For the moment, it will suffice to point out that before the arrival of the Celts and other Aryan tribes in Britain, these Euskarians spread over the whole of our islands, and were apparently the only people then inhabiting them. At least, the monuments of this date—perhaps from 5,000 to 20,000 years old—seem to be similar in type wherever they occur in Britain, and to contain the remains of an essentially identical race. I shall also add here, by anticipation, what I hope to show more in detail hereafter, that their descendants exist almost unmixed at the present day as the so-called Black Celts in certain parts of Western Ireland and Scotland, and in a few places in South Wales; while their blood may still be traced in a more mixed condition in Yorkshire, Lincolnshire, East Anglia, the Scotch Highlands, and many other districts of England and Scotland. How they have managed to survive and to outlive the various later Celtic and Teutonic conquests, we shall have to inquire when we come to consider the origin and progress of those subsequent waves of population.

II.—THE CELTS.

While the dark-haired and dark-skinned little Euskarians were living unmolested in the western coasts and islands of Europe—hewing patches out of the forest with their stone hatchets, building great barrows over their dead chieftains, and fighting among themselves from valley to valley, like the North American Indians of later days—a fairer and taller race was growing up unnoticed away to the east, among the great central table-lands of the Asiatic plateau. This fair-skinned, yellow-haired, and blue-eyed folk is known to us by the somewhat fanciful name of Aryans; and from it the chief conquering peoples of the whole Eastern hemisphere are derived. The Aryans spoke a language whose nature we can infer from the numerous modern dialects derived from it; and this language enables us in part to form some conception of the state of culture attained by the people who used it. In their earliest known condition, while they still all lived together among the high plains of Asia, they were hardly, if at all, superior in the arts of life to the Euskarians of Britain. They were ignorant of the use of metals, and armed only with weapons of polished stone. They fed their flocks like the semi-nomad tribes which still inhabit the same region, and they tilled a little grain of some coarse cereal kind. Altogether, if we regard them with calmly impartial eyes, and not with the excessive filial piety of some German thinkers, we shall probably be forced to admit that the primitive Aryans were, on the whole, about as good and as bad as most other barbaric peoples at the same period of the world's history. Stronger than the neighbouring nations they certainly showed themselves to be, but wiser or better there is no sufficient reason to suppose that they were.

From their original Central Asian home, these warlike Aryans began to disperse themselves as fighting colonists on every side, probably some five or six thousand years since. One great branch, now speaking the Celtic variety of the common language, moved westward across the face of Central Europe; and its members spread themselves, long before the beginning of written history, over all the western coasts of the continent as a conquering and superior race. Though at first they were only armed, like the Euskarians amongst whom they came, with stone hatchets and flint-tipped arrows, yet, as they were tall, big-limbed, powerful men, while the Euskarians were comparatively short, squat, defenceless folk, they seem easily to have overrun almost the whole of what is now France, Spain, and the Low Countries, and to have established themselves, at least as a rough aristocracy of chieftains, among the conquered and servile Euskarian population. But in some places the Euskarians, and their kinsfolk the Ligurians and Aquitanians, appear to have maintained their independence; while in others, though the Celts were masters, the dark-skinned aboriginal people yet survived in vast numbers. It was only in the most thoroughly conquered parts of the continent that the pure-blooded Celts themselves formed the principal mass of the population. The independent dark tribes of the extreme west retained their native language, which lives on to our own time as the Basque tongue; but the vanquished and enslaved Euskarians of the central French and Spanish regions learned to speak the dialect of their Celtic lords, as they afterwards learned to speak that of their Roman conquerors.

As yet the Celts had not attempted to attack Britain, which had long since been isolated from the continent, and could now only be invaded by a fleet of boats crossing the silver streak of sea. Before they took that last step in the conquest of Western Europe, they had learned the use of bronze, from which they manufactured beautiful axes, spears, and shields, besides producing many tools for more peaceable purposes. The employment of bronze enabled the Celts to make such improvements in ship-building that they could cross the Channel to Britain, which they found inhabited only by the small dark Euskarians, who were now at a still greater disadvantage, seeing that they were only armed with stone tomahawks, while their big assailants were armed with "weapons of precision," in the shape of bronze battle-axes, lances, and spears. The consequence was that the Celts soon overran nearly the whole island, and quickly subdued the better part of it to their own dominion. In the south-eastern plains, near the continent, they apparently settled in great numbers, so that when the Romans came they found that part of Britain mainly inhabited by a tall, fair-haired, light-skinned Aryan Celtic race. But in the west, the Celts only settled in comparatively small numbers, as lords of the soil, holding in subjection a large servile population of dark Euskarians; while in South Wales, and apparently in parts of the Scotch Highlands, the dark people remained wholly independent, as the inhabitants of those regions long afterwards did at the time of the English settlement. The South Welsh tribe of Euskarians were known as Silures, and they preserved their nationality intact down to the period of the Roman Conquest.

Now, what sort of people were the pure-blooded Celts who first came to Britain? No doubt it may be a shock to many readers to be told so, but they were undoubtedly a light-skinned, fair-haired, blue-eyed, and round-headed race—in fact, typical Aryans of the same sort as the modern Germans, and possessed of exactly those peculiarities which we ordinarily speak of as Anglo-Saxon. About this there can be no manner of mistake. Their barrows, known both by their shape and by their bronze implements, contain round skulls, quite different from the long skulls of the Euskarians; and the universal testimony of the Roman writers, whose knowledge of the Celts was obtained while they still lived in comparative purity in Gaul and south-eastern Britain, makes it quite certain that they had light hair, white skin, and blue eyes. How, then, comes it that most of us think of the Celtic type as essentially dark and black-haired? The reason is simply this. When the Celts conquered Britain, they left large numbers of Euskarians alive, in the northern and western part of the island, at least; and it is the mixed Celtic and Euskarian descendants of these people who now form the so-called Celts of the Highlands, Lancashire, North Wales, and Cornwall. Moreover, it is certain that the Euskarians of the conquered districts soon learned to speak Celtic alone, just as the Irish are now fast learning to speak English alone; and so after a short time they became as indistinguishable from the true Celts, as Normans and Danes in England have become indistinguishable from the rest of the community. Even the Silures, who maintained their position as an independent Euskarian tribe in South Wales, seem to have acquired the use of the Celtic Welsh tongue before the date of the Roman invasion. When contrasted with the Teutonic English, all these Celtic-speaking peoples came naturally at a later period to be regarded as Celts.

Thus, at the date when Britain first became known to the civilised southern world by the Mediterranean, and before any Englishmen had yet settled in the land, its ethnical arrangement was something of this sort: Along the southern and eastern plains, from Hampshire, by Sussex and Kent to East Anglia, Lincolnshire, and the vale of Yorkshire, there lived a light Aryan Celtic race, with more or less of subject or enslaved Euskarians—doubtless, a good deal intermixed, as negroes, mulattoes, quadroons, and whites, still are in the Southern States and the West Indies, though the light Celtic aristocracy probably kept up the purity of its own blood in the female line, as also happens in the analogous modern case. Further west and further north, among the hills of the Devonian peninsula, the West Riding, Cumberland, and the Highlands, the number of pure Celts was comparatively smaller, while the number of dark Euskarians was comparatively greater. And in Wales itself, the Silures remained as unmixed Euskarians, without a single drop of Aryan Celtic blood; while another small Euskarian principality seems also to have held out in the Athol district of Scotland. It is this compound mass of pure Celts, mixed Celt-Euskarians, and pure Euskarians, all speaking various Celtic dialects, that we ordinarily describe as Celtic, in contradistinction to the Teutonic English, who came to the country at a later date. As to Ireland, the primitive Celtic immigration there was very slight; and the mass of the population, though it acquired the Gaelic dialect of Celtic as its language, remained almost entirely Euskarian in blood up to the date of the Danish invasions, as it still remains in all except the northern and eastern coast. How far these arrangements of the various race-elements were upset by the English (or Anglo-Saxon) settlement, we shall have to inquire in our next paper.

III.—THE TEUTONS.

It does not seem likely that the Roman occupation left much permanent mark upon the ethnology of Britain. So far as we can judge, the Romans held the soil very much as we ourselves hold India—by a purely military tenure. A little sprinkling of Italian blood may perhaps have been indirectly introduced by the legionaries, though comparatively few even of these were really Roman. Most of them were Gauls, Spaniards, Germans, and Low Dutch peoples; and their influence could only have been felt, ethnographically speaking, in the immediate neighbourhood of the military stations, where a few half-breeds may have mingled scantily here and there with the native population. A more important result of the conquest, however, would doubtless be found in the general amalgamation of the older Celtic and Euskarian elements under stress of the new overlords. There is reason to believe that the greater number of Britons sank into the position of serfs, either employed on the great corn farms into which the land was parcelled out, or in the mines of Cornwall, Sussex, and the Forest of Dean. This grinding and levelling system of slavery must have pressed pretty equally upon Celts and Euskarians, light-haired Belgæ and dark Silurians, the former conquerors and the former slaves. Confused together in such a common serfdom, the two types seem to have coalesced, so that the lighter and numerically weaker Aryan Celts became practically almost merged into the darker and more numerous Euskarians. At least we know that ever since the Roman days, and down to modern times, the so-called Celts of Wales, Cornwall, and the Highlands are, for the most part, dark-haired and dark-skinned people of a more or less distinctly Euskarian physique, intermixed with comparatively few individuals of the true light Aryan type; and, as the races were distinct in the days of Cæsar and Tacitus, the coalescence probably took place during the period of the Roman occupation.

After the Romans were gone, however, a second flood of Aryan immigration began to spread over the land. The new comers were the English and Saxons, two Teutonic tribes of Low Dutch pirates, who then inhabited Sleswick and the coasts of Hanover and Friesland. There is no doubt that the original English were a light-haired, light-skinned, blue-eyed people of the ordinary Aryan sort. They came over in small clans or families, and settled first on the east and south coasts, from the Frith of Forth to Southampton Water, making their way, in most cases, into the interior, as was natural for pirates, by means of the inlets or estuaries. Whether the Teutons utterly exterminated the native Britons or not is a question that has been much debated from the historical point of view; and the weight of mere historical authority is certainly on the side of extirpation. Mr. Freeman and Canon Stubbs are both in favour of the belief that the early English conquerors killed off all the Britons—that is to say, in terms of our present discussion, the mixed Celtic and Euskarian inhabitants of the Romanised province—while Mr. J. R. Green, the very latest writer on the subject, is of opinion that the Britons were simply driven off in the struggle, but not to any appreciable extent absorbed or enslaved by the conquerors. From the anthropological point of view, however, such a belief is absolutely untenable. The existing English people is certainly not a pure Teutonic race, nor anything like one. It is a mixture, partly Teutonic, partly Celt-Euskarian; and to this fixed ethnological fact the history must somehow or other be accommodated. Every competent anthropologist, from the days of Phillips and Thurnam to the days of Professors Huxley and Rolleston, has consistently maintained that thesis. It is impossible to twist the evidence of plain modern facts to suit the supposed history, but it is very easy to reconstruct the history so as to accord with the existing facts.

The earliest English settlements were undoubtedly made along the coasts of Kent, Sussex, East Anglia, and Yorkshire. In Sussex, it seems as though the Saxon invaders did really drive away almost all the "Welsh" into the forest of the Weald, where their descendants may still, perhaps, be found; but elsewhere the Britons appear to have been partially subdued and enslaved. In Kent, where a body of Jutes landed, the dark type is still quite common; while in old interments of the heathen age, Jute and Briton are still recognised side by side, the anatomical peculiarities of their skulls being distinctly recognisable to a technical eye. In the plain of Yorkshire, Professor Phillips long ago pointed out that two very different types of physique still prevail, the one tall and light, of English or Danish origin; the other short, squat, dark, and black-eyed, of British or Euskarian origin.

Similar dark people are also common among the supposed pure English of Lincolnshire and East Anglia; while they are not infrequent in the oldest settled parts of Wessex, about Hampshire, Wiltshire, and the Isle of Wight. In fact, there is good ethnological reason for believing that, even in this most English part of England, the first Teutons did not wholly drive away the Britons, but conquered and enslaved some of them. This belief is fully countenanced by the few historians who have handed down to us some meagre traditional account of the English settlement; for both the Welsh monk, Gildas, who wrote a hundred years after the landing of the English in Kent, and the English monk, Bæda, who wrote nearly a century later, inform us that some of the Britons gave themselves up as slaves to their conquerors. No doubt such slaves would be quickly Teutonised in creed, and Anglicised in speech; but from the ethnological point of view a Euskarian is a Euskarian still, whatever religion he may happen to profess, or whatever language he may happen to speak. His tongue or faith would produce no immediate change in the colour of his skin and eyes. To this day, indeed, the darker people in the east of England are mainly to be found among the peasantry.

The midland districts of England were slowly conquered by the English, setting out from their earliest colonies on the coast; and as they moved inward, they appear to have spared more and more of the native Britons at each advance, and even to have substituted political subjugation for personal slavery. For example, it seems likely that the West Saxons landed in Southampton Water about fifty years after the Jutish conquest of Kent. They settled in Hampshire after some years' hard fighting, but more than half a century elapsed before they conquered Old Sarum and occupied Wiltshire. Still more slowly did they proceed across Dorset and Somerset, reaching Bath after nearly a century, Bradford after a century and a half, and Taunton after two centuries. In these two counties the proportion of Celt-Euskarian blood is very strong; in Devon, which was only finally annexed more than three hundred years after the first landing, the Teutonic element even now represents a mere fraction. As to Cornwall, that of course retained even its Celtic speech till the last century, as some parts of Devon did till the reign of Queen Elizabeth. Indeed, Alfred the Great in his will describes all the people of Wilts, Somerset, Dorset, and Devon, as Welsh-kind. This one example will show the comparatively small amount of Teutonic blood that the English invasion actually brought into the country. It was just the same elsewhere. In the Severn valley, for instance, Welsh and English coalesced very early, and the people of Gloucestershire, Worcestershire, Shropshire, and Cheshire, belong very largely to the dark type, while those of Herefordshire and Monmouthshire are purely Welsh by blood. So in the north, a great Welsh kingdom of Strathclyde long held out between Glasgow and the Mersey, and when at last it was conquered by the English of Northumbria, its people still remained upon the soil as subject inhabitants. To this day, the dark type is common in Lancashire, Ayrshire, and the hill districts of the West Riding, though in Cumberland and Westmoreland there is a large later infusion of light Scandinavian blood, about which more hereafter.

Thus, the English occupation was really, to a great extent, rather a mere Teutonisation of Britain than an extermination of the original Britons. The light Aryan stock, no doubt, received a large accession of strength; but the dark Euskarian stock was not by any means annihilated or driven away. In Sussex, Essex, and the Lothians, the English seem to have settled very thickly, and to have spared very few of the native Britons, though we must remember that these parts were probably inhabited for the most part by fairly pure Celts (not Euskarians), whose descendants we cannot now discriminate from those of the equally Aryan Teutons. In Yorkshire, Lincolnshire, East Anglia, Kent, and Hampshire, the conquerors apparently enslaved a considerable number of the dark serfs whom they found upon the soil; and their type is still preserved amongst the peasantry of those districts. As we move westward and inland, however, we find fewer and fewer pure English, mixed with a larger and larger proportion of dark natives. In the eastern midlands, the light type is commonest. In the western midlands and the Severn valley, the dark type distinctly predominates. In Devonshire, Herefordshire, Lancashire, and Ayrshire, a few English overlords seem, after a long struggle, to have settled at last among a very large subject population. And finally, into Cornwall, Wales, and the Highlands, the English never penetrated at all, except as purely political conquerors. But we must leave over for another paper the settlements of the Scandinavians in Scotland, the Lake district, and Ireland, as well as the existing distribution of the ethnical elements in the British Islands of our own day.

IV.—THE FINAL MIXTURE.

After the English settlement in south-eastern Britain, two other ethnical elements of less importance were added at different times to the population of our islands. Both were originally Scandinavian (and therefore Aryan) by descent, but more or less mixed with other strains from elsewhere. The first was that of the heathen Scandinavians from the North. In the eighth and ninth centuries, large bodies of Danes and Northmen began to settle all round the coasts of Britain. In Ireland they occupied all the large river mouths and havens, such as Dublin, Wexford, Waterford, and Cork, where they formed a set of Scandinavian colonies which gradually coalesced with the native Celt-Euskarian population. In Scotland they seized upon Caithness, Sutherland, and Ross, on the mainland, together with Orkney, Shetland, and the whole of the Western Isles, from Lewis to Arran. In

Wales they founded a few minor settlements around the south-west coast, near Milford Haven. Finally, in England itself, they occupied all Northumbria (including our Yorkshire), all Lincolnshire, Norfolk and Suffolk, and the greater part of the midlands. Important Danish "hosts" had their centres at Derby, Leicester, Nottingham, Huntingdon, Northampton, and Bedford. Norwegians also settled in the Lake District, till then peopled exclusively by the Strathclyde Welsh. How large an element in the population these Scandinavian invaders formed it would, perhaps, be difficult to estimate; but they must certainly have made a great accession to the number of light and fair-haired Aryan colonists. At the same time, since they came as mere pirates, they did not bring their women with them; and they therefore intermarried with the people of each district where they settled. Nor did they at all exterminate the earlier inhabitants. In Ireland their blood was thus almost lost in the prevalent Celt-Euskarian type; in the Lake district and the Scotch Highlands it has hardly had much more permanent influence; but in Eastern England, where the Scandinavians intermixed with the purest Aryan stock left in Britain, they must have afforded a very considerable reinforcement to the light type, and their fair hair has certainly left its mark upon a large part of the population.

The second Scandinavian admixture came later and more indirectly with the Normans from Normandy, under William the Conqueror. These Normans were originally Danes like those who colonised eastern England; but they had intermarried with the native women of Neustria (northern France), where they settled; and the Neustrians were, of course, Celtic Gauls, largely intermixed with Euskarian elements. Moreover, the Conquest brought over, not these half-breed Normans alone, but many pure Celt-Euskarian Gauls or Frenchmen from the neighbouring provinces as well, together with a considerable sprinkling of pure Celt-Euskarian Bretons from Brittany—a very dark stock, like the Black Celts of Ireland and Scotland. Accordingly, so far as numerical preponderance of the dark and light race goes, the Norman Conquest left things in Britain pretty much where they were before.

Thus, then, to sum up the general result of this brief inquiry, we may say that the ethnical composition of modern Britain is somewhat after the following fashion. First, there is a substratum or oldest stage of dark, non-Aryan people, whom we call Euskarians for convenience, and who are the descendants of the very earliest aboriginal inhabitants in recent times, the neolithic folk. These Euskarians are now nowhere to be found in very great purity, for they have married in with the later Aryan invaders till both are at present well-nigh indistinguishable. But they are still found in a fairly unmixed form among the Black Celts of Ireland and Scotland, where one or two little communities yet remain almost unaltered in the wilds of Connaught or the highlands of the central Scotch hills. They are also more sparsely recognisable in many parts of England itself, especially in the Yorkshire plain, in Lincolnshire, and along the Severn valley. And they are fairly frequent in wild Wales. All over the country, too, persons or families of this dark early type occur here and there sporadically. Indeed, it is probable that some relics of Euskarian blood survive everywhere in Britain, and that every one of us is more or less remotely descended on one side or the other from neolithic ancestors. Dark children of true Euskarian type are liable to be born from time to time in almost all families. It may be well to add also, in a science which is so personal to most of us as ethnology, that there is absolutely no sufficient proof that any one type or race in Britain is mentally or morally superior to any other. We must not fall into the easy habit of supposing that an earlier race is necessarily either a better or a worse one: the facts do not go to prove either supposition.

Secondly, there is a superstratum or later stage of light Aryan people, who have broken over the islands in three distinct waves—Celtic, English, and Scandinavian—and have everywhere mixed more or less with one another, and with the old Euskarian race. Ireland is, perhaps, mainly peopled by Euskarians, intermixed, in most parts, with Celts (but least so in Connemara and Kerry), while round its east coast there is much Scandinavian blood; and in Ulster there are many Scots, who are really Strathclyde Celt-Euskarians from the western lowlands. So-called English settlers, many of them Welsh or Lancastrian, and others Norman, are scattered throughout the Pale. But, as a whole, Ireland is probably more Euskarian and less Aryan than any other part of Britain. In Scotland, the north and the Isles are Celt-Euskarian, with a large Scandinavian admixture; the Central Highlands are Euskarian with a very small Celtic element intermixed; the Eastern Lowlands are mainly English; and the Western Lowlands are peopled by Strathclyde Welshmen—that is to say, Celt-Euskarians, probably with a larger dash of Aryan Celtic and English blood than elsewhere. Wales is Euskarian at bottom, slightly Celticised, and with a little English and Norse blood. England itself is mainly English (or Low Dutch) in the south-east; English and Danish, with a little Celt-Euskarian admixture, in the Eastern Counties, the North, and the Midlands; English and Celt-Euskarian in the West country, and the Severn Valley; and Norse and Celt-Euskarian in Lancashire and the Lake District. Cornwall alone remains almost wholly Euskarian in type. All these statements, however, must be accepted merely in the rough, and they apply especially to the agricultural classes and the mass of the people. At the present day, the upper classes have intermarried all over the three kingdoms; the mercantile classes have moved about till Mac's and O's are as common in London as in Perthshire and Mayo; and even the artisans have poured into every great manufacturing town from all parts of the country. Ever since the beginning of the modern industrial movement, there has been a steady southward and eastward return-wave of Celt-Euskarian emigrants towards the more organised regions. Irishmen have poured into London, Liverpool, Glasgow, and South Wales; Highlanders into Glasgow, Edinburgh, and Paisley; Welshmen into London, Birmingham, Liverpool, and Manchester. At the present day, as Professor Huxley remarks, the dark type seems once more to be numerically superseding the light one.

Almost all of us are English in language, but most of us are only very partially English in blood. To put the same matter another way, our oldest element is the dark one, now scattered up and down through the population, and only gathered very sparingly into a little nucleus here or there in Ireland and Scotland. This element was Celticised, but not exterminated, by the Aryan Celts, and became with them the Celt-Euskarian "Ancient Britons" of our history-books. Then the Celt-Euskarian was conquered by the Teutonic English, and Anglicised into the English of pre-Norman times. Next, these mixed English were conquered by Danes, whom they shortly absorbed. Dane and English were afterwards conquered by Normans, whom once more they absorbed. Dane and Irish in Ireland were next conquered and Anglicised by Norman-English, and the country further settled at various times by English and Scotch. Lastly, all these elements have coalesced with Welsh, Highland Scotch, and Scandinavians of the Isles, to form one heterogeneous British nation, so inextricably intermixed that its ethnology can now only be re-constructed in the rough. But all through, each earlier element has everywhere persisted in the resulting mixture, and it is probable that the numerical proportion of all the older elements, especially the Euskarian, is far greater than people generally at all imagine.

THE BEETLE'S VIEW OF LIFE.

BY GRANT ALLEN.

Here on a yellow crocus, buried deep in the beautiful golden cup, I have found a little bronze-mailed beetle, stealing the pollen as hard as he can eat it, and hugely enjoying his plentiful morning feast. I have picked him carefully out with a little bit of stick, and I have got him here now crawling about suspiciously upon my hand, and trying to find out what is the best way down from that unpleasantly warm and dangerously mobile valley—the hollow of my palm. I often wish I could discover how the world looks to that small creature here; and, perhaps, the question is not quite so unanswerable as it appears at first sight. When one remembers that brain and nervous system are on the whole a good index of mind, and that feelings and ideas depend upon the arrangement of the various sense-organs and their connected central parts, it will be clear that, after all, we may make a fair guess at what is passing in this little beetle's head, especially since his notions about things generally must in all probability be a good deal simpler and more directly dependent upon his sensations than our own.

Now, what, in the first place, are the beetle's senses? He can see, that we all know; and his sight is on the whole a good deal like our own. His eye can discriminate form, and that accurately, for in all flying creatures this sense is necessarily highly developed; it has been evolved and perfected side by side with their wings, or else they could never have learned to fly at all. They can doubtless distinguish colour, too; for we know positively from Sir John Lubbock's experiments that this is the case with bees, and there are good grounds for believing that the same thing is true of all flower-feeding insects as well, since all alike seem to be guided to the flowers by their brilliant hues. Sir John put drops of honey on slips of glass above bits of coloured paper; and when he had once taught a bee to feed from one slip, say the blue, he found that it would return straight to that slip, even when the relative places of the colours had been transposed. Now, almost all flowers which contain honey have also bright petals; and Mr. Darwin has shown that both honey and petals have been developed by the flowers for the sake of attracting insects, which carry their pollen from head to head, and so fertilise and impregnate the seeds. Moreover, the colours of the petals differ in different species, according to the kind of insects which they each wish to attract. Thus, bee-flowers are usually blue or red; and Sir John Lubbock has proved that bees show a distinct preference for these colours, while beetle-flowers are often yellow, and small fly-flowers are generally white. Such facts, and others like them, show that the beetle has sensations of sight essentially identical with our own, and also that he has certain special tastes for certain special hues and blossoms.

It is much the same with the other senses. The beetle certainly hears sounds; and his hearing appears to be analagous to our own; for though he himself is not musical, yet many other insects are; and these produce special notes and melodies to charm the ladies of their kind. He can also taste, and is fond of sweet things, like most other animals, for the flowers which seek to allure him lay by a drop of honey for his use; and this liking for sugary juices is shared by almost all insects, from the flies which crowd around a barrel of treacle at a grocer's door, to the ants which suck the honey-dew from the little green aphides that they keep as we keep cows. Last of all, he can smell, for the flowers which depend on him for fertilisation are usually perfumed, and both beetles and other insects are often attracted by scent, as all collectors well know; indeed, they frequently catch rare insects by enclosing one of their mates in a box, when the quick-scented and eager lovers soon sail up from leeward, evidently attracted by the distinguishing odour borne upon the breeze. Nay, some butterflies have special scent-glands among the feathery scales on their wings, to make them more charming to their pretty spouses, just as so many of the higher animals have a peculiar musky perfume. I may mention that Mr. Darwin similarly sets down the brilliant colours and ornamental spots of butterflies, as well as the curious horns and excrescences of many beetles, to the long selective action of their fair lady-loves, who always choose the handsomest and strongest among their numerous rival suitors. It is to this same cause that we probably owe the bright iridescent hues and bossy headpiece of the little creature who has now just escaped from my hand by clumsily transferring himself to yonder tall blade of rank meadow-grass.

Thus, as far as his outward picture of the world goes, the beetle's ideas must really be very similar to our own. The universe of sights, sounds, smells, tastes, and touches through which he moves must present the same general effect as that which we ourselves experience in our intercourse with outer things. But when we come to consider the relations which the beetle establishes between these primordial sense-impressions, the little ideas and emotions which he elaborates out of them, we find signs that the difference is vast indeed. Though the material is the same, the product is as unlike as the letters of the alphabet are to the "Iliad" or "Paradise Lost." The elements of human thought are there, but the organising and co-ordinating power is wanting.

If you were to cut open the beetle's head, you would find in it a small knot or lump of nervous matter, roughly answering to our own brains. To this lump the various sense-organs send up bundles of nerves; and in it the impressions derived from the different senses are compared and arranged, so as to produce the common impulse upon which the beetle acts. But the size of this nervous knot is vastly smaller in proportion to the insect than the human brain is to the body of a man. Our brain consists of numberless cells, arranged and united in definite subordination to one another, and so disposed that every part of our nervous mechanism can be brought into relation with every other; while in many cases we are not concerned in our mental operations with actual sense-impressions at all, or even with memories of such impressions combined into the shape of ideal objects, but with wholly abstract conceptions, elaborated out of them by the action of the brain itself in its higher parts. The beetle, however, can do nothing analogous to this. Its mental life is wholly made up of direct impressions and actions immediately dependent upon them. Memories it doubtless possesses in a slight degree, especially in the form of mere recognitions; but it is not probable that it can think of an object in its absence, or voluntarily recall it; while it certainly cannot reflect as we can about abstract ideas, or even about things which do not concern its immediately present needs and actions.

Indeed, the whole nervous system of the beetle is so loosely bound together—so little co-ordinated, as Mr. Herbert Spencer puts it—that it can hardly be said to possess any distinct voluntary capacity, or any strongly-marked personality at all. In the case of man and the other higher animals, almost the whole nervous system is bound up with the brain, sending messages up to it, and receiving orders from it in return, so that a single great nervous centre governs all our movements, and ensures that uniformity of action without which the complicated activities of human life would be impossible. The only nerves (worth mentioning) in the human body which are not thus under the control of the brain, are those of the heart and other internal organs; and over these parts, as everybody knows, we have not any voluntary power. But all our limbs and muscles are moved in accordance with impulses sent down from the brain, so that, for example, when I have made up my mind to send a telegram to a friend, my legs take me duly to the telegraph office, my hand writes the proper message, and my tongue undertakes the necessary arrangements with the clerk. But in the insect's body there is no such regular subordination of all the parts composing the nervous system to a single central organ or head-office. The largest knot of nerve-matter, it is true, is generally to be found in the neighbourhood of the sense-organs, and it receives direct nerve-bundles from the eyes, antennæ, mouth, and other chief adjacent parts; but the wings and legs are moved by separate knots of nerve-cells, connected by a sort of spinal cord with the head, but capable of acting quite independently on their own account. Thus, if we cut off a wasp's head and stick it on a needle in front of some sugar and water, the mouth will greedily begin to eat the sweet syrup, apparently unconscious of the fact that it has lost its stomach, and that the food is quietly dropping out of the gullet at the other end as fast as it is swallowed. So, too, if we decapitate that queer Mediterranean insect, the Praying Mantis, the headless body will still stand catching flies with its outstretched arms, and fumbling about for its mouth when it has caught one, evidently much surprised to find that its head is unaccountably missing. In fact, whatever may be the case with man, the insect, at least, is really a conscious automaton. It sees or smells food, and is at once impelled by its nervous constitution to eat it. It receives a sense-impression from the bright hue of a flower, and it is irresistibly attracted towards it, as the moth is to the candle. It has no power of deliberation, no ability even to move its own limbs in unaccustomed manners. Its whole life is governed for it by its fixed nervous constitution, and by the stimulations it receives from outside. And so, though the world probably appears much the same to the beetle as to us, the nature of its life is very different. It acts like a piece of clock-work mechanism, wound up to perform a certain number of fixed movements, and incapable of ever going beyond the narrow circle for which it is designed.

WHAT IS A GRAPE?

BY GRANT ALLEN.

They make a beautiful picture, these big English hot-house black Hambros, with their purple bloom and waxlike texture, clustered thickly together in rich luxuriance on their slender and heavily-weighted branching fruit-stalks. Indeed, we have now cultivated them to such a pitch of excellence, that their old wild ancestors would hardly recognise them to-day for members of the same original woodland family of Oriental climbers. Yet, after all, we have only been able to carry a little further, by careful selection and tillage, the peculiarities which Nature had long since produced in the primitive native stock. At best, man can only develop more fully what the plant itself has well begun. Our ornamental flowers are but the handsomest chosen wild blossoms; our cereals and edible roots are but the starchiest wild seeds and tubers; and our garden fruits are but the pick of the hips and haws and wayside berries, improved and altered by ages of cultivation.

The grape-vine, they say, comes to us originally from the shores of the Caspian. Even in its native condition it produces little sweetish acid grapes, hanging in purple clusters among its green festoons. The question is, then, of what use to the plant itself are these juicy fruits? For we now know that whatever use man may make of this, that, or the other organ in any particular plant or animal is, so to speak, an accidental after-thought; the organ always subserves besides some useful purpose in the economy of the plant or animal itself to which it belongs. Now, of course, the main use of all fruits is to produce or contain the seeds. They are merely seed-vessels, and, in most cases, they are dry and brown when ripe, like the pea-pod, the poppy-head, or the capsule of the mignonette. The problem we have to answer in the case of the grape is therefore this: Why should it be pulpy and prettily coloured, while these other fruits—and, indeed, the vast majority of all fruits—are mere dry and unattractive organs?

The analogy of red and white and yellow flowers affords us a good hint towards the solution of this problem. We know that flowers have acquired their bright hues, their honey, and their perfume, for the sake of attracting the insects which fertilise them by carrying pollen from head to head. Is there any way in which fruits can similarly benefit by alluring the eyes of any animal race? At first sight this would seem impossible; but a little consideration will show us a way out of the difficulty. Most plants, it is true, can only lose by allowing their seeds to be perceived and eaten by animals. In such cases the fruit, be it pod or capsule, is usually inconspicuous in colour, and drops its tiny little seeds quietly out upon the ground beneath. Those plants which best succeed in diverting the attention of seed-eating birds or mammals from their fruits, outlive, in the long run, their less adapted neighbours; and so the survival of the fittest has brought it about that ninety-nine kinds out of a hundred in our own day have unnoticeable little green or brown seed vessels, such as those of the chickweed, the pimpernel, and the clover tribe, which nobody but a botanist ever observes at all. Suppose, however, that any plant happens to have its seeds covered with a moderately hard and indigestible outer coat, would it not then be rather benefited than otherwise by having these seeds enclosed in a soft and juicy bed of edible pulp? For in that case birds and other animals might eat the seeds, fruit and all, for the sake of the pulpy covering; and as the hard little shell would protect the young embryo within, this vital part would not be digested, but would pass uninjured through the creature's body. By such an arrangement the plant would not only get its seeds dispersed—in itself a most important matter—but would also have the young seedling well manured and started in life under unusually favourable auspices. If such a tendency were ever to be set up even in the slightest degree by a mere sport or chance variation, we may be sure the variety in which it appeared would be so favoured by circumstances, that it would soon become a marked and distinct species.

As a matter of fact, it is pretty certain that such has been the origin of all edible pulpy fruits. Take, for example, these grapes here. If you cut one of them open, you will find inside a number of hard little seeds. Slice one of these again with a sharp penknife, and you will see that it consists of a tiny embryo plant in the centre, surrounded by a very solid bony shell. Each seed is in fact a miniature nut; and the kernel, so to speak, consists of the tiny plantlet within, together with the albumen on which it feeds when it first begins to germinate. Now, if any bird were to swallow and digest this vital part of the seed, the plant would, of course, be an obvious loser. But the hard shell prevents such a catastrophe from happening; and, therefore, the plant is benefited by the soft, eatable pulp which surrounds these little mimic nuts. Observe, too, that the fruity part of the grape is sweet; it contains grape sugar. Now sugar is always laid up in those parts of plants which specially seek to attract the animal world. In flowers, the nectar allures the fertilising bees and butterflies; in fruits and berries, the sweet juices allure the birds which disperse the seeds; nay, even the pitcher-plants secrete honey to wile flies into their insect-eating cups; and certain acacias store it up in hollow thorns to attract the epicurean ants, which, in turn, protect the tree by driving away their leaf-eating relations. In almost every case, one may say that where sugar is found in any organ of a plant, it is placed there for the sake of engaging the attention of some animal ally; while, conversely, all flower-feeding and fruit-eating creatures always manifest a marked taste for sweet substances, dependent upon their long habituation to sugary food.

Not only, however, are the grapes sweet, but they are also brightly coloured. Naturally, among succulent fruits bidding for the attention of birds, those would best succeed which were most visible at some little distance. Accordingly, just as the insect-fertilised flowers have developed brilliant pigments in their petals, so the fruits which depend upon birds for the dispersion of their seeds have acquired prettily-coloured coverings. We all know how noticeable are the hips and haws, the holly-berries and rowan-berries, even among our northern woodlands; while the oranges, mangoes, and pomegranates of the tropics appeal even more vividly to the sharp eyes of monkeys, parrots, and toucans. At the same time, it is noteworthy that the tastes of birds with regard to colour seem to differ somewhat from those of insects; for, as Mr. Wallace points out, white, which is a common colour for flowers, is rare among fruits; while purple and bluish-black, which are seldom met with among flowers, may almost be considered as the ordinary colours of most wild fruits.

Looking closely into my cluster of grapes, again, I see that it still contains two or three unripe and stunted specimens. These, of course, are pale-green, like the leaves, and when I taste one of them I find it unpleasantly harsh and acid to the palate. This reminds me that grapes, like other fruits, are not at all stages of their existence sweet and brightly coloured. While the seeds are still immature, they would only lose by being eaten, because they are not yet fit for germination. In this stage, therefore, the skin is filled with green colouring matter, and the cluster is quite inconspicuous among the foliage which surrounds it. It does not *want* to attract attention in its present stage. Furthermore, the pulp at this period is filled with tartaric acid and other sour juices, to repel any too-inquiring or too-impatient visitor. But as the seeds mature, the fruit ripens, that is to say, a chemical change goes on in the pulpy portion, which results in the formation of grape-sugar. At the same time other chemical changes taking place in the skin result in the production of the purple bloom, which advertises to the birds the presence of the sweet juice within. The whole process obviously aims at concealing the fruit and rendering it unpalatable while the seeds are immature, and at making it conspicuous as well as pleasant the moment the seeds are ripe for dispersion. Hence we are justified in concluding that the development of the grape is due to the long selective action of fruit-eating birds. Originally, no doubt, the primitive ancestral vine produced smaller and harder seed-vessels, which were probably green when young, and brown when ready to fall upon the ground. But some of them happened to show a tendency towards producing larger and juicier fruits, and these were constantly favoured by the unconscious friendliness of the neighbouring birds. The colour and the sweetness would soon follow, as they have followed a thousand times over in the development of each separate edible fruit. A grape, in short, viewed from the standpoint of the vine itself, is merely a cunning device for ensuring the assistance of birds or mammals in dispersing the little, nut-like seeds of which man takes, as a rule, such scanty notice.

GERMS OF DISEASE AND DEATH.

BY DR. ANDREW WILSON, F.R.S.E.

MOST readers have heard of the "Germ Theory," and there are few persons who do not know what the hypothesis of that name means and implies. Popularly regarded, this theory holds that a very large proportion of the diseases that affect and afflict man and his neighbour animals, owe their origin to minute forms of life —whether animal or vegetable, or both, is still, in most cases, a matter of doubt. To select a single illustration of the application of this theory, we may take the case of small-pox, and its analogous condition the fever produced by vaccination. When an infant is vaccinated, the physician introduces into its system, through an abrasion of its skin, a minute quantity of vaccine lymph, which, as everybody knows, is obtained either from the vaccination pustule of an already vaccinated child, or direct from the calf. In either case, there are introduced into the infant body, certain minute germs—suspended in and living naturally amongst the vaccine lymph—and in due course these germs multiply and increase within the frame, thereby producing the characteristic fever, and the equally characteristic pustule at the seat of the operation. So, also, with small-pox, which vaccination imitates in a mild way, and of which, moreover, it is a preventive. Here the germs of small-pox, obtained directly or indirectly from an already infected person, attack the body. Gaining admittance thereto, they propagate themselves within the tissues and through the medium of the blood. Sooner or later all the characteristic symptoms of the disease are manifested, and having run its course, it dies away as mysteriously, to all appearance, as it came. Now, there is something strikingly analogous in all this to the growth of an animal or plant. There is a period of "incubation" in the fever, just as in the production of the living being there is a period of development. There is a growth of the fever, as the animal or plant grows towards its maturity; and there is a decline of the disease, as the living form passes to its old age and death. So far, then, the parallel between ordinary life and the birth, growth, and decline of a disease, is very close and clear.

But the analogies are not yet exhausted. Each fever produces its like, as do animals and plants. Each disease reproduces its kind, as Tyndall has somewhere observed,[1] as rigorously as dog and cat reproduce their like. The phenomena, or, as a doctor would call them, the "symptoms," of each disease are as a rule, highly distinctive. The symptoms of scarlatina are not those of small-pox; measles is different from the other two; whilst typhus fever is again thoroughly different from all three. Analogy may, as Darwin says, be a deceitful guide; but when the facts are so closely allied, as are the facts of epidemic diseases to those of animal and plant development, the use of analogy cannot be doubted in rendering the relationship clearer.

We are now in a position to understand more clearly the utility and strength of the germ theory in certain of those aspects which bear most materially on science at large. It would only serve to strengthen the idea that our epidemic diseases are simply the offspring of lower life, if we reflect in passing that there are known to science a very considerable number of lower plants which produce in man's skin effects and diseases as characteristic as those which a fever induces in his system at large. Thus, the disease known as "ring-

[1] Quoting a remark by Miss Nightingale.—Ed.

worm" is caused by the growth in the human skin of a parasitic fungus, and a whole series of skin affections is known wherein lower plants play the part of direct causes. Thus, if it is a matter of certainty that a particular skin-disease is caused by lower-plant growth, so no less is it by analogy likely that all other contagious and epidemic diseases are in reality the products of life.

So much for the general idea that permeates the "germ theory" of disease. Within the past few months some highly important additions have been made to our knowledge of the part played by lower organisms in the production of disease. M. Pasteur, whose researches into the development of lower organisms have placed him in the foremost rank of scientific workers, has detailed at length the results of his investigations into the causes which produce the curious disease known as *charbon*, *anthrax*, and *splenic fever*. This disease, whilst but rarely attacking man, is fatal to horses, cattle, and sheep. France suffers greatly from this "plague of boils," and it is also known in various other countries as a literal scourge. Pasteur, it should be mentioned, had already acquired much valuable experience in the investigation into the cause of the *pébrine*, or silkworm disease, which in 1863 had devastated the silk industry of France. Pasteur showed that *pébrine* was caused by the growth and multiplication, within the bodies of the insects, of minute "corpuscles," which were practically lower forms of life. Even the eggs from which the worms were hatched, were shown to be liable to infection from *pébrine*; the eggs, in such a case, inheriting the disease from the parent moth which laid them. As the result of a long and laborious series of experiments, Pasteur showed that the *pébrine* would spread like an infectious disease by the contact of whole with diseased worms. He showed that, just as man isolates his fever patients, so the French silk-grower had to isolate and separate his diseased worms. But the knowledge which led to this effectual result was knowledge that had been won by an uphill fight, and that had been gained by the object-glass of the microscope, and by the whole-souled devotion of many months' industry.

Turning now to the *Charbon* or *Splenic Fever*, we witness another veritable triumph of Pasteur's industry and research. In 1850, certain observers noted the interesting fact that minute, rod-like bodies, which appeared to be lower forms of plant life, existed in the blood of animals affected with this disease. The "rods," it was observed, originated from particles which might, with perfect accuracy, be called "Germs." And as we watch the "rods" in turn, we see that, sooner or later, microscopic specks appear in their substance; these grow to form regular bead-like rows within the "rods"; and when finally the "rods" themselves break up and fall to pieces, these beads are liberated as the "germs," which in time will grow into new rods. Thus countless myriads of rods and germs grow and are reproduced within the body of the animal suffering from *splenic fever*. The fever, in a word, is the result of the growth and development within the living soil, of these rod-like plants. But exact demonstration of the truth of the latter statement can be had.

If we grow and cultivate in a proper fluid—such as the aqueous humour of the eye of an ox—the "rods," we may inoculate with our "rods" the body of a healthy animal. We may *sow* in that animal's body the germs of splenic fever. Thus a drop of a solution containing the "rods" sown within the body of a guinea-pig, produces splenic fever in that animal. And more wonderful still, it has been shown that the dried blood taken from an animal affected with this fever will reproduce the fever, even after an interval of four years, if the dried particles of blood with their "rods" be introduced into the body of a healthy animal.

Pasteur, armed with knowledge of the kind just detailed, set himself to ascertain the "reason why" splenic fever should suddenly appear in districts which knew it not, and wherein only healthy animals lived. Obviously, if the germ theory were true, such sudden and apparently isolated outbreaks must be capable of being explained on this hypothesis. The idea of the "spontaneous," or *de novo*, or *ex nihilo* origin of the disease would, if supported by facts, prove fatal to the "germ theory." Here, then, was a typical case for scientific investigation. Let us see how the genius of Pasteur overcame the difficulties of the situation.

The localities in which splenic fever seemed to burst out suddenly and without warning were, as Pasteur learned, former seats of the disease. But the interval between the visitation was to be measured by years. How, then, could the new outbreak be accounted for? It seemed, in truth, as if the one outbreak had little or nothing to do with the other. The infected animals which had died, or had been killed, whilst suffering from the fever, were duly buried, and that very deeply, in the soil. Such a method of interment would seem to obviate all risk of infection. But the possibilities of nature are illimitable, and no man knew this better than Pasteur. If the poison had been buried in the soil, why should it not be there still? And, further, why should it not be conveyed upwards to infect the fresh flocks that fed on the graves of their predecessors? With a gift of scientific divination, Pasteur sought in the earthworm, the type of the "middle-man" betwixt the living and the dead. He now examines the bodies of the worms which live in the soil wherein the bodies of the animals infested with splenic fever, years before, were entombed. By experimental means, he solves his problem. He makes a preparation of the contents of the digestive system of the worms. This he administers in the food of healthy animals, entirely removed from the pastures. And once again a scientific principle dawns in view. The rabbits and guinea-pigs which devoured the matter obtained from the worms at once developed splenic fever, whilst in their blood the rods were seen developing in full force. Once again Pasteur had sown the fever, and had argued thus from the result, backwards to the cause. It has also been proved, that even grain may convey the subtle "rods" to healthy animals, and may in this way engender splenic fever. Following close upon the heels of the discovery of the germ-origin of this fatal malady, comes the gratifying announcement that, as small-pox is modified by vaccination, so splenic fever may be modified by an analogous process. Pasteur has proved that we can inoculate sheep and cattle with a mild form of fever which protects the animal from a recurrence of the disease; and this protective influence, as we write, is being practically utilised by the breeders of France.

Such is a brief recital of a new step towards a perfect knowledge of the nature of the diseases which decimate, not merely animal life, but human existence as well. It may not be inappropriate if, by way of close, we remind our readers of two very noteworthy points in connexion with this all-important topic, bearing, as it does, in the most intimate manner upon the physical welfare of man.

The first of the points to which we refer concerns the apparently trivial origin of an all-important subject. It was in the city of Florence, some two hundred or more years ago, that a certain physician, Francesco Redi by name, demonstrated to the Florentine wiseacres that the maggots in meat do not arise from the dead meat by "spontaneous generation," but were produced from the eggs of flesh-flies. This result he achieved by covering over the meat with gauze, so that whilst the meat-decay proceeded, there was likewise a convincing absence of maggots. Childishly simple as was Redi's experiment, it laid the basis and method of all succeeding research; for from his day to ours the progress of the "germ theory," or of that doctrine which holds that all life, however mysteriously generated, must spring from pre-existing life, has been uniform and triumphant.

But the second point to which attention is worthy of being directed, exists in the statement that the practical and actual benefits which have flowed to human health, and which are likely to flow in the future as well—the saving of life by the prevention and extermination of disease—arise from a simple study in natural history. So-called "practical" minds are often given to loudly express their disapproval of any science which deals with what, to them, seem mere abstractions. Doubtless, to such minds the study of the development of the "rods" of splenic fever under a watch-glass, must seem a piece of scientific *dilettantism;* just as information respecting the solar system may seem despicable enough, because its results cannot be measured by a profitable currency, or, in plain language, because it "doesn't seem to pay." The best answer to such foolishness, is found in a recital of the results to human and animal life to which natural history study seems likely to lead. Just as two hundred years ago, in Florence, Redi began the good work by a simple study in zoology, so to-day we are reaping the reward of the earnest work of the botanists and zoologists who toil and labour to spread abroad their saving knowledge.

A WONDERFUL DISCOVERY.

BY R. A. PROCTOR.

NOT long since a story was started in an Australian paper to the effect that a means had been found by which animals could be frozen into insensibility, and restored to life after months or even years had passed. If the narrative had any foundation in scientific possibilities, the discovery would involve results far more remarkable than those affecting the exportation of cattle. Indeed, to consider the matter only from an agricultural point of view, our farmers at home would gain much more than the Australian squatters. The great difficulty of profitably feeding cattle during the winter months would be disposed of very simply and effectively. Nothing more would be needed than to congeal the larger part of the live stock late in the autumn and to restore them to life in spring. But the application of the process of "congelation without killing" to human beings would be altogether the most important result of the wonderful discovery—if only the wonderful discovery had really been made or were in any way possible. Unfortunately, it would seem that our cousins in Australia are beginning now to do what the Americans were famous, or rather were notorious, for doing a quarter of a century since or more. They invented lately for our benefit the telegastograph, an instrument by which a dinner, with appropriate wines, could be communicated by the electric wire, at least so far as the taste of the food was concerned. And now they provide for us a story of a still more stupendous kind. We believe, however, that they can claim credit in this case only for preserving and exporting the concoction of American artists, the wonderful discovery having been originally published in New York, though even then purporting to be an Australian invention.

It is singular how these ingenious narratives resemble each other in style and turns of expression, even when they unquestionably come from different sources. The writer of the clever paper called "The Lunar Hoax" must long since have joined the majority, since that hoax appeared 44 years ago, and he was not a young man then. But the account of the Australian discovery might have been written by the same hand, so closely does it resemble "The Lunar Hoax" in manner of treatment. To begin with, both stories contain just that germ of scientific truth which is necessary to give an air of probability to such inventions. In the "Lunar Hoax" the optical relations on which the possibility of detecting living creatures in the moon is made to turn, are so dealt with that unscientific persons might readily have been deceived, and, in fact, many were deceived. It was said that even Arago was entrapped and circulated all over Paris the wonders related in the pamphlet. But there were errors in the optical discussion of the subject which would have saved a junior optime at Cambridge from being deceived, to say nothing of one so well acquainted with optical laws as Arago. Still, the idea of first illuminating the optical image (the so-called "real image" as distinguished from the virtual image of the Galilean telescope) by the transfusion of light, and then magnifying the image so illuminated, was ingeniously devised to deceive the inexperienced. "Why," says Sir John Herschel, in conversation with Sir David Brewster, "why cannot the illuminating microscope—say, the oxyhydrogen—be applied to render distinct, and, if necessary, even to magnify, the focal object?" The idea is enthusiastically received by Brewster. In an ecstasy of conviction he sprang from his seat, exclaiming, "Thou art the man!" And starting from this utterly unscientific but apparently quite plausible conception, all the rest of the story follows naturally enough. So, in the Australian "discovery," the idea underlying the whole story is that the hibernation of animals can be artificially imitated and extended, so that, as certain animals lie in a state of torpor and insensibility throughout the winter months, all animals may be caused to lie in such a state for an indefinite length of time if only a suitable degree of cold is maintained, and some special contrivance (in this consists the wonderful discovery) adopted to prevent insensibility passing into death. Precisely as the real wonders of telescopic discovery are so great that scarcely anything will be believed to be impossible by those unacquainted with the circumstances limiting telescopic power, so the hibernation of warm-blooded animals is in itself so wonderful that the inexperienced might well believe in any marvels resulting from an extension of the hibernating process. It has been well said that if hibernation had only been recognised among cold-blooded animals, its possibility in the case of mammals would have appeared inconceivable. Possibly in that case the first recognition of the complete hibernation of the bat and hedgehog would have been received with as little respect as the wonderful Australian discovery, though one case is, we know, not only possible, but actually existent, whereas the other is not consistent with scientific possibilities. For no one who understands what hibernation really is will for a moment confound it with the form of insensibility imagined by the inventor of this hoax. The bat and the hedgehog resign themselves to torpor when the insects disappear on which they live while their active life continues. The breathing becomes slower and slower, and at last ceases altogether. The heart beats more and more slowly, more and more feebly, but it never ceases altogether to pulsate. If it did, life would pass away. The chemical changes on which animal heat depends cease with the cessation of respiration. But life is still preserved, though only passive or latent life, because the heart's fibre, excited to contract by the carbonised blood, continues slowly to propel the blood through the torpid frame. This slow circulation of venous blood continues during the whole period of hibernation. It is the only vital act which can be recognised, and the marvel is great that in any mammal this process should suffice to maintain life. It would seem that the material conveyed by the absorbents into the circulating fluid suffices to counterbalance the process of waste occasioned by the slow circulation; but of course this does not explain how vitality remains under conditions which, if we judged from other warm-blooded animals, we should consider altogether inconsistent with life. For, so far as mere waste is concerned, the imagined Australian process is as effectual as hibernation. In that process of course the circulation would be as completely checked as the respiration; thus there would be no waste, and the absorbents (which would also be absolutely dormant) would not have to do even that slight amount of work which they accomplish during hibernation. Science can only say that cases of hibernation among warm-blooded animals show that the vital forces may be reduced much lower without destroying life than, but for such cases, we should have deemed conceivable.

The question whether the process which takes place in the hibernation of certain animals can occur with other animals, including man himself, is one of considerable real interest in itself, and derives a factitious interest from the strange thoughts suggested by the imagined application of the "wonderful discovery" to human beings. It has been supposed by some that the phenomena observed during trance indicate the survival in man of a power, or rather a quality, resembling that possessed by the hibernating animals. It is said that in some cases of trance the vital powers have been so completely suspended that even experienced medical men have sanctioned the arrangements made for the funeral of the entranced person as of one supposed to be dead. Crichton describes such a case, where nothing saved the patient from premature burial but the appearance at the last moment of beads of perspiration on the patient's forehead. The young lady who underwent this terrible experience—for she was conscious of all that went on—had been several days regarded as dead. "She heard her friends lamenting her death. She felt them put on the dead-clothes and lay her in the coffin, which produced an indescribable mental anxiety. She tried to cry, but her mind was without power, and could not act on the body. . . . The internal anguish of her mind was, however, at its utmost height when the funeral hymns began to be sung, and when the lid of the coffin was about to be nailed on. The thought that she was to be buried alive was the first one which gave activity to her mind and caused it to operate on her corporeal frame. Just as the people were about to nail on the lid, a kind of perspiration was observed to appear on the surface of the body. It grew greater every moment, and at last a kind of convulsive motion was observed in the hands and feet of the corpse. A few minutes after, during which fresh signs of returning life appeared, she at once opened her eyes and uttered a most pitiable shriek." In most cases trance is produced independently of any effort of the will. But some persons seem to have possessed the power of producing all the phenomena of trance—nay, one may say all those observed among hibernating animals—at will. Thus there is the well-known case of Colonel Townsend, who "possessed the remarkable faculty of throwing himself into a trance at pleasure. The heart ceased, apparently, to throb at his bidding, respiration seemed at an end, his whole frame assumed the icy chill and rigidity of death, while his face became colourless and shrunk, and his eyes fixed, glazed, and ghastly; even his mind ceased to manifest itself, for during the trance it was as utterly devoid of consciousness as his body of animation. In this case he would remain for hours, when these singular phenomena wore away and he returned to his usual condition."

The strange stories told of the Fakirs and their power of suspending active vitality for much longer periods has been attested by English officers and medical men. We are told that the less-advanced Yogi can only enter the state of abstraction called reverie; but the higher orders can simulate absolute inanition, the heart apparently ceasing to beat, the lungs to act, and the nerves to convey impressions to the brain, even though the body be subjected to processes which would cause extreme torture under ordinary conditions. "When in this state," says Dr. Carpenter, "the Yog, are supposed to be completely possessed by Brahmai 'the supreme soul,' and to be incapable of sin, in thought, word, or deed;" indeed, it would be difficult to imagine how a man in a state of absolute inanition could be capable of sin. Dr. Carpenter ascribes this singular power to the influence of the will forcibly concentrating the attention upon one subject.

Few however would be likely to believe that even if the power of producing inanition at will for long periods of time became commoner than it is, the duration of life could in this way be prolonged. These spells of insensibility would be far more apt, we should imagine, to shorten life than to be simply abstracted from the total duration of life, so as to increase the actual interval separating the day of death from that of birth. It is true we are told that Old Parr, in the later years of his unduly prolonged life, passed nearly the whole of the 24 hours in semi-torpid sleep, during which, doubtless, his natural powers wasted far more slowly than they would have done had he kept awake. But sleep is one thing, artificially-produced insensibility another. If however the wonderful discovery were real instead of imaginary; if men could at their own will be reduced to a state of absolute lifelessness for months and years together, the time thus passed being "so many unvalued and profitless years added to a lifetime," what strange results might follow! A man might extend the threescore years and ten over as many centuries, being brought to life for a week or two at a time after intervals of two or three years passed in frozen lifelessness. One who found himself, or supposed himself, in advance of his age, might be congealed until the age had overtaken or passed beyond him. A father who had been shelved for a while in the family ice-vault might be restored to children older than himself. Or again, a first-born who had displeased his father might be frozen until all his brothers had got the start of him, and re-appear among men as a younger brother. But indeed there is no end of such fancies. We may safely leave their further discussion until Signor Rotura has returned from his journey to South America "for a large supply of the two necessaries for the safe-conduct of his process, both of which substances at present remain a secret."

BRAIN TROUBLES.

BY R. A. PROCTOR.

In these days, when the energies of the mind have become more important than those of the body, and when even the health of the body is chiefly of value because of its direct association with the health of the mind, it is well that all who have much brain-work to do should know and understand the symptoms indicating derangement or overwork of mental powers. Of course, in all cases where, through whatever cause, any specific mental malady is in question, the assistance of physicians who have given special attention to cerebral diseases must be obtained. But fortunately with most, even of those who work the brain hardest, no more real occasion arises (whatever some doctors would assure us) for medical advice respecting mind troubles, than commonly arises in the case of corporal troubles among men who pass their days in hard but healthy bodily toils. The saying that every man is either a fool or a physician at forty (thirty would, perhaps, be nearer the mark) may be applied at least as well to the case of the mind as to that of the body. It is as easy for one who is not the fool of the proverb to understand the signs which indicate mind-mischief, and to minister to the mind when out of sorts (not actually diseased), as it is for him to note the signs of bodily ill-health, and apply the remedies which experience has shown him to be appropriate. And here we would note generally, what it is one object of this article to indicate specifically, that the analogy may be carried somewhat further. There are few greater mistakes, so far as the body is concerned, than to imagine every little ailment to be a sign of actual disease, and to have recourse for such slight troubles either to medical advice, or (which may prove more mischievous still) to active medicines or other strong remedies. The physician of the proverb, that is, the man who, not being a fool, has learned to understand his own constitution under ordinary conditions, may be watchful, if he so pleases, of even the slightest indications of ill-health, general or local, so long as such watchfulness does not degenerate into hypochondria. But most of these indications should suggest to him only such changes of diet, exercise, hours of resting, and so forth, as his experience has found to be suitable, and should in the greater number of cases suggest negative rather than positive remedies even of this kind. Many signs of illness, indeed, which obtrude themselves on the attention even of those who watch themselves least in such matters, may far better be dealt with by the patient himself than by the physician. For instance, I have learned to regard severe headaches of a certain type simply as affording evidence that certain articles of food (milk, butter, cheese, and the like) must either be given up altogether for several days, or taken in much-reduced quantity. When this course is followed, I am freed from all such attacks, until after the lapse, perhaps, of two or three months a headache of this particular kind shows me that I have taken such articles of food in greater quantity than is desirable for one of my constitution. A doctor might prescribe with advantage for the cure of the attack itself, and there can be no reason why a person troubled by some severe attack of headache, muscular rheumatism, or the like, should not obtain from a doctor some active medicine by which to diminish the pain from which he suffers; but it is a far more important matter to ascertain the regimen by which such attacks may be prevented from occurring, and this is a matter which a man (not being the "fool" of the proverb) should manage for himself. Now what is true of bodily troubles is true of mental mischief, short of actual disease, though doctors who have learned, rather late, to leave men a good deal to themselves, so far as the former are concerned, are by no means ready to admit that mental troubles can also for the most part be remedied without calling in the physician. Writers like Forbes Winslow, and others, who have dealt with obscure diseases of the mind, have done service in calling attention to certain signs of cerebral mischief which laymen might be apt to overlook; but they insist rather too strongly on these as indicative of actual disease, whereas it is within the experience of thousands that such signs, in the majority of cases, are no more to be regarded as necessarily indicating disease than a passing feeling of nausea necessarily indicates an approaching fever, or than a pain in the bowels necessarily indicates an approaching attack of Asiatic cholera.

It should also be noted, that much mischief may be caused by suggesting that tricks and failings of the mind, which are quite common, are signs of serious cerebral mischief. Not long after the first edition of Forbes Winslow's treatise on "Obscure Diseases of the Mind" appeared, a friend of mine, who had begun to read the book only because of his interest in matters scientific, found that it possessed for him a strong fascination, because nearly all the phenomena mentioned by Winslow as indicative of approaching insanity were such as he had frequently noticed in his own case. Thereafter regarding these symptoms in the light in which they were thus presented, this unfortunate student of cerebral science found himself presently possessed by a strange terror lest the state which Winslow seemed to indicate as a necessary sequel of these familiar signs should be close at hand in his own case. The evil progressed until his mind was really endangered by these mistaken fears; but fortunately for him (if madness is rightly regarded as the greatest of all evils), a series of misfortunes befell him which for a time altogether withdrew his attention from the mental phenomena which had so excited his fears. For two or three years he had to contend against great pecuniary difficulties, and to endure a series of domestic calamities of no ordinary order. Compelled to withdraw his attention from his own mind, he forgot that, according to the teachings of mental physiologists, he had been fairly on the way towards either mania or idiocy. Four or five years later, chancing to take down Forbes Winslow's book from his library shelves, he read with amusement the passages which had formerly excited his fears. He knew that the mental symptoms graphically described by Winslow still presented themselves from time to time—when, for instance, he was tired or unwell bodily—but he had learned in a very practical way that they are not quite so ominous as the mind-doctors assert. It is indeed possible (perhaps probable, or even certain) that no cases of acute mania may be noticed which have not been preceded by such symptoms; but assuredly these symptoms are not in every case—probably not in one case out of hundreds of thousands—the signs of actual mental disease, nor in one case out of millions followed either by acute mania or by apopletic seizure, as in the exceptional cases dealt with by Dr. Forbes Winslow.

We propose hereafter briefly to consider some of the signs which show that the mind is temporarily out of order, requiring rest, relaxation, or change of employment. We may in some cases have to enforce the lesson we wish to inculcate by citing cases in which such symptoms have been followed by serious mental disturbance; but we wish at the outset to persuade our readers that, in far the greater number of cases, these signs suggest only the necessity for ordinary precautions, not for medical advice or active remedial measures.

I.—IMPAIRED MEMORY.

The first mind trouble we propose to consider is the apparent temporary impairment of the memory. The gradual progressive decay of the power of memory with advancing years is, of course, a change which all may expect who attain great length of years; though, as Cicero long since pointed out, and as has been repeatedly exemplified by modern instances, the change is to some degree under control, and those matters in which an aged person takes special interest may be well remembered, when others about which he cares little are easily forgotten. "I never heard," says Cicero, "of any old man that has forgotten where he had hid his treasure; things which they regard, old men remember—the securities they have out, and who are indebted to them, as well as to whom they are indebted." And so forth. The points to be noticed here are, first, that memory is seen to be in large degree a question of attention as well as of retention; and, secondly, that decay of memory implies a change in the mind analogous to that which makes the old incapable of great bodily efforts. So that when the memory of a person who is not old becomes impaired, we may infer that unless there is actual disease, the symptom indicates overwork of the mind, precisely as bodily weariness indicates that the body has been overwrought. We may, perhaps, be led to inquire here whether a distinction should be drawn between loss of memory, as shown by a weakening of the power of committing to mind new matter (of whatever kind) which we may wish to remember, and the passing away from the mind of matter which had been already committed to it, and retained so long and so recently that its being forgotten can be explained only as due to some marked and recent change in the state of the mind. Suppose, for instance, that after carefully noting a number of facts, which under ordinary conditions we should remember thenceforward for weeks, we find that they have left no sufficient impression on the mind; here we obviously have evidence that the power of attention on which, in the first instance, memory depends, is for the time being enfeebled. Can we, however, infer that it is weakened in the same way and in the same degree as we should judge it to be if we found that numbers, dates, names, or words, which we had had occasion to employ daily for years, were suddenly clean forgotten? Making use, as we conveniently may (though we must not place too much stress on the method), of the analogy between bodily and mental relations, we may compare a change of the former kind to a diminution of the power of acquiring some new feat; a change of the latter kind, to the sudden loss of a feat already acquired and long practised. It can hardly be doubted that an athlete who should find himself unable to perform some new gymnastic trick, which he had supposed well within his powers, would not be so much struck by the circumstance, as he would be if he should suddenly find himself unable to achieve a feat in which he had hitherto found no difficulty.

Let us inquire, however, whether known cases of loss of memory of either kind afford any means of answering the question which has thus arisen. Of course, those cases in which the trouble has been only temporary, though far more numerous than those in which loss of memory has been symptomatic of actual disease, stand far less chance of being kept on record, so that we may have to consider cases of the latter kind to discover the relative importance of the two forms in which loss of memory may be noticed. The reader must not judge from cases thus cited that either class of symptoms is necessarily, or even probably, indicative of serious brain mischief.

We will begin, however, with a case in which the trouble was only temporary, and, moreover, its cause obviously indicated.

Sir Henry Holland gives the following suggestive account of a transient loss of memory due to fatigue. It will be seen that the failure of memory belongs to the second class above referred to, that, viz., in which what had been long and well known is suddenly forgotten. "I descended," he says, "on the same day, two very deep mines in the Harz Mountains, remaining some hours underground in each. While in the second mine, and exhausted both from fatigue and inanition, I felt the utter impossibility of talking longer with the German Inspector who accompanied me. Every German word and phrase deserted my recollection, and it was not until I had taken food and wine, and been some time at rest, that I regained them." This case would seem to show that transient loss of memory, even of this kind, need not be regarded as necessarily an alarming symptom.

The following case points in the same direction even more decisively. "A gentleman," says Dr. Winslow, "well known for his intense passion for field sports (living, as may be said, upon the saddle during the greater part of the year), frequently complained of transient attacks of loss of memory after a hard day's run with the hounds. His remedy for this affection was half a pint to a pint of port wine *at a draught!* The effect of this heroic dose of vinous stimulant upon the depressed energy of the brain was evidenced by the memory immediately recovering its vigorous activity." It would, however, be unwise to infer that this sportsman, in thus prescribing for these attacks, showed himself the "physician" of the proverb relating to fools and physicians. The remedy was a dangerous one. His was specially a case where prevention was better than cure. The transient attacks of loss of memory showed that the hard day's run with the hounds overtaxed his strength. He would have done wisely to have limited his exertions in the field (not giving up hunting, but restraining his zeal on those occasions when the day's run promised to be harder than usual).

The effect of wine used regularly, not in pint draughts, is in many cases undoubtedly good where the memory is apt to fail. We have an illustration of this in the following case, belonging to the first of the two classes above considered. A gentleman whose mental and physical powers had been severely taxed, lost all power of recollecting recent events. "Whilst engaged in active conversation, he was able, by a strong effort of will, to retain possession of the ideas suggested by others to his mind; but if there were the slightest interruption, even to the extent of a minute, in the conversation, he lost all recollection of what he had been previously saying. This gentleman had been living for some weeks below par, with the view of enabling him to perform an amount of mental work requiring for its execution the lengthened concentration of clear and vigorous intellect. He had been in the habit of drinking a fair portion of wine, but had unwisely abandoned the use of stimulants, fancying that by so doing he would be better fitted for clear-headed mental occupation." Under Dr. Forbes Winslow's advice, the patient "lived generously, took iron tonics, quinine, and valerianate of zinc, and resumed his daily quantity of wine. This treatment eventually restored his memory to a state of health." Dr. Forbes Winslow adds that he has known other instances of temporary loss of memory cured within a short time by the free use of tonics and stimulants. "In these cases," he says, "the brain is generally in a starved and impoverished condition, arising from a deficient supply of blood; it is in a state of enervation and inanition." On the other hand, the excessive use of stimulants produces unmistakably mischievous effects. Temporary attacks of loss of memory have been caused by intemperance. "By an old Spanish law," Dr. Winslow mentions, "no person was admitted into the witness-box to give evidence in a disputed case who was proved to indulge in habits of intemperance, as an excessive use of stimulants was considered to weaken and destroy the memory."

The following case is one of those in which sudden failure of memory implies serious cerebral mischief. "An eminent provincial surgeon, of large and anxious practice, was seized with a sudden failure of memory. He forgot all his appointments, and to such a degree was the faculty of retention impaired" (so far as the names and cases of patients were concerned) "that he was obliged to make memoranda of every trifling and minute circumstance which it was important for him to remember, and to these he was constantly referring in order to refresh his memory. This attack was preceded by headache, of which he had complained for nearly a fortnight." Up to the period of the case being brought to the attention of Dr. Forbes Winslow, who treated it, no suspicion had been entertained of the existence of any prior state of cerebral ill health, sufficient to account for the patient's sudden loss of mental power. Dr. Winslow ascertained, however, that "about eight weeks, or nearly three months previously" (not a very clear way of putting the matter, by the way), the patient had been seized, whilst in the act of applying a stethoscope to the chest of a patient, with severe epileptic vertigo. For about a second he lost consciousness. This had been succeeded by an attack of distressing sick headache. "Three days subsequently he had a second paroxysm of giddiness, and nearly fell out of the carriage in which he was sitting at the time. His spirits subsequently became much depressed, but in a few days he again rallied, flattering himself that he had quite recovered. He made no mention of these attacks to any member of his family, and carefully avoided all conversation on the subject of his health with his medical brethren." "When I saw this gentleman," says Dr. Winslow, "the only appreciable mental symptom was inability to retain in his mind, for many consecutive minutes, any recent impressions. His pulse was feeble, face pallid, and general health shattered. His spirits were, however, at times buoyant, and the prognosis which he formed of his own case was favourable." The result showed that he was a false prophet. Two weeks later he had an epileptic fit. He then became rapidly worse, and ten months after he died "in a deplorable state of mental imbecility."

But against such a case as this, which was obviously exceptional, may be set the following case, in which, under similar conditions, so far as appearances were concerned, a complete cure was effected:—A barrister complained to Dr. Winslow of occasional attacks of enfeebled memory. "He attributed this mental impairment," says Dr. Winslow, "to the fact of his having been engaged as counsel the previous year in several anxious and severely-contested election cases. I advised an entire cessation from all professional work, but had great difficulty in persuading him to recognise the necessity for a complete abstinence from mental occupation. He promised a guarded acquiescence in my strict injunctions, but finding himself relieved after an interval of a few weeks, he returned, in opposition to my solicitations, to his chambers, and recommenced active practice. As I predicted," proceeds Dr. Winslow, "he soon broke down, and I was once more conferred with. He then acknowledged it to be a matter of vital necessity that he should give his mind prolonged rest, and agreed unreservedly to do so. I kept him for a period of *two years* from all anxious and severe mental occupation, and by that time his powers of mind had rallied to a surprising extent; in fact, they became, according to his own impression, more vigorous than they were prior to his attack of illness. For many years this patient has continued steadily at work, never having had a return of loss of memory. I should premise that I extracted from him a promise that he would read no briefs after dinner. He has rigidly adhered to this understanding, but being an early riser and a man of remarkable quickness of apprehension, he is enabled to master a large amount of work before breakfast. I also made it a *sine quâ non* that he should go abroad every year for a period of two months, thus ensuring for him a complete diversion and relaxation of mind from all injurious pressure. He has scrupulously complied with my instructions, and the result is an entire freedom from all symptoms of mental impairment and cerebral disorder." A case such as this is full of encouragement, because here it would seem that at the outset overwork had seriously injured the brain, yet attention to a few simple rules resulted in a complete cure.

Apart from actual injury to the substance of the brain, transient loss of memory seems to be usually caused by a deficient supply of blood to the brain, whether through loss of blood generally, or owing to defective circulation. This is illustrated by the following case:—A lady had been reduced to a state of such extreme prostration by hæmorrhage, that for nearly a week she seemed simply lingering between life and death. After this she remained for a long time in a state of extreme mental depression and vital prostration. When she was able to articulate, her husband was astonished to find that her memory was paralysed. "She had forgotten where she lived, who her husband was, how long she had been ill, the names of her children, and, in fact, her own name was obliterated from her recollection. She was unable to call anything by its right name. In attempting to do so she made the most singular mistakes. She had been in the habit, before her illness, of speaking in French, her husband being a Frenchman; but while in the state of mind described, she seemed to have lost all recollection of the French language. When her husband spoke to her in French, she did not seem to understand in the least what he was saying, though she could at this time speak English without difficulty. Seven or eight weeks elapsed before her memory began to improve, and months passed before her mind regained its original strength."

Intense cold seems to have the power of paralysing the memory. During the retreat from Moscow, many of Bonaparte's officers and men found their memories greatly enfeebled. Bonaparte himself was affected, especially as to dates and names. "For a time he was constantly confusing one person with another, and making odd mistakes in dates." In his case the affection of the memory lasted only a few days;[1] but one of Bonaparte's *aides-de-camp* lost his memory for several years.

Instances such as these enable us to understand the true meaning of those comparatively slight attacks of failure of memory which most of us experience from time to time. In the first place, we do not find much evidence enabling us to assign to one or other of the two classes of memory-failings above indicated a greater or less degree of importance, whether such failings occur in a marked or slight degree only. Inability to commit new matter to the memory with customary facility seems as likely to be a sign of mischief as inability to recollect matters forming (ordinarily) a part of our stock of familiarly known facts. Again, it is clear we need not fear that the mind is necessarily going astray because for a time the memory fails in slight degree. We see that very serious failures of the power of memory may occur where the brain has suffered no irreparable mischief. But since we see that much overwork will cause serious temporary mischief of this particular kind, we

[1] During this time Bonaparte's mind seems to have been affected. "He merely made some gestures of melancholy resignation on every occasion when," during the battle of Semenowska, the *aides-de-camp* sent by Ney "informed him of the death of his best generals. He rose several times to take a few turns, but immediately sat down again. Every one looked at the Emperor with astonishment. Hitherto, during these great shocks, he had displayed an active coolness; but here only a dead calm, a mild and sluggish inactivity." Count Segur, referring to Napoleon's state at this time says: "The Russian autumn had triumphed over him."

learn that where a slight lapse of memory is noticed, the indication may be taken as a sign that rest is needed. But there are, as we have seen, other ways in which this special power may come to be affected; so that if the memory should show signs of failure where we have no reason to believe that overwork has caused the mischief, we may infer that some one or other of the causes which, as we have seen, may affect the memory seriously have operated injuriously in slight degree. Nor in general need we be in much doubt as to the true nature of the cause, simply because we cannot fail (usually) to recognise in the circumstances preceding the attack the origin of the mischief. Thus, although a serious failure of the memory considered apart from the circumstances preceding it might leave the physician in doubt whether depletion or plethora (to mention two possible causes) had produced the mischief, yet the physician, apart even from an examination of the patient's condition, could learn at once from him whether either of these two opposite conditions had existed before the attack. In like manner, any person whose memory suddenly seemed weakened could, as his own physician, ascertain (unless, indeed, his memory failed to remind him how he had passed the hours or days preceding the attack) whether the mischief resulted from deficiency or excess in the amount of food or stimulants he had previously taken, whether the proper remedy would be, on the one hand, some such medicine as a glass of wine and a chop, or, on the other hand, a diminution during two or three days of the amount of food consumed, or the avoidance of some of the more stimulating articles of diet. Here, however, we are considering rather those mental troubles which are produced by mental work, whether relating to subjects of great difficulty or carried on too long. We would notice also that in dealing with other indications of mental mischief we need not be careful to show how the more serious cases of each kind suggest the significance of the slighter and far commoner mental troubles which form our real subject of inquiry; for this reason, simply that what we have here said about failure or loss of memory applies equally to other signs of temporary mischief.

II.—DISTRACTED ATTENTION.

The next of these signs—one, indeed, which many mental physiologists set first—is an inability to fix the attention on any subject till the mind has done with it. We have taken the failure of memory first, simply because we believe that this symptom can ordinarily be recognised earlier than inability to fix the attention. The fact would seem to be that since in the ordinary processes of thought, we first recognise or ascertain particular facts, and then commit them to the keeping of the memory, the latter process is naturally the one which first fails us. That it should be taken first is indicated, too, by the circumstance that although many cases can be cited of persons who, although able to direct their attention to a subject, are unable to retain in their memory what has been suggested to their thoughts while thus directed, no case is on record in which this state of things has been reversed, and a person has been able to remember recent facts distinctly after he had lost the power of arriving at fresh ideas by efforts of attention. To mention only one case of the former kind, Dr. Winslow tells of one patient whose memory as to recent events was seriously damaged, while yet his perceptive faculties and reasoning powers were not at all affected. "He conversed with great sagacity, fluency, and acuteness on every subject, but if I permitted a second to elapse in the conversation, he entirely forgot what he had been previously talking of." From the time when his memory thus failed him, he retained his former power of reasoning. "He could discuss at short intervals the most subtle and abstruse political, professional, and literary matters with apparently unimpaired mental vigour; but his memory never recovered its healthy tenacity." It may hence be inferred that temporary loss of the power of fixing the attention (which must be carefully distinguished from mere forgetfulness, that is, the habit of being inattentive), is more likely to be a sign of serious mental mischief, than failure of the power of memory. Yet the former, like the latter symptom, indicates in the great majority of cases, no serious mischief, though it would be exceedingly unwise to overlook it.

The failure of the power of directing the attention to a subject may show itself in several ways. Thus the mind may be unable even to begin the study of a subject; or it may begin the study and presently wander off to other subjects, despite the most anxious efforts to restrain it from so doing; or suddenly it will seem to cease its action, remaining for a short time confused and as it were lost, and then resuming the consideration of the same subject at the point where it had left it, and apparently as acutely and attentively as before. These three forms of distraction are of different significance as symptoms of mental trouble. The first, though undoubtedly it would be very serious in this respect, if persistent, nearly always indicates only that the mind wants rest, and no one who is wise will neglect the warning. The second equally implies that the mind wants rest, though not in equal degree. But the third is usually a sign of serious mischief. We consider it here, not as belonging to those indications of mental disturbance which, without being alarming, should be attended to by all who wish to keep their brains in good working order, but because the nature of the cerebral mischief indicated by such symptoms has been ascertained, and we may hence infer the general nature of the mischief indicated when the less serious symptoms of distraction are recognised, and may so judge what is the appropriate remedy. For, unfortunately, several of the cases in which the mind has been observed suddenly to become confused or lost. resuming its activity and clearness after a short interval, have been followed by severe illness, which has proved eventually fatal.

Amongst the most remarkable and carefully-observed cases of this kind is that of King Oscar of Sweden, the circumstances of which were minutely detailed by Dr. P. O. Liljewalch, the king's first physician. King Oscar had enjoyed fairly good health during the greater part of his life; but before his last illness it had been noticed that occasionally the heart's action was irregular, oftener in spring than in other parts of the year. In 1851 the heart became very irregular in its movements, and the digestive functions were impaired. Although he soon after recovered to some degree, an attack of typhus fever, following the loss of a beloved son, severely tried his constitution. When slowly recovering strength after this, he unwisely omitted his usual autumn rest and excursion, and devoted his mind to political matters requiring close and anxious attention. In 1857 his health again gave way, and it was at this time that the nervous mischief was first noticed, which subsequently proved the characteristic feature of the king's illness, and, in Dr. Liljewalch's opinion, "brought him to his death." The first trace of this nervous disease, says Liljewalch, "manifested itself long since, although it was not until the last six or eight years of his life that, as we have seen, it occurred with more definite, and at last with such threatening symptoms. No one who had an opportunity of observing him during a long period in his daily intercourse, could avoid being amazed at the very extraordinary power the king always exhibited of retaining in his memory the most varied details, or could cease admiring" (really one could imagine that some few could achieve this, however impossible it might seem to the courtly Liljewalch) "the rapid apprehension, the unerring judgment, and the singular clearness of statement which were exhibited whenever he spoke. But at the same time he could not fail to recollect how the king sometimes, in the middle of a conversation to which he was directing all his attention, would of a sudden appear to be abstracted, and would actually transfer his thoughts to some other subject on which, unless he might be disturbed, he would allow them to rest, usually only for a few moments, but sometimes for many minutes, after which the conversation would be resumed as if it had not been interrupted. The peculiar expression of the king's features—particularly his look, assumed on such occasions, and the spasmodic state, or the involuntary movements which at the same time took place in one or other part of his muscular system—render it probable that this distraction, which at times was of frequent recurrence, was due to an incipient affection of the central organ of thought. This symptom, referable to the most important organ of the nervous system" (the care and ingenuity with which the court physician avoids any direct statement that the king's brain was effected is worthy of all praise) "was of late years accompanied, as has been already mentioned, with increasing weakness in the muscles of the lower extremities, and with uncertainty in the combination of movement, probably depending on a commencing organic change, either in the organ alone on which the power of motion depends, or else in that by which the co-ordination of movements is effected." The king himself was not misled by the phraseology in which the court physicians endeavoured to cloak the fact that his brain was disordered. "Incapacity to discharge his royal functions now brought on a deep melancholy, and the king, even in the commencement of his illness, expressed his conviction of its incurability." The strength of the body failed more and more as "the organ on which the power of motion depends" became more and more diseased. "The lower extremities, the muscles of which were always weak, began to totter under the weight of the body, and at the same time the power of combination for the motions of those parts was impaired, and the king was troubled with vertigo, particularly accompanying the movements of the head, and with vomiting, which symptoms, in combination with diminution of strength and the occurrence of involuntary muscular spasms, indicated the existence of a more deeply-seated affection, probably a softening in the central nervous system." (One could imagine that as, of old, Spanish courtiers adopted the conventional hypothesis that a Queen of Spain has no legs, Dr. Liljewalch held that the Kings of Sweden, and "royal personages" generally, have no brains.) The means employed to combat the disease produced no good effects; "the paralysis, which commenced in the lower extremities, gradually increased, and, after the king, feeling his inability any longer to fill the high position to which Providence had called him, transferred into the hands of the crown prince the government of the United Kingdoms, his deep melancholy gave way to a progressive indifference, even for those things which in his health he had regarded with the most lively interest." The rest of Dr. Liljewalch's account relates to the gradual failing of King Oscar's powers, mental and bodily, and is too technical to be quoted *verbatim*. It is noteworthy that the power of speech began to be affected early during the progress of the disorder, and later was lost altogether. From this we should be led to regard failure in the power of verbal expression as a later, and therefore a more alarming, symptom of cerebral mischief, than diminution of the power of fixing the attention. The *post-mortem* examination of King Oscar revealed extensive disorganisation of the brain.

A case somewhat similar to that of King Oscar is related by Dr. Forbes Winslow:—"A gentleman connected with the Stock Exchange was suspected to have disease of the brain. His symptoms were as follows: general muscular weakness, occasional paroxysms of severe headache, slight paralysis of the superior palpebræ and of the left eye, occasional sensation of numbness in the right foot. The mind was not apparently at all impaired. He continued, up to the period of my being consulted, fully competent to discharge all his commercial duties, attended to his accounts, and wrote letters of business with his usual ability and clearness. His brother informed me that at times he was greatly *ab*stracted and *dis*tracted; that whilst engaged in conversation, he would suddenly pause, put his hand to his head, and appeared vexed with himself at having lost all consciousness of what he was saying. This symptom was observed *two* years before any question arose, or suspicion existed, as to the state of the brain! The family, judging from the subsequent progress of the case, were of opinion that the cerebral disorder was first exhibited by the sudden lapses of thought to which he was subject for many years previously to the manifestations of other and more unequivocal symptoms of brain disease. Such, also, was my opinion. . . . . In about a year and a half he died, quite paralytic. Considerable organic disease of the brain was discovered after death."

In another case, which also ended fatally, an Irish barrister, three years before an attack of acute mania, was observed to stop occasionally while addressing the courts of law, as if for the moment lost. "So marked was this symptom, that a professional friend, often associated with him in the conduct of legal matters, considered it his duty to direct the attention of the gentleman's wife to the fact, considering that such attacks of mental distraction, on occasions when it was of essential importance for the mind to be in a state of continuous activity, looked suspicious, and, according to his judgment, were not consistent with a healthy state of the brain." About two years after this peculiarity had been noticed, this patient experienced a slight epileptiform seizure whilst at his chambers, during a very hot day in the month of July. "As this attack was considered to have been one of syncope, and to be caused by the then high state of the temperature, little or no notice was taken of it. Previously to travelling on the Continent, he had been working unusually hard, eating and drinking very sparingly, sitting up late at night, and rising early in the morning. In fact, he acted with great indiscretion and imprudence, and the result was an attack of brain disease, affecting the mind, a fortnight after his arrival in Paris." In this case, the *post-mortem* examination revealed the existence of chronic disease of the membranes of the brain—mischief which seemed to have lasted for a considerable time before death.

As we have already explained, it is not so easy to find illustrative cases of the less alarming forms of distraction. Even in cases where serious mischief has followed these slighter mind-troubles, the symptoms immediately preceding such serious illness have commonly been of a more marked kind, and these alone have usually been regarded as really belonging to the case. Nevertheless, all who have given careful attention to mental maladies, can speak of instances in which the less serious forms of distraction have been noticed early in the progress of cerebral disorders; so that, though they need not alarm those who note them in their own case, they should not be neglected. They are always signs that the mind wants rest, and they may be signs that some more specific remedy is required, which can be readily determined by noting whether rest brings relief. "I am anxious," says Dr. Forbes Winslow (and it could be wished that throughout his valuable work he had been similarly careful to avoid occasioning unnecessary alarm), "to attach no undue importance to this evidence of morbid intelligence, but I cannot close my eyes to the fact that a debilitated power of attention is a prominent symptom in the early stage of cerebral disorder. Cases of incipient brain disease have occurred in which patients have, previously to other symptoms, lost all ability to read continuously twenty lines of a book without a painful effort of thought." It will be noticed that Dr. Winslow here puts distraction as a phenomenon preceding, in cases of cerebral disorder, the loss of memory: albeit, we believe that had he had the means of ascertaining the precise progress of mental disorder, in cases where he supposed this to have been the case, he would have found that the memory had begun to go in the first instance. "If," he proceeds, "there be impairment of attention and debility of memory, it is illusory for the patient to imagine that he is able, until his *physical* condition of ill-health is attended to, by repeated and persevering efforts, to resuscitate these prostrated powers. In his attempt to do so he still further taxes the morbid state of these faculties" (meaning, apparently, that he overtaxes the faculties, and makes them still more morbid), "and, instead of invigorating, still further debilitates, and often entirely extinguishes his intelligence." This caution cannot be too carefully attended to. Returning to the analogy between bodily and mental powers, which we touched upon at the outset, we may compare the power of attention to actual muscular strength,—as the power of memory may be compared to skill in mastering such and such feats of muscular dexterity, and acquired mental knowledge to the various athletic exercises which a man has learned to achieve. Now if an athlete finds that his bodily strength is unequal to a task which has hitherto been well within his powers, he would not think (if he were wise) of trying repeatedly to achieve the muscular effort which he has found too much for him. Or (extending the analogy to other ways in which the power of attention may fail) if an athlete finds that he is unable to continue some muscular effort so long as usual, he does not compel Nature to achieve the task which for the nonce has become too great for him. In either case he perceives that for the time being he is not himself, and by rest or change of some kind (diet, mode of training, or the like), he seeks to restore his powers. At any rate, if he is so unwise, in either case, as to endeavour to master Nature, he increases the mischief, and may entirely lose the powers which had been weakened, and might otherwise have been soon restored, or might at least have been saved from further weakening. So, remembering how close in reality is the analogy between the mental and bodily powers, we can well believe Dr. Forbes Winslow, when he tells us that when the attempt to fix and concentrate thet houghts requires a continuous, painful, and vigorous effort of the will, "serious and irreparable injury may be done to the delicate organisation of the brain and mind by injudicious attempts to exercise, stimulate, and *force* into activity the morbidly flagging and sluggish mental faculties." These symptoms show that the brain is for the time being unfit for sustained action or for intense action, though not necessarily (or even probably) diseased, and that rest is essential to restore its enfeebled energies. Whether such rest should be long-continued or not, will depend upon the question whether the symptoms of weakened powers of attention are marked or otherwise, and also in no slight degree on the length of time during which these symptoms, whatever they may be, have been neglected. If they are attended to so soon as they are noticed (in which case they will probably be slight), a very brief rest will generally restore to the mind its wonted energies. Many a man, who in the midst of prolonged and arduous mental exertion has noticed signs of flagging in his power of attention, has found in even half an hour of sound sleep a remedy more effective than a three months' rest would be after such signs had been neglected during several successive weeks of mental labour.

Some physiologists assert that defective speech, the next symptom which we have to deal with, has been the first symptom noticed in cases of cerebral disorder. Dr. Forbes Winslow says:—"The first evidence of approaching apoplexy and paralysis is occasionally a sudden loss of speech." This may have been the first symptom noticed, but we question very much whether it has ever been the first symptom which has existed.

We ought to distinguish, perhaps here, between defective speech and defective power of expression (by words indicated otherwise than by actual articulation). In fact, an important distinction exists even between the loss of the power of articulation and the affection of the vocal organs indicative of cerebral disease. Here, however, we consider generally the impairment of the power of linguistic expression which usually precedes serious mental trouble, and is often enough noticed where rest only or change of diet is necessary as a remedy. Usually, however, this symptom is serious. Indeed, one writer on the subject of cerebral disease remarks that it is a most unusual circumstance for the symptom to exist without being followed by acute cerebral mischief. Possibly the remark refers only to the absolute loss, whether for a short or long period, of the power of expressing ideas by language, spoken or written. That the power of expression may be effected, and even for a time affected seriously, while nevertheless there is no serious cerebral mischief, is within the experience of most persons who have occasion to exercise this power freely. The symptom, like others we have dealt with here, is one to be noticed, and its warning voice should be heeded early. This done, there is usually little occasion for alarm, startling though some of the stories now to be related may appear.

Dr. Winslow relates that "a literary gentleman, whose vocation in life was that of a public lecturer, noticed for nearly eight weeks before he was seized with paralysis, that occasionally whilst speaking he lost for a second or two all power of articulation. This occurred on five or six occasions previously to an attack of decided hemiplegia. This patient had taxed his powers of mind to their utmost by lecturing twice, and often thrice, a day; but independently of this amount of literary labour, he had been exposed to much anxiety respecting family matters, and this had produced restless, and, in some instances, sleepless nights."

III.—PARTIAL LOSS OF SPEECH.

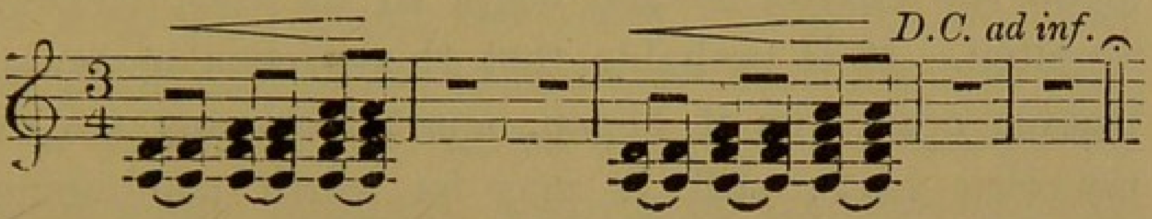
Let us consider next a case where the almost complete loss of the power of fixing the attention was followed by the partial loss of the power of expression, —a sequence which would, we believe, be far more commonly noticed than usual were all the circumstances of each case carefully noted. The case also illustrates the dangers resulting from the endeavour to over-tax the powers of nature :—"I was engaged this morning," says Dr. Alexander Crichton, "with a great number of people, who followed each other quickly, and to each of whom I was obliged to give my attention. I was also under the necessity of writing much, but the subjects were various, and of a trivial and uninteresting nature, and had no connexion the one with the other; my attention, therefore, was constantly kept on the stretch, and it was continually shifting from one subject to another. At last it became necessary that I should write a receipt for some money I had received on account of the poor. I seated myself, and wrote the two first words, but in a moment found that I was incapable of proceeding, for I could not recollect the words which belonged to the ideas that were present in my mind. I strained my attention as much as possible, and tried to write one letter slowly after the other, always having an eye in order to observe whether they had the usual relationship to each other; but I remarked, and said to myself at the time, that the characters I was writing were not those which I wished to write, and yet I could not discover where the fault lay. I therefore desisted, and partly by words and syllables, and partly by gestures, I made the person who waited for the receipt understand that he should leave me. For about half an hour there reigned a kind of tumultuous disorder of my senses, in which I was incapable of remarking anything very particular, except that one series of ideas forced themselves involuntarily into my mind." The patient goes on to describe the various thoughts which occurred to him at this time, and how he tested his mental condition by thinking of the principles of religion, conscience, and the future life, finding to his relief that these principles he found "equally correct and fixed as before" (a degree of assurance which some do not possess who are quite free from mental disorder). Passing over these matters, as not bearing specially on our subject, we find that so soon as he tested his power of expressing his ideas, either by spoken or by written words, he found that for the time being the power was lost. "I endeavoured to speak, in order to discover whether I was capable of saying anything that was connected; but although I made the greatest efforts of attention, and proceeded with the utmost caution, I perceived that I uniformly spoke other words than I intended. My soul was at present as little master of the organs of speech as it had been before of my hand in writing. Thank God, this state did not continue very long, for in about half an hour my head began to grow clearer, the strange and tiresome ideas became less vivid and turbulent, and I could command my own thoughts with less interruption." It is interesting to notice how the loss of the power of expression was associated thus with confusion of thought and inability to fix the attention. "I now wished," proceeds the patient, "to ring for my servant, and desired him to inform my wife to come to me." (The power of correctly expressing his ideas does not seem to have been possessed in any very remarkable degree by this gentleman, even when his mind had fully recovered its usual health.) "But I found it still necessary to wait a little longer, to exercise myself in the right pronunciation of the few words I had to say, and the first half-hour's conversation I had with her was, on my part, preserved with a slow and anxious circumspection, until at last I gradually found myself as clear and serene as in the beginning of the day. All that now remained was a slight headache. I recollected the receipt I had begun to write, and in which I knew I had blundered, and upon examining it, I observed to my great astonishment, that instead of the words *fifty dollars, being one half-year's rate,* which I ought to have written, the words were, *fifty dollars, through the salvation of Bra——*, with a break after it, for the word '*Bra*' was at the end of the line. I cannot recollect any business I had to transact that could by means of an obscure influence have produced this phenomenon."

In this case it is obvious that the temporary loss of the power of verbal expression was occasioned by overwork; but it is noteworthy that the work was of a special character, involving the special exercise of the power which failed first (that of fixing the attention). It may be worth while to inquire whether that kind of mental confusion, which, when it has passed beyond a certain point is followed by impairment of the power of speech, is generally or often a consequence of distracting occupations. The following case seems to some degree to bear on this question. It is related by Dr. Watson. A patient who had had an attack of apoplexy seemed to be recovering under the influence of perfect quiet. But, "after a long and imprudent conversation with a friend, he suddenly lost the thread of his discourse, and could not recover it." Memory was affected first, be it observed: next went the power of attention. "Then he became confused." Thirdly, the power of speech was affected. "He misapplied words. I asked him how he felt. He answered, 'Not quite right,' and this he repeated very many times, abbreviating it at first into 'not right,' and at length into 'n'ight.' Wishing to mention '*camphor*,' he called it '*pamphlet*.' I mention these as specimens." Afterwards, signs of bodily weakness, indicating paralysis, were observed. The weakness degenerated gradually into complete palsy, and before long the case ended fatally. In this case the patient had not suffered originally from undue mental work, the mental trouble being caused by an abscess. But the case seems to illustrate well the trying effect of distracting conversation on a wearied, weakened, or (as in this case) diseased brain.

The tendency to use one word for another, where, so far as meaning is concerned, there is no connexion whatever, though there is some resemblance of sound, is one which probably most literary men have noticed at times, when they have been wearied or their attention has been much distracted. It is not by any means so alarming a symptom as temporary failure of the power of articulating words, or actual inability to write the desired words; but it is a circumstance which should not be overlooked. A little rest, or the substitution for a while of some light reading for hard brain-work, will generally set matters right. If not, a longer rest or open-air exercise should be taken. Time will be gained by waiting till the brain is fitter for work. I have repeatedly had occasion to time myself over certain forms of literary work, and my experience has been this, that where four or five hours are to be occupied in steady work, a good half-hour will often be saved by taking half an hour's sleep, when such signs of mental weariness are noticed as have been described above. There is, however, one point to be observed. Rest must be taken as soon as such signs are recognised, for if an effort is made to struggle against the occasion for rest, the power of resting may be lost. Precisely as an over-tired pedestrian often tries in vain to sleep when he has but a short time for rest, so the over-wearied brain may be kept by confusing thoughts from obtaining rest.

IV.—THE ECHO SIGN.

A symptom called the "*echo*" sign, which usually indicates very serious brain mischief, has, like other such signs, its analogue among the symptoms of minor mental trouble. Most of us have noticed how, when we are weary and overworked, we are apt to repeat mentally words or sounds which we have heard or had occasion to utter. Sometimes the tendency becomes exceedingly annoying—a circumstance which, though not necessarily indicating serious mischief, must be regarded as a warning not to be neglected. On one occasion, a time of great domestic trouble, I was haunted for two or three days in succession by these three chords, repeated in the way here indicated.



They had been first heard (or imagined, perhaps) during church-time on a calm, still Sunday, when, after several days of cold and bitter winter weather, the sun shone brightly, and the air was warm and pleasant. There was illness "even unto death" in the house, and a loss such as changes the colour of life was approaching. But probably, long and anxious night-watching had more to do with this strange affection of the mind than anxiety or sorrow. The haunting chords ceased only during sleep (a trained nurse had the evening before taken my place); when consciousness returned, after heavy dreamless sleep, the chords were heard again, now loud and clear, anon distant and indistinct, usually in slow succession, with rather long intervals between each triplet, but at times less slowly and with scarcely the intermission of a single bar's rest. At another time, I should probably have been rendered exceedingly anxious by the monotonous repetition of these mental chords, though I might have found it difficult to determine whether they indicated or were the cause of mental mischief. As it was, other thoughts engrossed my mind too much to allow of any anxiety on this account; and after a few days the chords ceased to trouble me; though to this day I am careful not to allow the mental voice to utter these sounds to the mental ear, lest again the chords should begin to be monotonously repeated. It is probable that this particular mental trouble ceased as it began, apart from any act on my own part; still it may be worth mentioning that I obtained relief, and was, at the time, under the impression that I had driven away the haunting chords, by adding mentally, after each set of six chords, a series of others, as follows[1]:—

I noticed that the interval before the paired chords began to be mentally heard again, gradually increased, after the above plan had been followed, until the intervals of silence became so long that the mind

[1] It is probably not necessary for me to explain to musicians that I know nothing whatever of harmony. Perhaps the above arrangements of chords is full of mistakes, so far as the laws of harmony are concerned, but it represents exactly, first, the chords which troubled me, and secondly, those which I added to put the former out of my head.

could, as it were, forget that it was troubled by these haunting notes.

The "echo" or repetition sign, as we have said, is commonly indicative of serious cerebral mischief. Dr. Winslow was of opinion that it arose, to some extent, from that sluggish and abstracted state of thought, amounting to reverie, which is so often seen in cases of long-existing and sometimes undetected affections of the brain. "The mind seems incapable," he says, "of apprehending, under these circumstances, the most simple questions, and, parrot-like, repeats them. I have noticed this symptom in other conditions of depressed vital and nervous power, but it more particularly accompanies softening of some portion of the brain." It can scarcely be doubted that the monotonous mental repetition of words or sounds is indicative of mental trouble; yet not necessarily or probably of any really serious mischief. Rest or change of occupation will in general prove a sufficient remedy. If not, it is time to seek for advice, though rather from a sensible general practitioner (preferably a family doctor) than from those who have directed special attention to cerebral diseases; for the latter are apt to alarm patients by suggesting the possibility, or even the probability, of approaching mental derangement.

As an illustration at once of the morbid phenomena of speech, and of the tendency among certain students of mental disease to exaggerate the significance of such phenomena, we may take the following passage from Dr. Forbes Winslow's book:—"It will not be out of place," he says, "to direct attention to a precursory symptom, not only of approaching paralysis, but of insanity. I allude to the practice of many patients suffering from incipient brain and mind disease, of talking aloud when alone. A distinguished physician observed this symptom to precede an attack of paralysis, in the case of a nobleman who for many years was Prime Minister of this country. In many cases of irritation of the brain, as well as of structural disease, the patient is observed to talk to himself, and the commencement of insanity is often detected by this symptom." True, Dr. Winslow goes on to say that this eccentric habit is consistent with a perfect state of health of body and mind; but these few words suggesting comfort to those who occasionally talk to themselves, are likely to be overlooked in a long passage indicating this common habit as one of the signs of approaching insanity.

V.—IRRITABILITY.

Among the most characteristic signs of mental weariness, irritability may be mentioned. We use the word rather in its technical than in its ordinary sense. Nervous irritation may be indicated quite as much by gloom and melancholy, as by temper or impatience. When we find ourselves disposed to take unreasonably gloomy or unreasonably fretful views of our affairs, to be troubled or vexed (that is, made sorry or angry) by trifling matters, we may be assured that there is something wrong with us. The mischief may be bodily, or it may arise from external causes; but usually—at any rate with those who exercise the mind more actively than the body—the cause of the change is mental. It is not always easy to distinguish between these various forms of irritability. Those who are affected by the east wind can ascertain, when they find themselves out of sorts, whether the wind is easterly or not; but it is probable that the mere liability to be thus affected is a sign of nervous weakness, which may result from mental overwork.[1] And there are some meteorological causes of irritability not so easily inquired into as the influence of an

[1] Dr. Forbes Winslow discribes a curious instance of morbid irritability of this kind. "A military man, suffering from severe mental dejection, was in the habit," he tells us, "of promenading backward and forward in a certain track, towards evening on the rampart of the town in which he resided. When he walked forward, his face fronted the east, where the sky was hung with black, as was, alas! his poor soul. Then his grief pressed doubly and heavily upon him; he was hopeless and in deep despair. But when he turned with his countenance towards the west, where the setting sun left behind a golden stream of light, his happiness returned. Thus he walked backward and forward, with and without hope, alternating between joy and melancholy, ecstasy and grief, in obedience to the baleful and benign influence[s] of the eastern and western sky!" Alfieri says, in his "Memoirs," "I have observed, by applying to my intellect an excellent barometer, that I had greater or less genius or capacity for composition according to the greater or less weight of the atmosphere: a total stupidity during the solstitial and equinoctial winds; an infinitely less perspicacity in the evening than in the morning; and much more fancy enthusiasm, and invention in midsummer than in the intervening months.

easterly wind. (Has it been commonly noticed, or is the experience exceptional in the writer's case, that when the mind has been heavily taxed, blusterous weather produces the effects usually attributed to easterly winds ?)

Again : some of the forms of irritability due to bodily mischief are not easily distinguished from those due to mental overwork. Thus, a case is related of a young man noted for his gentleness, who, forming one evening a member of a brilliant party (his companions being of his own age), was quarrelsome and cross-grained, wrangling with, and in the end offending, everybody in the room. Two hours after he was seized with nephritic torments, caused by a calculus, which did not cease to trouble him till the next day. I can recall an even more striking case of the sort in my own experience. I had been struck by my exceeding ill-temper (which, utterly wrong-headed though it seemed, I felt quite unable to control), while visiting at the request of several of the professors of Yale College, the laboratories and technological collections of that institution. I could in no way distinguish this irritability from that which I had learned to regard as the effect of over-work. But it continued (though I had had and availed myself of an opportunity for resting) for more than twenty-four hours. Soon after (for there was an interval during which the sense of ill-temper and despondency passed away), I was attacked by renal tortures, which, unlike those of the amiable young man of the previous story, lasted more than a week, and amply justified (in my opinion) all the ill-temper I had displayed beforehand,—if at least the disorder of the nervous system before the attack could be measured by the intensity of the pains suffered during its continuance.

Usually, however, an indefinable feeling of irritability and ill-temper signifies that the mind has been overworked. So also does that state in which, to use a commonplace but convenient expression, everything seems to go wrong. In reality, we do everything wrong, though we may be unable to recognise any difference between our way of attending to those slight matters on which the pleasant progress of our work depends and our customary methods. We misplace this and upset that, tear, smear, blot, and so forth, not because the fates are for the time being against us, but because we are weary and overwrought (though we may not be conscious of it), and our hands and fingers are not under the usual control of the mind and will.

THOUGHT-READING.

BY RICHARD A. PROCTOR.

We have received from several correspondents communications on the subject of Thought-Reading, and the Willing Game as now practised in parlours and drawing-rooms. Several very remarkable narratives have been sent to us, which we have been invited to publish, along with the various theories suggested by the narrators, these theories usually resolving themselves into a vague impression that the observed results are due either to electricity or to animal magnetism.

Now, there can be no question that among the phenomena observed during these experiments there are many which are well worth scientific investigation. Even in cases where there is wilful trickery, a degree of sensibility is manifested by some among the "subjects" which is far greater than had been previously imagined, at least by those unacquainted with such remarkable instances as Dr. Carpenter and others have described in treatises on mental physiology. Take, for instance, such a case as the following, de scribed by Professor Barrett in a recent number of the *Nineteenth Century* :—"A young lady could write words, or even rudely copy sketches which had been shown to her mother and not to herself, the mother sitting behind her and placing her finger on the girl's bare arm, even above the flexed elbow." In this case careful experiments proved that indiscernible and probably unconscious movements of the touching finger served to convey a sufficient guidance to the girl's delicate skin and quick intelligence. But no one who has examined such cases as this, and recognised the wide range of difference between one person and another in sensibility to slight muscular impressions, can attach any weight to the customary protestations in drawing-room experiments. On the one hand, the person guiding asserts that there has been no guiding, and probably often believes there has been none; on the other, the person guided is as ready to asseverate that there has been no guiding influence whatever (and possibly may have recognised none). But experiment shows that there has been.

Thus, we must not be expected to find space for accounts of remarkable cases of apparent mind-reading or mind-guiding,—generally sent without any of the details that have scientific value, and without any attestation more satisfactory than some remark that the writer *knows* there was no trickery. Nor can we admit, as a scientific explanation, the expression of a belief that there must have been magnetism. As Professor Barrett remarks, the explanation "It is magnetism," seems perfectly sufficient "to many who, for a thousand pounds, could not write down a single true sentence on the ascertained laws of magnetic attraction"; while "if one ventures euphemistically to suggest this, they usually take refuge in 'animal magnetism,' a phrase so obviously ordained by Providence as a safe retreat, that it would be brutal to drive them to bay on it."

But there is room for scientific research into this matter. Some of the experiments already made under suitable test conditions have led to results so remarkable, as to show that the subject is well worth examining closely. Professor Barrett, Mr. Edmund Gurney, and Mr. Frederic W. H. Myers have been at some pains to collect evidence which is, indeed, as yet incomplete, but still seems to indicate a real power of mind on mind which, to say the least, has not yet been explained. They attach somewhat more weight, relatively, to the mind-reading side of the question than I am disposed to do. It seems to me the real point to be attended to is the power of mind in guiding mind, not the aptitude of some minds to be guided —though, of course, both are parts of the same subject of inquiry. There are cases in which mind-guiding seems the prominent feature; others, in which mind-reading seems chiefly in question; others, in which it is doubtful whether one or the other has been principally at work.

Take, for instance, the following case described by Dickens in a letter to Foster. Dickens is here speaking of a professional conjuror, and therefore trickery may have, or rather must have, the fullest possible influence assigned to it; but trickery will not explain the mental phenomena. Dickens speaks of the man as "a perfectly original genius, putting any sort of knowledge of legerdemain such as I supposed that I possessed at utter defiance":—

"You are to observe," says Dickens, "that he was *with the company*, not in the least removed from them, and that we occupied the front row. He brought in some writing-paper with him as he entered, and a black-lead pencil; and he wrote some words on half-sheets of paper. One of these half-sheets he folded into two, and gave to Catherine [Mrs. Dickens] to hold. 'Madame,' he says aloud, 'will you think of any class of objects?' 'I have done so.' 'Of what class, madame?' 'Animals.' 'Will you think of a particular animal, madame?' 'I have done so.' 'Of what animal?' 'The lion.' 'Will you think of another class of objects, madame?' 'I have done so.' 'Of what class?' 'Flowers.' 'The particular flower?' 'The rose.' 'Will you open the paper you hold in your hand?' She opened it, and there was neatly and plainly written in pencil: *The Lion. The Rose.* Nothing whatever had led up to these words, and they were the most distant conceivable from Catherine's thoughts when she entered the room."

Unless we suppose that by some amazing feat of legerdemain the conjuror, after Mrs. Dickens had named the rose and the lion, substituted for the paper in her hand one on which he had written these two words, doing this in the mementary interval between her naming the rose, and opening the paper in her hand, we must suppose that he influenced her mind in some way (the determination of which is what science yet has to seek) to think first of a lion and then of a rose. The interpretation of the trick as a feat of *legerdemain* is of course quite out of the question. There were thousands of objects of which Mrs. Dickens might have thought first, thousands of which she might have thought next; therefore millions of combinations of two objects of which she might have thought. The conjuror could not possibly, then, have ready to hand, among a multitude of papers, one containing in right order the two Mrs. Dickens had selected. He could not possibly have written those two names on a piece of paper in the moment between her answering "the rose" and opening the paper in her hand at his request. Still less could he have combined (in this momentary interval of time) the accomplishment of this feat, with the extraction of one paper from her hand and the substitution of another, without any knowledge of the change either on her part or on that of the audience, including such a keen observer as her husband. It seems certain then that the conjuror guided her mind by will power to think of the objects whose names he had already written on the paper.

Dickens describes another feat performed by the conjuror, which, were it not that the first can only be explained as a feat of mind-ruling, we might explain as a trick merely of legerdemain and quickness of vision. But under the actual conditions it seems to indicate powers of mind-reading far more surprising than any ever noticed in parlour experiments. The conjuror "had several common school-slates about a foot square. He took one of them to a field-officer from the camp, *décoré* and what not, who sat about six from our seats, with a grave, saturnine friend next him. 'My General,' says he, 'will you write a name on this slate, after your friend has done so? Don't show it me.' The friend wrote a name, and the General wrote a name. The conjuror took the slate rapidly from the officer, threw it violently down on the ground with the written side to the floor, and asked the officer to put his foot on it and keep it there, which he did. The conjuror considered for about a minute, looking devilish hard at the General. 'My General,' says he, 'your friend wrote Dagobert upon the slate under your foot.' The friend admits it. 'And you, my General, wrote Nicholas.' General admits it, and everybody laughs and applauds. 'My General, will you excuse me, if I change that name into a name expressive of the power of a great nation, which, in happy alliance with the gallantry and spirit of France, will shake that name to its centre?' [This was in 1854]. 'Certainly, I will excuse it.' 'My General, take up the slate, and read.' General reads: 'DAGOBERT, VICTORIA.' The first in his friend's writing; the second in a new hand. I never saw anything in the least like this; or at all approaching to the absolute certainty, the familiarity, quickness, absence of all machinery, and actual face-to-face, hand-to-hand fairness between the conjuror and the audience with which it was done."

It is clear that in this feat there was legerdemain, and (in a sense) machinery, too. Several common school-slates were brought in, but one slate only was used. We may be sure this, however it resembled the others, was not, like them, a common school-slate; and that the name, Victoria, was already written on it under the surface which was prepared to receive whatever name the General's friend might write. We might also explain the conjuror's knowledge of what the General and his friend had written, by the wonderful quickness and keenness of sight which conjurors obtain with constant practice. That some can tell what name is being written, by watching the movements of the pencil-end remote from the slate or paper, is certain. I am disposed, however, to consider this a case of mind-reading,—after the much more wonderful case cited before, which can only be explained as an instance of mind-ruling. In the following cases it seems doubtful whether mind-reading or mind-guiding were in question. Professor Barrett is referring to trials made with the children and a young servant-girl of the Rev. Mr. C——, of whose personal integrity he was convinced (though, of course, this statement respecting a person unnamed must be taken only for what it is worth, that is, as an expression of opinion).

"Having selected at random one child, whom we desired to leave the room and wait at some distance, we would choose a card from a pack, or write on paper a number or a name which occurred to us at the moment. Before leaving the room the child had been informed of the general nature of the test we intended to select, as 'this will be a card,' or 'this will be a name.' On re-entering she stood—sometimes turned by us with her face to the wall, often with her eyes directed towards the ground, and usually close to us, and remote from her family—for a period of silence varying from a few seconds to a minute, till she called out to us some number, card, or whatever it might be. . . . The first attempt was to state, without searching, the hiding-place of some small object, the place having been chosen by ourselves, with the full range of the house, and then communicated to the other members of the family. This was effected in one case only out of four. The next attempt was to give the name of some familiar object agreed on in the child's absence, as 'sponge,' 'pepper-caster,' &c. This was successful on a first trial in six cases out of fourteen. We then chose a card from a full pack in the child's absence, and called upon her to name it on her return. This was successful at once in six cases out of thirteen. . . . . A harder trial was now introduced. The maid-servant having left the room, one of us wrote down the name 'Michael Davitt,' showed it round, and then put the paper in his pocket. The door was now opened, and the girl recalled from the end of the passage. She stood close to the door amid absolute silence, and with her eyes on the ground—all of us meanwhile fixing our attention on the appointed name—and gave after a few seconds the name

'Michael,' and then almost immediately 'Davitt.' To avoid any association of ideas, we then chose imaginary names, made up by ourselves at the moment, as 'Samuel Morris,' 'John Thomas Parker,' 'Phœbe Wilson.' The names were given correctly *in toto*, at the first trial in five cases out of ten. Three cases were complete failures, and in two the names given bore a strong resemblance to those selected by us, 'Jacob Williams,' being given as 'Jacob Wild,' and 'Emily Walker,' as 'Enry Walker.' It was now getting late, and both we and the younger children were very tired: and four concluding attempts to guess the name of a town in England were all failures, though one of us had previously obtained remarkable success in this very experiment."

It appears to me that the failures in these and other cases yet to be cited, are as important a part of the evidence in favour of mind-reading or mind-ruling, as the successes. For they tend to show that there was no general system of deception by which the members of the family who had been present when the names were selected informed the children by signals previously agreed upon. However, as it will be obvious that there can be no absolute certainty on this point in cases in which any members of the family knew what was selected, we proceed to consider cases in which only the committee of investigation knew the words or things chosen.

In the cases last considered, the explanation may be suggested that some code of signals may have been arranged by which the proper answer was communicated to those questioned. The following cases are free from this objection:—

"It will be well to give," writes Professor Barrett, "a group of results obtained when no member of the family was aware of the selected object. Eleven times running we chose a card at random, and on six of these occasions one of the children named the selected card (giving both suit and pips, or fully designating the court card) correctly at the first trial; twice the card was named correctly on the second trial; and three cases were failures. On none of these occasions was it even remotely possible for the child to obtain by any ordinary means a knowledge of the card selected. Our own facial expression was the only index open to her; and even if we had not purposely looked as neutral as possible, it is difficult to imagine how we could have unconsciously carried, say, the two of diamonds written on our foreheads. The outline of results during the present investigation, which extended over six days, stands as follows:—Altogether, 382 trials were made. In the case of letters of the alphabet, of cards, and of numbers of two figures, the chances against success on a first trial would naturally be 25 to 1, 51 to 1, and 98 to 1, respectively; in the case of surnames they would, of course, be indefinitely greater. Cards were far most frequently employed, and the odds in their case may be taken as a fair medium sample; according to which, out of the whole series of 382 trials, the average number of successes at the first attempt by an ordinary guesser would be $7\frac{1}{3}$. Of our trials, 127 were successes on the first attempt, 56 on the second, 19 on the third, making 202 in all. On most of the occasions of failure, 180 in number, second trials were made; but in some cases the guesser professed inability, and declined to make more than one, and in others we allowed three; no trial beyond the third was ever allowed. During the last day or two of trial, after it had occurred to us to notice the point, we found that of the failures to guess a card at the first trial, those wrong both in suit and number were a small minority. Our most striking piece of success, when the thing selected was divulged to none of the family, was five cards running, named correctly on a first trial; the odds against this happening once in our series were considerably over a million to 1. We had altogether a good many similar batches, the two longest runs being eight consecutive successes, once with cards and once with names; where the adverse odds in the former case were over 142 millions to one, and in the latter something incalculably greater. If we add to these results others obtained on previous visits, it seems not too much to say that the hypothesis of mere *coincidence* is practically excluded."

"The exceptional nature of this inquiry," proceeds Professor Barrett, "goes far to invalidate arguments founded on character and demeanour; and, on this head, we will only state our conviction that any candid critic, present during the whole course of the experiment, would have carried away a far more vivid impression of their genuineness than the bare printed record can possibly convey. Of more real importance is the hypothesis of exalted sensibility of the ordinary sense organs. We could discover no indication of this in any of its known forms; but by way of precaution, as has been already stated, we commonly avoided even whispering any word, number, or name that we had selected; and the position of the excluded child, when the door was opened, would in every case have satisfied the most exacting critic. The explanation which might be sought in unconscious indications given by the sitters, and especially in the movement of the lips, has been already adverted to. Coming as we did to this investigation with considerable previous experience of the same kind, we were throughout strictly on our guard against giving such indications ourselves; the possibility of their being given by the family was, of course, excluded where the family were ignorant of the selected word or thing; and on the remaining occasions our perpetual vigilant watch never detected a trace of anything of the kind. The absolute docility of the children—both the guesser and the others—in taking any position in the room that we indicated, was naturally an assistance to our precautions. It may be further mentioned that, on a previous visit made by one of us, the child called the required name through the shut door, or from an adjoining room, having thus been completely isolated from the very beginning to the very end of the experiment."[1]

Other evidence of this sort will be considered further on. At this stage it may be well to note the objection raised by Professor Donkin. "The matter in question," he says, "has obtained a somewhat undue prominence of late; but if it is as simple and intelligible as it appears to be to most who have investigated it with care, and with minds free from mystical bias, any aid towards the extinction of what must then be regarded as an *ignis fatuus* of pseudo science carries with it its own justification." Passing over cases in which there was actual contact between the persons guiding and guided, Professor Donkin remarks that in cases where there was no actual contact, "common sense demands that every known mode of explanation of facts should be exhausted before the possibility of an unknown mode is considered." "It is equally obvious that in all scientific inquiries the good faith of individuals concerned

[1] "Among the friends above referred to as having taken part in these inquiries are Professor Balfour Stewart and Professor A. Hopkinson, of Owen's College. A communication lately received by us from them, embodying the results of their visits, and written without any knowledge of the contents of this paper, states facts and instances criticisms as to the possible (or impossible) relation to those facts of *coincidence*, *collusion*, *sight*, and *hearing*, precisely similar to those we have given. Their experience was that 'in about half the cases the first guess was right, and in most cases of mistake there was some marked point of similarity between the object proposed and the thing guessed.

should form no part of the data on which the conclusion is to rest. We can never call on science to put deception out of court by a belief in any one's integrity. Half of the evidence which has propped up the spiritualistic craze is based on the results obtained through mediums of 'unblemished character' in private families, whose virtuous reputation has been largely sustained by the fact that they did not take money for their trouble; no regard being paid to innumerable other motives and tendencies to deception." (This is very well put.) He then considers the "code of signals" explanation, which "fully serves to cover all the facts in question," though it is only by straining the evidence that the cases in which no members of the family were present when an object was selected, that Professor Donkin makes out this point. "From the only rational point of view," he says, "that of scientific scepticism, and, therefore, with total disregard of the personal factor, this consideration seems in no way to invalidate the line of comment here taken. It is not clear to how many of the three observers the pronoun 'we' in the passage [above] refers, but at any rate we miss entirely in the paper any specific quotation of results obtained in the latter set of circumstances. But even if this evidence had been forthcoming, no mere *ipse dixit* on such a matter could for one moment be admitted. Reason would require us to entertain the great probability of mental bias in some, at least, of the observers, or to discredit the accuracy of their memory, rather than to allow that anything has been adduced in this account of what (to say the least) must be regarded as superficially-conducted experiments, to warrant a recognition of any novelty, or by consequence to stand in need of explanation by a theory of 'brain-waves.'"

The spirit of extreme caution here indicated is altogether sound; the objection to novelty, as such, is as entirely unsound. *Nothing* could prove that mind acts on mind if Professor Donkin's principle were accepted in its full extent. The theory might be established so far as he himself was concerned, by an experience of his own, but no one else would be bound to accept it, and it cannot possibly be proved to each person separately and individually.

Professor Donkin seems unaware of the fact that Dr. Carpenter, who has dealt with such subjects more closely perhaps than any living man of science, and always from the sceptical side, admits all that, as I conceive, even Professor Barrett and his colleagues consider proved. In the following passage the reader will note the distinction between what Dr. Carpenter has been led to suspect, and what he regards as beyond question:—

"Every one who admits that 'there are more things in heaven and earth than are dreamt of in our philosophy,' will be wise in maintaining a 'reserve of possibility' as to phenomena which are not altogether *opposed* to the laws of physics or physiology, but rather *transcend* them. Some of my own experiences have led me to suspect that the power of intuitively perceiving what is passing in the mind of another, which has been designated as 'thought-reading,' may, like certain forms of sense-perception, be extraordinarily exalted by that entire concentration of the attention which is characteristic of the states we have been considering. There can be no question that this divining power is naturally possessed in a very remarkable degree by certain individuals, and that it may be greatly improved by cultivation. So far, however, as we are acquainted with the conditions of its exercise, it seems to depend upon the unconscious interpretations of indications (many of them indefinable) furnished by the expressions of the countenance, by style of conversation, and by various involuntary movements; that interpretation, however, going, in many instances, far beyond what can have been learned by experience as to the meaning of such indications."[1] "Looking at nerve force as a special form of physical energy, it may be deemed not altogether incredible that it should exert itself from a distance, so as to bring the brain of one person into direct dynamical communication with that of another, without the intermediation, either of verbal language,

[1] Dr. Carpenter then mentions some very curious examples related in the autobiography of Henrich Zschokke, who (according to his own statement) possessed this power in a very remarkable degree, frequently being able to describe, not only the general course, but even many particulars, of the past life of a person whom he saw for the first time, and of whose history he knew nothing whatever.

or of movements of expression. A large amount of evidence, sifted with the utmost care, would be needed to establish even a probability of such communication. But would any man of science have a right to say that it is *impossible?*"

Supposing trickery eliminated by the various tests employed by Professor Barrett and his colleagues, the point to be determined would be, of course, the method by which the person questioned was led to a correct reply. It must be remembered that the necessity of guarding against trickery interfered to some degree with the prosecution of a systematic inquiry into the laws underlying the observed phenomena. It is unfortunate that in inquiries of the sort this difficulty always arises. Thus the real phenomena underlying so-called mesmerism are full of interest, and might be readily made the subject of scientific inquiry, were it not for the trickery practised by many professed mesmerists, who, to impress audiences, pretend to do what, in reality, is outside their powers. In fact, the most satisfactory experiments in mesmerism or hypnotism, or whatever we choose to call the mental phenomena involved, are actually those performed on animals, simply because animals cannot be persuaded to be tricky "subjects." That thought-reading should in like manner be tested by experiments on animals may seem a wild and fanciful idea; yet the responses of the Mastiff Kepler, described in the article on 'Intelligence in Animals' (see p. 198), show that a dog may possess a power of reading his master's thoughts akin to that which, on the thought-reading hypothesis, is possessed by some of ourselves.

To return to Professor Barrett's inquiries :—

"We endeavoured," he says, "to gather such indications as we could of the way in which the impression flashed on the mind of the child. The first question concerns the respective parts in the phenomena played by mental *eye* and mental *ear*. Among the experiments which we counted as *failures* were very many where the number or card selected was guessed, as it were, piecemeal. For instance, the number 35 was selected, and the guesses were 45 and 43. So 57 was attempted as 47 and 45. So with cards : the seven of diamonds being chosen, the guesses were six of diamonds and seven of hearts ; the three of spades being chosen, the guesses were queen of spades and three of diamonds. These cases seem somewhat in favour of mental eye, the similarity in *sound* between three and thirty in 43 and 35, or between five and fifty in 45 and 57, not being extremely strong ; while the *picture* of the three or the five is identical in either pair. A stronger argument on the same side is the frequent guessing of king for knave, and *vice versâ*. On the other hand, names of approximate sound (also reckoned as failures) were often given instead of the true one ; 'Chester' for Leicester, 'Biggis,' for Billings. Frogmore was guessed first as 'Freemore,' Snelgrove was given as 'Singrore,' the last part of the name was soon given as 'grover,' and the attempt was then abandoned; the child remarking afterwards that she thought of 'Snail' as the first syllable, but it had seemed to her too ridiculous. One of us has, moreover, successfully obtained from the maid-servant a German word of which she could have formed no visual image. The children's own account is usually to the effect that they 'seem to see' the thing; but this, perhaps, does not come to much, as a known object, however suggested, is sure to be instantly visualised. Another question would be as to the effect of greater or less distance between the sitters and the guesser, and of the intervention of obstacles. It will have been seen that, in the experiments conducted by one of us on a former occasion, the intervention of a door or wall seemed to make no difference. It would be interesting, again, to discover whether numerical increase in the observers increases the effect, and how far the presence of special persons is influential. In our experience the presence of the father—though by no means essential, and very often dispensed with—seems decidedly to increase the percentage of successes. A still more interesting and important question concerns such conditions of success and failure as may lie in the circumstances, disposition, general capacity, and mood of the subject, including such points as consanguinity and familiarity with members of the circle, and also in the temper and manner of the latter. We are dealing, not with chemical substances, but with childish minds, liable to be reduced to shyness and confusion by anything in the aspect or demeanour of visitors which inspires distaste or alarm. The importance of a 'childly way with children,' and the slightness of the differences of manner which will either paralyse them into stupidity or evoke unexpected intelligence and power, are commonplaces to any one whose duties have lain among them; and attention to such points may be as prime a factor of success in these delicate experiments as any other. The delicacy of the conditions was illustrated in our own inquiry partly by the inexplicable fluctuations of success and failure affecting the whole household, partly by the wide difference observed in the capacities of particular members of it from day to day. The common notion that simplicity, and even comparative blankness of mind, are important conditions, seems somewhat doubtfully borne out by our experience; but of the favourable effect of freedom from constraint, and of a spice of pleasurable excitement, we can speak with entire assurance. The particular ill-success of a sitting which we held one close afternoon was attributed by the children themselves—and it seemed to us correctly—to inertness after their early dinner. We could find no resemblances between these phenomena and those known as *mesmeric*; inasmuch as a perfectly normal state on the part of the subject seemed our first prerequisite. Nor did we find any evidence that 'strength of will' has any particular effect, except so far as both subjects and circle may exercise it in patient attention. On one or two occasions it seemed of advantage to obtain vivid simultaneous realisation of the desired word on the part of all the sitters; which is most easily effected if some one slowly and gently claps time, and all mentally summon up the word with the beats."

This last observation is significant, and if it could be confirmed by a sufficient series of experiments, would go far to establish the theory that mind can act on mind at a distance—that is, without actual contact by which mind impressions can be conveyed by a sort of unintended signalling.

On this point, and especially on the theory of brain-waves, which has been suggested in explanation of the numerous stories related of apparitions seen by friends at a distance at the time of the death of the person so seen, or of some serious accident befalling them, we shall have a few words to say further on.

In endeavouring to explain those phenomena which come out, after careful elimination of doubtful cases, we must be careful to avoid equally undue confidence and scepticism. For my own part, I am disposed to agree with Professor Barrett in considering that the assumption of *à priori* impossibility is more to be deprecated in the present state of our knowledge of Nature. There is very little fear that science will accept any wild hypothesis in explanation even of phenomena most unlike those which have hitherto been brought within its sphere; for the corrective capacity of science, already strongly developed, increases daily. On the other hand, there is always some degree of danger that questions of interest may unwisely be put on one side as not worth inquiring into, *because* they do not at first seem explicable by known physical laws. The two dangers are, however, closely related together. It is noteworthy that the mind which most recklessly rejects evidence which seems new or strange, is the readiest eventually to accept the most wildly impossible theories. It appears to me that Professor Barrett and his colleagues very fairly present the *à priori* difficulties in this case. Apart from the legitimate grounds of suspicion, open —as they say—to all who have chanced to encounter the alleged phenomena in their vulgarest or most dubious aspects, "it is inevitable that, as the area of the known increases by perpetual additions to its recognised departments, and by perpetual multiplication of their connexions, a disinclination should arise to break loose from association, and to admit a quite new department on its own independent evidence. And it cannot be denied that the department of research towards which the foregoing experiments form a slight contribution, presents as little apparent connexion with any ascertained facts of mental and of material science. Psychological treatises may be searched in vain for any amount of transmission of mental images otherwise than by purely sensory channels."

Yet the only explanation science can seek is a physical one. It is open, Professor Barrett considers, to surmise that there is some sort of analogy to the familiar phenomenon of the transmission and reception of vibratory energy.

We are led along this line to conceive that some association may exist between the phenomena of so-called thought-reading, and those strange stories of apparitions at the time of death or of intense suffering, which have been narrated by so many persons of good repute (by so many, indeed, well known to fame), as to make the simple rejection of such accounts a very unsatisfactory way of dealing with the evidence.

Respecting these experiences, the editor of the *Nineteenth Century* formulated thirteen years ago in the *Spectator* the following attempt at an explanation :—

"Let it be granted that whensoever an action takes place in the brain, a chemical change of its substance takes place also ; or, in other words, an atomic movement occurs. . . . .

"Let it be also granted that there is, diffused throughout all known space, and permeating the interspaces of all bodies—solid, fluid, or gaseous—a universal, impalpable, elastic 'ether,' or material medium of surpassing and inconceivable tenuity. . . . .

"But if these two assumptions be granted, and the present condition of discovery seems to warrant them, should it not follow that no brain action can take place without creating a wave or undulation in the ether? for the movement of any solid particle submerged in any such medium must create a wave.

"If so, we should have, as one result of brain action, an undulation or wave in the circumambient, all-embracing ether—we should have what I will call Brain-Waves proceeding from every brain when in action.

"Each acting, thinking brain, then, would become a centre of undulations transmitted from it in all directions through space. . . . Why do not such undulations, when meeting with and falling upon duly sensitive substances, as if upon the sensitised paper of the photographer, produce impressions, dim portraits of thoughts, as undulations of light produce portraits of objects?

"The sound-wave passes on through myriads of bodies, and among a million makes but one thing sound or shake to it; a sympathy of structure makes it sensitive, and it alone. A voice or tone may pass unnoticed by ten thousand ears, but strike and vibrate one into a madness of recollection. In the same way the brain-wave of Damon, passing through space, producing no perceptible effect, meets somewhere with the sensitised and sympathetic brain of Pythias, falls upon it, and fills it with a familiar movement. The brain of Pythias is affected as by a tone, a perfume, a colour with which he has been used to associate his friend; he knows not how or why, but Damon comes into his thoughts, and the things concerning him by association live again. If the last brain-waves of life be frequently intensest—convulsive in their energy, as the firefly's dying flash is its brightest, and as oftentimes the 'lightening before death' would seem to show—we may, perhaps, seem to see how it is that apparitions at the hour of death are far more numerous and clear than any other ghost stories.

"Such oblique methods of communicating between brain and brain (if such there be) would probably but rarely take effect. The influences would be too minute and subtle to tell upon any brain already pre-occupied by action of its own, or on any but brains of extreme, perhaps morbid, susceptibility. But if, indeed, there be radiating from living brains any such streams of vibratory movements (as, surely, there must be), these may well have an effect even without speech, and be, perhaps, the *modus operandi* of 'the little flash, the mystic hint' of the poet—of that dark and strange sphere of half-experiences which the world has never been without. . . .

"No doubt atomic movements, causing waves in space, must start from other parts of the body as well as from the brain. . . . But the question here is simply limited to how *brains* are affected by the movements of other brains; just as the question of how one pendulum will make other pendulums swing with it is a fair mechanical inquiry by itself, though doubtless other questions would remain as to how the movement of the pendulum would affect all other material bodies, as well as pendulums, in the same room with it."

Of course, the difficulty in this, as in all other attempts at explaining these occasional and extraordinary experiences, is that there are no known physical laws which would account for the supposed physical action, and that as yet there seems no possibility of any experimental researches on either of the brain-powers supposed to be involved — the power of originating the suggested brain-waves, or the power of receiving them. Then again, it is difficult to understand why, if the theory be true, the observed instances are so few, compared with the number of occasions on which (considering the 1,500,000,000 persons existing on the globe) we might suppose the suggested powers would be exerted.

MONKSHOOD.

BY GRANT ALLEN.

To look at these queer, irregular blue flowers, growing on a long and handsome spike in the old-fashioned garden border, nobody would ever dream of saying that they were in reality altered and modified butter-cups. And yet that is just what they really are, with all the marks of their curious pedigree still clearly impressed upon their very form. Pull one of the blue blossoms off, and pick it carefully to pieces, and you will see how strangely and profoundly it has been distorted by insect selection. Monkshood is most essentially a bee-flower, and in examining it we see the results of bee action plainly set forth in every organ. If we pick a common meadow buttercup for comparison with it, we shall be able to see exactly wherein the two flowers differ, as well as why the one has gained an advantage in the struggle for existence over the other.

The outside whorl of the buttercup consists, of course, of five separate greenish sepals, which together make up its calyx. Inside the sepals come the five golden petals composing the cup-shaped corolla; and inside the petals, again, come the numerous stamens, and the equally numerous carpels, or unripe fruits, each containing a single, solitary little seed. Moreover, all these parts are regularly and symmetrically arranged round a common centre, so as to form a series of concentric whorls. But when we look at the monkshood, we see no such simple and orderly arrangement in its architectural plan. At first sight, we recognise no distinct sepals or petals; and the coloured organs that take their place are very irregular in shape, and disposed in an unsymmetrical fashion—or rather, to speak more correctly, their symmetry is not radial, but bilateral. When we begin to pull our blue blossom to pieces, however, we gradually recognise the various parts of which it is composed. First of all come five sepals, not greenish, as in the buttercup, but bright blue; and not all alike, but specially modified to fulfil their separate functions. The uppermost sepal of all is helmet-shaped, and it forms the curious cowl which gained the plant its suggestive name from our mediæval ancestors. The two side sepals, to right and left, are flatter and straighter, but very broad, while the two lowest of all are comparatively small and narrow. The whole five are bright blue in colour. Pull off these petal-like sepals, and you come to the real petals beneath them. At first you can hardly find them at all; you see only two long blue horns, covered till now by the helmet-shaped upper sepal or cowl, and each with a queer cup-like sac at its extremity, containing a small drop of clear fluid. That fluid is honey, but I should advise you to be careful, in tasting it, not to bite off any of the flower, for monkshood is the plant from which we get the now famous poison, aconitine; and a very little of it goes a long way. Unlike as they are to the familiar yellow petals of the buttercup, one can still gather from their position that the two long horns are really petals. But where are the three others? Well, you must look rather close to find them, and perhaps even then you won't succeed after all; for sometimes the three lower petals have disappeared altogether, being suppressed by the plant, as of no further use to it. In this particular specimen, however, they still survive as mere relics or rudiments, three little narrow blue blades, not nearly as big as a gnat's wing, placed alternately to the lower sepals. As for the stamens, they are still present about as numerously as in the buttercup; whereas the carpels, or fruit-pieces, are reduced to three only, which in the ripe seed-vessels here on the lower and older part of the spike grow into long pods or follicles, each containing several seeds.

Thus, then, the flower of monkshood agrees fundamentally with the flower of the buttercup; while, at the same time, it has undergone some very singular and suggestive modifications. In both there are five sepals; but in the buttercup all five are alike, and all five are greenish; whereas in the monkshood they have acquired different shapes, exactly fitting them to the bee's body, and they have become blue, because blue is the favourite colour of bees. Again, in both there are five petals; but in the buttercup all five are similar and yellow, and all five secrete a drop of honey at the base; whereas in the monkshood two of them have become long and narrow specialised nectaries, while the other three, being no longer needed, have grown obsolete or nearly so. Once more, the stamens remain the same; but the carpels have been immensely reduced in number, at the same time that the complement of seeds in each has been greatly increased by way of compensation.

Well, how are we to account for these peculiar modifications? Entirely by the action of the fertilising bees. The secret of the monkshood depends, in the first place, upon the fact that its flowers are clustered into a spike, instead of growing in solitary isolation at the end of the stem, as in the common buttercups. Now Mr. Herbert Spencer has pointed out that solitary terminal flowers are always radially symmetrical, and never one-sided, because the conditions are the same all round, and the visiting insects can light upon them equally from every side. But flowers which grow sideways from a spike are very apt to become bilaterally symmetrical; indeed, whenever they are not so, one can always give an easy explanation of their deviation from the rule. Probably the blossoms of the monks-hood began by arranging themselves in a long and handsome spike, so as more readily to attract the eyes of insects, and that was the real starting point of all their subsequent modifications. Or, to put the same thing more literally, those monkshoods which happened to grow spike-wise succeeded best in attracting the bees, and therefore were most often fertilised in the proper manner. Next, we may suppose, the large green sepals, being much exposed to view, began to acquire a blueish tinge, as all the upper parts of highly developed plants are apt to do; and the bluer they became, the more conspicuous they looked, and therefore the better they got on in competition with their neighbours, especially since bees are particularly fond of blue. As each bee would necessarily light on the middle or lower portion of the flower, he would begin by extracting the honey from the two upper petals; but it would be rather awkward for him to turn round, head downward, and suck the nectaries of the three bottom ones. Hence, in course of time, especially after the flower began to acquire its present shape, the two top petals became specialised as nectaries, while the three lower ones gradually atrophied, since the coloured sepals had practically usurped their attractive function. But as the flower can only succeed by being fertilised, all these changes must have been really subordinate to the great change which was simultaneously going on in the mechanism for ensuring fertilisation. Slowly the blossoms altered to the bilateral shape—they adapted themselves by the bee's unconscious selection to the insect's form. The uppermost sepal grew into the hood, so arranged that the bee must get under it in order to reach the long nectaries containing their copious store of honey. At the same time the bee must brush against the stamens, and cover his breast with a stock of adhesive pollen-grains. When he flies away to the next flower he carries the pollen with him; and as he rifles the nectaries in the second blossom, he both deposits pollen from the last plant upon the sensitive surface of the carpels in this, and also collects a fresh lot of pollen to fertilize whatever other flower he may next favour with a call. The increased certainty of fertilisation thus obtained enables the plant to dispense with some of the extra carpels which its buttercup ancestors once possessed; and by lessening the number to three, it manages to get the whole set impregnated at a single visit. But, as three seeds would be a small number to depend upon in a world of overstocked markets and adverse chances, it makes up for the diminution of its carpels by largely increasing the stock of seeds in each.

Thus the whole shape and arrangement of the monkshood bear distinct reference to the habits and tastes of the fertilising bees. It is a mountain plant by origin, belonging to a tribe which took its rise among the great central chains of Europe and Asia, and these Alpine races are usually highly developed in adaptation to insect fertilisation, because they depend more absolutely upon a few upland species than do the eclectic flowers of the plains, which may be impregnated hap-hazard by a dozen different flies, or moths, or beetles. We can still dimly trace many of the links which connect it with very simple and primitive buttercups, if not directly, at least by the analogy of other plants. For all the buttercup tribe show us regular gradations in the same direction. The simplest kinds are round, yellow, and many-carpelled, like the buttercups. Then those species which display their sepals largely have dwarfed petals, like hellebore and globe-flower, or have lost them altogether, like marsh-marigold, which trusts entirely for colour display to its big golden calyx. The still higher anemones have the sepals white, red, or blue; and the very advanced columbine has all the petals spurred, and developed into nectaries, like those of monkshood. But columbine still keeps to single terminal flowers, so that here the five petals remain regular and circularly symmetrical, though the carpels are reduced to five. Fancy a number of such columbine flowers crowded together on a spike, however, and you can readily picture to yourself by rough analogy the origin of monkshood. The sepals would now become the most conspicuous part; the two upper petals would alone be useful in insuring fertilisation, and the lower ones would soon shrivel away from pure disuse. The development of the hood, and the lengthening of the upper petals, would easily follow by insect selection. It is a significant fact that our only other spiked buttercup, the larkspur, has equally irregular and bilateral flowers, though its honey is concealed in a long spur formed by the petals, and accessible to but one English insect, the humble bee.

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