PUBLISHED UNDER THE SUPERINTENDENCE OF THE SOCIETY FOR THE DIFFUSION OF USEFUL KNOWLEDGE.

THE LIBRARY

OF

ENTERTAINING KNOWLEDGE.

INSECT TRANSFORMATIONS.

COMMITTEE.

Chairman—H. BROUGHAM, Esq , F.R.S., M.P.
Vice Chairman—LORD JOHN RUSSELL, M. P.
Treasurer—WILLIAM TOOKE, Esq., F.R S.

Rt. Hon. J. Abercrombie, M.P.
W. Allen, Esq., F.R.S.
Viscount Althorp, M.P.
Rt. Hon. Visc. Ashley, M.P.
Rt. Hon. Lord Auckland.
W. B. Baring, Esq., M.P
Capt. F Beaufort, R.N, F.R.S.
C. Bell, Esq. F R.S., L. & E
T. F. Buxton, Esq., M.P., F.R S.
R Otway Cave, Esq., M.P.
John Conolly, M.D.
William Coulson, Esq.
Wm. Crawford, Esq.
Fred. Daniell, Esq , F.R.S.
John Davis, Esq , F.R.S.
T. Denman, Esq.
Hon. G. Agar Ellis, M.A. M.P.
T. F. Ellis, Esq., M.A.
Thomas Falconer, Esq.
I. L Goldsmid, Esq., F.R.S.
B Gompertz, Esq., F.R.S.
H. Hallam, Esq., F.R.S., M.A.
M. D. Hill, Esq.
Rowland Hill, Esq.
Edwin Hill, Esq
Leonard Horner, Esq., F.R.S.
David Jardine, Esq.
Henry B. Ker, Esq , F R.S.
J G. S. Lefevre, Esq., F R.S.
Edward Lloyd, Esq., M.A.
James Loch, Esq., M.P., F.G.S.
George Long, Esq., A.M.
J. W. Lubbock, Esq. F.R.&L.S.
Dr. Lushington, D.C L., M.P.
B. H. Malkin, Esq., M.A.
Rev Ed Maltby, D.D., F.R.S.
James Manning, Esq.
F. O. Martin, Esq.
J. Marshall, Esq , M.P.
John Herman Merivale, Esq.
James Mill, Esq
James Morrison, Esq , F.(
Sir H. Parnell, Bart., M.]
Professor Pattison.
T. Spring Rice, Esq., M. F.A S
Dr Roget, Sec R.S.
C. E. Rumbold, Esq., M.]
J. Smith, Esq., M P.
Wm. Sturch, Esq.
Rt. Hon. Lord Suffield.
C. P. Thomson, Esq., M.
Dr. A. T. Thomson, F.L.
A. N. Vigors, Esq , F.R.S
H Warburton, Esq., M F R S.
H. Waymouth, Esq.
J Whishaw, Esq , M.A , F
Mr. Serjeant Wilde.
J. Wood, Esq., M.P.
John Wrottesley, Esq. M

THOMAS COATES, *Secretary*, 4, South Square, Gray's Inn.

LOCAL COMMITTEES OF THE SOCIETY.

Ashburton—J. F. Kingston, Esq.
Birmingham Local Association.
Rev. John Corrie, *Chairman.*
Paul Moon James, Esq., *Treasurer.*
Jos Parkes, Esq. } *Hon*
Wm Redfern, Esq. } *Secs.*
Bristol—J. N Sanders, Esq., *Chairman.*
J. Reynolds, Esq , *Treas.*
J. B. Estlin, Esq F.L S., *Sec.*
Cambridge—Rev James Bowstead, M.A.
Rev. Prof. Henslow, M.A., F.L S. & G. S.
Rev Leonard Jenyns, M.A., F.L.S.
Rev John Lodge, M A.
Henry Malden, Esq , M A.
Fred Malkin, Esq., M.A.
Rev Geo. Peacock M A., F.R.S. & G.S.
Marmaduke Ramsay, Esq., M.A., F.L.S.
Rev. Prof. Sedgwick, M.A., F.R.S & G S.
Professor Smyth, M.A.
Rev. Connop Thirlwall, M.A.
Derby—Joseph Strutt, Esq.
William Strutt, Esq.
Devonport—Major J. Hamilton Smith, F.R. & L.S.
Dublin—Hon. Thos. Vesey.
Edinburgh—R Greville, LL.D.
D Ellis, Esq., F.R S.
Capt. Basil Hall, R.N., F.R.S L. & E
Fras. Jeffrey, Esq.
Prof. Napier, F.R.S.E.
Rev. A. Thomson, D D.
W. Thomson, Esq.
Etruria—Jos. Wedgwood, Esq
Exeter—Rev. J. P. Jones.
J. Tyrrel, Esq.
Glasgow—K. Finlay, Esq.
D Bannatyne, Esq
Rt. Grahame, Esq.
Professor Mylne.
Alexander McGrigor, Esq.
Charles Macintosh, Esq. F.R.S.
Mr. T. Atkinson, *Hon. Sec.*
Hull—Dl. Sykes, Esq , M.P.
Keighley, Yorkshire—Rev. Th. Dury, A M.
Launceston—Rev. J. Barfitt
Leamington Spa—Dr. Loudon.
Leeds—Benjamin Gott, Esq.
J Marshall, Jun , Esq
Lewes—J. W. Woollgar, Esq.
Liverpool Local Association.
Dr. Traill, *Chairman.*
J. Mulleneux, Esq., *Treas.*
Rev. W. Shepherd.
J. Ashton Yates, Esq.
Maidenhead—R. Goolden, Esq., F.L.S.
Manchester Local Associa
G. W. Wood, Esq., *Cha*
B. Heywood, Esq *Tr*
T. W. Winstanley, *Hon. Sec*
Sir G Philips, Bart.,
Monmouth—J. H. Mog Esq.
Newcastle—James Losh,
Rev. W. Turner
Newport—Ab Clarke, E
T Cooke, Jun , Esq
R G. Kirkpatrick, E
Newport Pagnell—Jam lar, Esq.
Norwich—Rich. Bacon,
Plymouth—Geo Harvey F.R.S.
Portsmouth—E. Carter,
G. Grant, Esq.
D. Howard, Esq.
Rev. Dr. Inman, Na
Sheffield—J. H. Abraha
South Petherton—J. Ni Esq
Tavistock—Rev W Ev
John Rundle, Esq.
Truro—Wm. Peter, Esq
Waterford—Sir John N Bart , M P.
Wolverhampton—J. Pearı
Worcester—Dr. Corbet,
Dr. Hastings, M.D.
C. H. Hebb, Esq.
Mr. Henry Martin.

THE LIBRARY OF ENTERTAINING KNOWLEDGE.

INSECT TRANSFORMATIONS.

LONDON:
CHARLES KNIGHT, PALL MALL EAST;
LONGMAN, REES, ORME, BROWN, & GREEN, PATERNOSTER ROW;
OLIVER & BOYD, EDINBURGH; T. ATKINSON, GLASGOW;
WAKEMAN, DUBLIN; WILLMER, LIVERPOOL; & BAINES & CO., LEEDS

MDCCCXXX.

LONDON:
PRINTED BY WILLIAM CLOWES,
Stamford Street.

CONTENTS.

SECTION I.—EGGS OF INSECTS.

CHAPTER I.—Introductory.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

SECTION II.—LARVÆ.

CHAPTER VI.

CHAPTER VII.

CHAPTER X.

SECTION III.—PUPÆ.

CHAPTER XI.

CHAPTER XII.

CHAPTER XIII.

SECTION IV. PERFECT INSECTS.

CHAPTER XIV.

CHAPTER XV.

CHAPTER XVI.

CHAPTER XVII.

INSECT TRANSFORMATIONS.

SECTION I.—EGGS OF INSECTS.

CHAPTER I.

All Insects come from Eggs as Plants do from Seeds.—Vulgar errors of Insects being generated by Putrefaction and Blighting Winds disproved by experiment.

IT was universally believed by the ancient philosophers, that maggots, flies, and other insects were generated from putrefying substances. This opinion continues to be held by uninformed persons among ourselves;—though it would be equally correct to maintain, that a flight of vultures had been generated by the dead carcass which they may be seen devouring, or a flock of sheep from the grass-field in which they graze. Another opinion, perhaps still more generally diffused, is that caterpillars, aphides, and other garden insects which destroy the leaves of plants, are generated, propagated, or, at least, spread about, by certain winds or states of the air, mysteriously and indefinitely termed *blight*. The latter belief is, probably, not so easy of immediate refutation as the former;—but, as we shall endeavour to shew, it seems to us to be equally erroneous.

The small size of insects renders it somewhat easy to pass off fanciful opinions regarding them, since it is difficult for common observers to detect mistakes;

B

but similar notions have been entertained by writers of no mean reputation, respecting even the larger animals. The celebrated Kircher, for example, one of the most learned men of the seventeenth century, goes so far as to give the following singular recipe for the manufacture of snakes:—

"Take some snakes," says he, "of whatever kind you want, roast them, and cut them in small pieces, and sow those pieces in an oleaginous soil; then, from day to day, sprinkle them lightly with water from a watering-pot, taking care that the piece of ground be exposed to the spring sun, and in eight days you will see the earth strewn with little worms, which, being nourished with milk diluted with water, will gradually increase in size till they take the form of perfect serpents. This," he subjoins with great simplicity, "I learned from having found in the country the carcase of a serpent covered with worms, some small, others larger, and others again that had evidently taken the form of serpents. It was still more marvellous to remark, that among these little snakes, and mixed as it were with them, were certain flies, which I should take to be engendered from that substance which constituted the aliment of the snakes*."

Kircher's more shrewd and less fanciful correspondent, Redi, determined to prove this singular recipe before he trusted to the authority of his friend. "Moved," he says, "by the authentic testimony of this most learned writer, I have frequently tried the experiment, but I could never witness the generation of those blessed snakelets made to hand†." But though Redi could not, in this way, produce a brood of snakes, his experiments furnished an abundant progeny of maggots,—the same, unques-

* Athan. Kircher, Mund. Subterran. lib. xii.

† Redi, Generat. Insectorum, edit. Amstel. 1686.

tionably, that the imagination of Kircher had magnified into young snakes,—which, being confined in a covered box, were in a short time transformed into flies, at first of a dull ash colour, wrinkled, unfinished, and their wings not yet unfolded,—as is always the case with winged insects just escaped from their pupa case. In less than an hour, however, they "unfolded their wings and changed into a vivid green, marvellously brilliant"—most probably the green flesh-fly (*Musca Cæsar.* LINN.)

It is a common opinion in this country, particularly in the north, that if a horse's hair be put into the water of a spring or a ditch, it will be in process of time transformed, first into a hair-worm, and afterwards into an eel. The deception, as in the instance of Kircher's snakes, arises from the close resemblance between a hair and the hair-worm (*Gordius aquaticus*, LINN.), and between this and a young eel. This fabled transformation of hair, which we have heard maintained even by several persons of good education, is physically impossible and absurd.

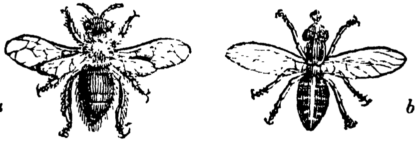
The method laid down by Virgil in his Georgics for generating a swarm of bees is precisely of the same description as the snake recipe of Kircher; and though the "Episode of Aristæus recovering his bees" has been pronounced to be "perhaps the finest piece of poetry in the world," we must be permitted to say that it is quite fabulous and unphilosophical. The passage runs thus:—

Oft from putrid gore of cattle slain
Bees have been bred. * * * A narrow place,
And for that use contracted, first they choose,
Then more contract it, in a narrower room,
Wall'd round, and cover'd with a low built roof,
And add four windows, of a slanting light
From the four winds. A bullock then is sought,
His horns just bending in their second year;

Him, much reluctant, with o'erpow'ringforce,
They bind; his mouth and nostrils stop, and all
The avenues of respiration close;
And buffet him to death: his hide no wound
Receives; his batter'd entrails burst within.
Thus spent they leave him: and beneath his sides
Lay shreds of boughs, fresh lavender and thyme.
This, when soft zephyr's breeze first curls the wave,
And prattling swallows hang their nests on high.
Meanwhile the juices in the tender bones
Heated ferment; and, wondrous to behold,
Small animals, in clusters, thick are seen,
Short of their legs at first: on filmy wings,
Humming, at length they rise; and more and more
Fan the thin air; 'till, numberless as drops
Pour'd down in rain from summer clouds, they fly.
TRAPP'S VIRGIL, Georg. iv. 369.

Columella, a Roman writer on rural affairs, after directing in what manner honey is to be taken from a hive by killing the bees, says, that if the dead bees be kept till spring, and then exposed to the sun among the ashes of the fig-tree, properly pulverised, they may be restored to life.

These fancies have evidently originated from mistaking certain species of flies (*Syrphi*, *Bombylii*, &c.) for bees, which, indeed, they much resemble in general appearance; though they have only *two* wings, and *short* antennæ, while all bees have *four* wings, and *long* antennæ. Neither the flies nor the



a b

Comparative figures of a bee (*a*) and a syrphus (*b*).

bees are produced by putrefaction;—but as the flies are found about animal bodies in a state of decomposition, the ancients fell into an error which accurate observation alone could explode. The maggots of blow-flies, as Swammerdam remarks, so often found in the carcasses of animals in summer, "somewhat resemble those produced by the eggs of bees. However ridiculous," he adds, "the opinion must appear, many great men have not been ashamed to adopt and defend it. The industrious Goedart has ventured to ascribe the origin of bees to certain dunghill worms*, and the learned De Mei joins with him in this opinion; though neither of them had any observation to ground their belief upon, but that of the external resemblance between bees and certain kinds of flies (*Syrphidæ*) produced from those worms. The mistake of such authors should teach us," he continues, "to use great caution in our determinations concerning things which we have not thoroughly examined, or at least to describe them with all the circumstances observable in them. Therefore, although this opinion of bees issuing from the carcasses of some other animals by the power of putrefaction, or by a transposition of parts, be altogether absurd, it has had, notwithstanding, many followers, who must have in a manner shut their eyes in order to embrace it. But whoever will attentively consider how many requisites there are for the due hatching of the bee's egg, and for its subsistence in the grub state, cannot be at a loss for a clue to deliver himself out of that labyrinth of idle fancies and unsupported fables, which, entangled with one another like a Gordian knot, have even to this day obscured the beautiful simplicity of this part of natural history†."

Redi was by no means satisfied with the first results of his experiments upon the flesh of snakes, for several

* The maggots of *Eristalis tenax*, FABR. *E. apiformis*, MEIGEN, and other *Syrphidæ*, well known in common sewers by their long tails, like those of rats.

† Swammerd. Book of Nature, i. 228.

species of flies were produced, giving some countenance to the opinion of Aristotle, Pliny, Mouffet, and others, that different flesh engenders different flies, inheriting the disposition of the animal they are bred from. He accordingly tried almost every species of flesh, fish, and fowl, both raw and cooked, and soon discovered (as he could not fail to do) that the same maggots and flies were produced indiscriminately in all. This ultimately led him to ascertain that no maggots are ever generated except from eggs laid by the parent flies: for when he carefully covered up pieces of meat with silk or paper sealed down with wax, no maggots were seen; but the parent flies, attracted by the smell of the covered meat, not unfrequently laid their eggs on the outside of the paper or silk, the maggots hatched from these dying, of course, for want of nourishment.

With respect to bees, it becomes even more absurd to refer their generation to putrefaction, when we consider that they uniformly manifest a peculiar antipathy to dead carcasses. This was remarked so long ago as the time of Aristotle and of Pliny *; and Varro asserts that bees never alight upon an unclean place, nor upon any thing which emits an unpleasant smell. This is strikingly exemplified in their carrying out of the hive the bodies of their companions who chance to die there; and in their covering over with propolis the bodies of snails, mice†, and other small animals which they cannot remove ‡.

These facts, which are unquestionable, may at first view appear to contradict the Scripture history

* Aristotle, Hist. Animal. ix. 40. Pliny says, "Omnes carne vescuntur, contra quam apes, quæ nullum corpus attingunt."

† Huish on Bees, p. 100.

‡ Insect Architecture, p. 109.

of Samson, who, having killed a young lion in the vineyards of Timnath, "after a time turned aside to see the carcass of the lion: and behold a swarm of bees and honey in the carcass*." It only requires us, however, to examine the facts, to shew that this docs not disagree with the preceding statement. Bochart, in his Sacred Zoology, tells us that the word rendered "carcass" literally signifies *skeleton;* and the Syriac version still more strongly renders it a *dried body* (corpus exsiccatum). Bochart further contends, that the phrase "after a time" is one of the commonest Hebraisms for a year. But when we consider the rapid desiccation caused by the summer suns of Palestine, this extension of time will be unnecessary; for travellers tell us that the bodies of dead camels become quite parched there in a few days. We have the testimony of Herodotus, that a swarm of bees built their cells and made honey in the dried carcass of a man placed above the gate of Athamanta. Soranus also tells us of a swarm of bees found in the tomb of the celebrated Hippocrates. "I have been told," says Redi, "by Albergotto, a man of profound erudition, that he had seen a swarm in the cranium of a horse. Bees," he adds, "not only do not live upon dead bodies, but they will not even come near them, as I have often proved by experiment." "It is probable," says Swammerdam, "that the not rightly understanding Samson's adventure of the lion gave rise to the popular opinion of bees springing from dead lions, oxen, and horses." Kirby and Spence seem disposed to consider Samson's bees, as we have done those of Virgil, to be flies resembling bees; but the "honey" which Samson "took in his hands and went on eating," is fatal to such an exposition.

The ancients had another fancy respecting the

* Judges, xiv. 8.

propagation of bees, equally absurd, though much more poetical. Virgil tells us that,

> From herbs and fragrant flowers, with their mouths
> They cull their young. *Georg.* iv.

Aristotle* had long before stated, and De Monfort in modern times repeated the assertion†, that the olive, the cerinthus, and some other plants, have the property of generating young bees from their purest juices. We may well say, with Lactantius, that "they make shipwreck of their wisdom, who adopt without judgment the opinions of their ancestors, and allow themselves to be led by others like a flock of sheep ‡." Modern naturalists, being accustomed to minute accuracy in their observations, can both disprove and readily explain most of those erroneous fancies, by tracing the causes which led, and may still lead, inaccurate observers into such mistakes.

It would have been well if such unfounded fancies had rested here; but philosophical theorists, both of ancient and modern times, have promulgated dreams much more extravagant. The ancients taught that the newly-formed earth (hatched as some said from an egg) clothed itself with a green down like that on young birds, and soon after men began to sprout up from the ground as we now see mushrooms do. The refined Athenians were so firmly convinced of their having originally sprung up in this manner, that they called themselves "Earth-born" (*Erichthonii*), and wore golden tree-hoppers (*Cicadæ*) in their hair, erroneously supposing these insects to have a common origin with themselves §. Lucretius

* Hist. Animal. v. 22.

† Le Portrait de la Mouche à Miel. Liege, 1646.

‡ Divin. Instit. ii. 7; in Redi's motto. Shepherds on the continent lead their sheep, as those of Israel did. See Menageries, vol. i. p. 81.

§ The Cicadæ do not deposit their eggs in the earth, but on trees, &c. See *Insect Architecture*, chap. vii.

affirms, that even in his time, when the earth was supposed to be growing too old to be reproductive, "many animals were concreted out of mud by showers and sunshine*."

But the ancients, it would appear, had the shrewdness seldom to venture upon illustrations of their philosophical romances by particular examples. This was reserved for the more reckless theory-builders of our own times. We find Robinet, for example, asserting that, as it was nature's chief object to make man, she began her "apprentissage," as he calls it, by forming minerals resembling the single organs of the human body, such as the brain in the fossil called Brain-stone (*Meandrina cerebriformis*, PARKINSON†). Darwin, again, taking the hint from Epicurus, dreams that animals arose from a single filament or threadlet of matter, which, by its efforts to procure nourishment, lengthened out parts of its body into arms and other members. For example, after this filament had improved itself into an oyster, and been by chance left dry by the ebbing of the tide, its efforts to reach the water again expanded the parts nearest to the sea into arms and legs. If it tried to rise from its native rocks, the efforts produced wings, and it became an insect, which in due course of time improved itself by fresh efforts till it became a bird, the more perfect members being always hereditarily transmitted to the progeny. The different forms of the bills of birds, whether hooked, broad, or long, were, he says, gradually acquired by the perpetual endeavours of the creatures to supply their wants. The long-legged water-

* Multaque nunc etiam existunt animalia terris,
Imbribus et calido solis concreta vapore.
De Nat. Rer. v. 795.

† Robinet, Consid. Philosophiques de la Gradation Naturelle des Formes de l'Etre. Paris, 1768.

fowl (*Grallatores*, VIGORS) in this way acquired length of legs sufficient to elevate their bodies above the water in which they waded. "A proboscis," he says, "of admirable structure has thus been acquired by the bee, the moth, and the humming-bird, for the purpose of plundering the nectaries of flowers*." Lamarck, an eminent French naturalist, recently deceased, adopted the same visions; and, among other illustrations of a similar cast, he tells us that the giraffe acquired its long neck by its efforts to browse on the high branches of trees, which, after the lapse of a few thousand years, it successfully accomplished.

Theories like the preceding all originate in the endeavours of human ingenuity to trace the operations of nature farther than ascertained facts will warrant; and the necessary blanks in such a system, which presupposes much that cannot be explained, are filled up by the imagination. This inability to trace the origin of minute plants and insects led to the doctrine of what is called spontaneous or equivocal generation, of which the fancies abovementioned are some of the prominent branches. The experiments of Redi on the hatching of insects from eggs, which were published at Florence in 1668, first brought discredit upon this doctrine, though it had always a few eminent disciples. At present it is maintained by a considerable number of distinguished naturalists, such as Blumenbach, Cuvier, Bory de St. Vincent, R. Brown, &c. "The notion of spontaneous generation," says Bory, "is at first revolting to a rational mind, but it is, notwithstanding, demonstrable by the microscope. The fact is averred: Müller has seen it, I have seen it, and twenty other observers have seen it: the Pandorinia exhibit it every instant †.'

* Darwin's Zoonomia, sect. xxxix. 3d edit. London, 1801.

† Dict. Classique d' Hist. Nat., Art. Microscopiques, p. 541.

These pandorinia he elsewhere describes as probably nothing more than "animated scions of Zoocarpæ" (propagules animés des Zoocarpes)*. It would be unprofitable to go into any lengthened discussion upon this mysterious subject; and we have great doubts whether the ocular demonstration by the microscope would succeed except in the hands of a disciple of the school. Even with naturalists, whose business it is to deal with facts, the reason is often wonderfully influenced by the imagination.

But the question immediately before us happily does not involve these recondite discussions; for if even pandorinia and other animalcules were proved beyond a doubt to originate in the play of chemical affinities or galvanic actions—(a more refined process, it must be confessed, than Kircher's chopped snakes), it would not affect our doctrine that all insects are hatched from eggs: for no naturalist of the present day classes such animalcules among insects. Leaving animalcules and zoophytes, therefore, out of the question, we have only to examine such branches of the theory of spontaneous generation as seem to involve the propagation of genuine insects,—like the fancies about putrefaction which we have seen refuted.

The notion that small insects, such as aphides and the leaf-rolling caterpillars, are spread about, or rather generated, by what is termed *blight* (possibly from the Belgic *blinkan*, to strike with lightning), is almost universally believed even by the most intelligent, if they have not particularly studied the habits of insects. Mr. Main, of Chelsea, an ingenious and well-informed gardener and naturalist, describes this as an "easterly wind, attended by a blue mist. The latter is called a blight, and many people imagine that the aphides are wafted through the

* Dict. Class., Art. Pandorinées.

air by this same mist*." "The farmer," says Keith, "supposes these insects are wafted to him on the east wind, while they are only generated in the extravasated juices as forming a proper nidus for their eggs†." A more detailed account, however, is given by the late Dr. Mason Good, and as he speaks in part from personal observation, and was not only one of the most learned men of his time, but an excellent general naturalist, his testimony merits every attention:—

"That the atmosphere," says Dr. Good, "is freighted with myriads of insect eggs that elude our senses, and that such eggs, when they meet with a proper bed, are hatched in a few hours into a perfect form, is clear to any one who has attended to the rapid and wonderful effects of what, in common language, is called a blight upon plantations and gardens. I have seen, as probably many who read this work have also, a hop-ground completely overrun and desolated by the *aphis humuli*, or hop green-louse, within twelve hours after a honey-dew (which is a peculiar haze or mist loaded with poisonous miasm) has slowly swept through the plantation, and stimulated the leaves of the hop to the morbid secretion of a saccharine and viscid juice, which, while it destroys the young shoots by exhaustion, renders them a favourite resort for this insect, and a cherishing nidus for myriads of little dots that are its eggs. The latter are hatched within eight and forty hours after their deposit, and succeeded by hosts of other eggs of the same kind; or, if the blight take place in an early part of the autumn, by hosts of the young insects produced viviparously; for, in different seasons of the year, the aphis breeds both ways. Now it is highly probable that there are minute

* Loudon's Mag. of Nat. Hist. i. 180.

† Keith's Physiological Botany, ii. 486.

eggs, or ovula, of innumerable kinds of animalcules floating by myriads of myriads through the atmosphere, so diminutive as to bear no larger proportion to the eggs of the aphis than these bear to those of the wren or the hedge-sparrow; protected at the same time from destruction, by the filmy integument that surrounds them, till they can meet with a proper nest for their reception, and a proper stimulating power to quicken them into life; and which, with respect to many of them, are only found obvious to the senses in different descriptions of animal fluids*."

It appears to us that it can be nothing more than a fancy, which is quite unsupported by evidence, to say that the eggs of *any species* of animalcules or insects float about in the atmosphere; for, independent of their weight, (every known species being greatly heavier than air,) the parent insects of every species whose history has been accurately investigated manifest the utmost anxiety to deposit their eggs upon or near the appropriate food of the young. To commit them to the winds would be a complete dereliction of this invariable law of insect economy. But admitting for a moment this hypothesis, that the eggs of insects are diffused through the atmosphere, the circumstance must be accompanied with two conditions,—the eggs must either be dropped by the parents while on the wing, or be carried off by winds from the terrestrial substances upon which they may have been deposited.

On the supposition that the eggs are dropped by the mother insects while on the wing, we must also admit (for there is no avoiding it) that they continue to float about, unhatched, from the end of the summer till the commencement of spring, at which time only the broods make their appearance. Yet when we

* Good's Study of Medicine, v. i., p. 339, 3rd edition, London, 1829.

consider the rains, snows, and winds, to which they must be exposed for six or nine months, we think the hardiest theorist would scarcely maintain that a single egg could out-weather these vicissitudes, and continue to float in the air. It may not be out of place to remark, that the female aphides, which deposit eggs in autumn, have no wings.

Again, on the supposition that the eggs are deposited on plants, trees, or other objects, it is still more unlikely that they could be carried into the air; for, on exclusion, they are, with very few exceptions *, enveloped in an adhesive cement which glues them to the spot on which they are deposited. When eggs are deposited singly, this cement usually envelopes each with a thin coating, as in the instance of the admirable butterfly (*Vanessa Atalanta*); but when they are placed in a group the cement is sometimes spread over the whole, as in the instance of the white satin moth (*Leucoma salicis*, STEPHENS). This cement is evidently intended by Nature (who seldom accommodates her plans to our theories) to prevent the eggs from being carried from the place selected by the mother insect for their deposition. Those eggs, therefore, which are placed on the outside of substances, have this provision for their secure attachment to the locality chosen by the instinct of the mother. But, on the contrary, the principle does not always hold in the case of those deposited in nests and excavations, and particularly as to those of ants and termites. The working ants, indeed, carry the eggs from the top to the bottom of their galleries, according as the weather is favourable or unfavourable for hatching. The labourers of the white ants (*Termites*), again, attend their queen with the utmost care when she is laying; for as she cannot then move about, they are under the necessity

* Latreille, Hist. Génér., xiv., p. 342.

of carrying off the eggs, as they are laid, to the nurseries. The extraordinary labour which this requires in the community may be understood, when, according to Smeathman, she lays 60 eggs in a minute, which will amount to 86,400 in a day, and 31,536,000 in a year. The exceptions now mentioned, however, do not in the least invalidate our general position.

Cell of a queen of the Termites bellicosi, broken open in front; the labourers surrounding the queen and carrying off her eggs.

Another no less remarkable circumstance is the great weight, or specific gravity, of the eggs of insects. From numerous experiments we may venture to say that those of all the species which we have tried sink rapidly in water the moment they are thrown into it, from the egg of the drinker moth (*Odonestis Potatoria*, Germar), which is nearly as large as a hemp-seed, to that of the rose-plant louse (*Aphis rosæ*), which is so small as to be barely visible to the naked eye. Some eggs of the gipsey moth (*Hypogymna dispar*, Stephens), indeed, floated in water, because they were covered with down. It is well known, as we shall presently shew, that the diffusion of many of the seeds of plants is accomplished by the winged down with which they are clothed;

but the down upon the eggs of insects does not conduce to this end. Whether insect eggs be naked or clothed with down, they are invariably, as far as their history has been investigated, deposited close to or upon substances capable of affording food to the young when hatched. In making experiments upon the specific gravity of eggs, it should be remembered that no infertile or unimpregnated egg will sink; for having some hundreds of these laid by different species of insects reared in our cabinet, we found, upon trial, that they uniformly floated, while those which we knew to be impregnated as uniformly sunk. A female, for example, of the rose-leaf roller (*Lozotænia Rosana*, STEPHENS) was reared by us, in solitude, under an inverted wine-glass, upon the side of which she glued a patch of eggs, of course, unimpregnated: these, upon trial, all floated in water. But eggs of the same species taken from the outside of a pane of glass close to a rose-tree, all sunk in water; and it is to be fairly presumed, as the parent of the latter was in a state of freedom, that these were impregnated. We found the same distinction, indeed, to hold in the eggs of the drinker moth, the gypsey moth, and numerous other insects*.

Dr. Good's account of "honey-dew," which he describes as "a peculiar haze or mist loaded with a poisonous miasm," that stimulates "the leaves of the hop to the morbid secretion of a saccharine and viscid juice"—appears to us unsupported by facts. Linnæus†, on the contrary, who was not wedded to the meteorological theory of a miasmatous haze, ascribes the honey-dew on the hop leaves to the caterpillar of the ghost moth (*Hepialus humuli*) attacking the roots. Dr. Withering, favouring this account, recommends covering the roots with stones as a preventive; for

* J. R.

† Quoted by Keith, Phys. Bot., ii. 143.

the caterpillars, he avers, never attack wild hops which grow in stony places, because they cannot get at the roots*. It appears to us, however, that there can be little doubt that the sweet syrupy coating, called honey-dew, found on the leaves of the hop, is nothing more than the excrement of the insect (*Aphis humuli*) whose propagation we are discussing. "The honey-dew," says Loudon, "mostly" (we believe always) "occurs after the crops have been attacked by these insects" †. Sir J. E. Smith, who admits this to be the common cause of honey-dew, contends that what is found on the leaves of the beech is an exception; but he adduces no evidence at all satisfactory in proof of its being caused by unfavourable winds ‡; while the undoubted fact of its being the excrement of aphides in so many other instances § weighs strongly against him.

A novel theory of honey-dew has just been published by Mr. John Murray, who ascribes it to an electric change in the air. "Last summer," he says, "we investigated the phenomenon with great care: the weather had been parched and sultry for some weeks previous, and the honey-dew prevailed to such an extent, that the leaves of the currant, raspberry, &c., in the gardens, literally distilled from their tips a clear limpid honey-dew, excreted from the plant; for the phenomenon was observable on those plants that were entirely free from aphides, and so copious was it, where these insects were found, that had their numbers been centuple they could not certainly have been the source of the supply. The question with me, however, was set at rest by applying a lens, having previously washed and

* Botan. Arrangement, ii., 440, 3d ed.
† Encycl. of Agriculture, p. 865, s. 5444.
‡ Introduction to Botany, p. 189.
§ See Linn. Trans. vol. vi. and Willdenow, Princ. of Botany, p. 343.

dried the leaf by a sponge, for in this case the immediately excreted globules became apparent *."

In all observations upon insects, and the other minute parts of creation, it is often exceedingly difficult to distinguish between a cause and an effect. The question of the formation of honey-dew appears to us particularly liable to erroneous conclusions; and we therefore venture to mention a few circumstances which seem irreconcileable with Mr. Murray's ingenious theory. The hop fly (*Aphis humuli*), we think, neither does, nor (for want of appropriate organs) can, feed on the honey-dew; and if it did, this feeding would prove rather beneficial than otherwise to the plant, by clearing it from the leaves whose respiratory functions it obstructs. So far from feeding on diseased plants, an aphis only selects the youngest and most healthy shoots, into the tender juicy parts of which it thrusts its beak (*haustellum*), which in some species is much longer than the body, and no more fitted for lapping honey-dew than the bill of Æsop's crane was for eating out of a shallow plate. In the experiment, tried by Mr. Murray, of wiping a leaf, might not the leaf have been previously wounded, perhaps, by the beak of some aphis, and hence the exudation of sap, not honey-dew? and may not the circumstance of his finding the honey-dew on leaves where there were no aphides be accounted for on the principle that the aphides had abandoned, as they always do, the parts covered with their ejecta, unless these fell from insects on some over-hanging branch? It is justly remarked by M. Sauvages, that they are careful to eject the honey-dew to a distance from where they may be feeding †. We have now in our study a plant of the Chinese chrysanthemum (*Anthemis Artemisiæ*

* Treatise on Atmospherical Electricity, p. 147, Lond. 1830.

† Trans. Soc. Roy. de Montpellier.

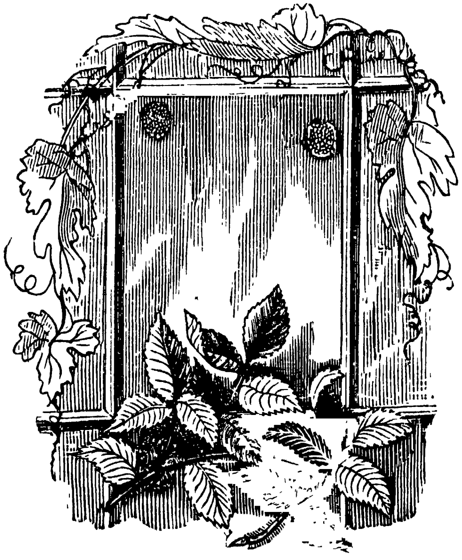
folia, WILLD.), the young shoots of which have swarmed with aphides all the winter, and the leaves below are covered with honey-dew. We tried the experiment of wiping it off from a leaf, but no more was formed when it was protected by a piece of writing-paper from the aphides above; while the writing-paper became sprinkled all over with it in a few hours. By means of a lens, also, we have actually seen the aphides ejecting the honey-dew*.

The almost instantaneous appearance of these destructive insects in great numbers at the same time, is taken notice of with wonder by almost every writer. This circumstance, it must be confessed, gives considerable plausibility to the notion of their being brought by winds,—for whence, we may be asked, could they otherwise come? Simply, we reply, from the eggs deposited the preceding autumn, which, having all been laid at the same time, and exposed to the same degrees of temperature, are of course all simultaneously hatched. In the case of the aphides, also, the fecundity is almost incalculable. Réaumur proved by experiment, that one aphis may be the progenitor of 5,904,900,000 descendants during its life; and Latreille says, a female during the summer months usually produces about twenty-five a day. Réaumur further supposes, that in one year there may be twenty generations. We ourselves have counted more than a thousand aphides on a single leaf of the hop; and in seasons when they are abundant—when every hop-leaf is peopled with a similar swarm—the number of eggs laid in autumn must be, to use the words of Good, " myriads of myriads." The preservation and hatching of these eggs in the ensuing spring must, it is obvious, depend on the weather and other

* J.R.

accidental circumstances, seldom appreciable by our most minute observations *.

The history of other insects, erroneously referred to blighting winds, is more easily traced, from their being of a larger size than the aphides. The caterpillar, for example, of *Lozotænia Rosana*, mentioned before, which rolls the leaf of the rose-tree, is one of this kind. It is well known as furnishing the common poetical comparison of " a worm i' the bud." Early in autumn the mother insect deposits an irregularly oval-patch of yellowish eggs, covered with a cement



Two groups of eggs of the Rose-leaf roller (*Lozotænia Rosana*) on a pane of glass.

* J. R.

of the same colour, sometimes upon the branches of the rose-tree, but more frequently, as we have observed, upon some smooth object contiguous. For several successive seasons, we have found more than one group of these eggs upon the glass panes, as well as the frame-work, of a window, beneath which a rose-tree has been trained. At present (January 1830) there are two of these groups on one pane, and three on the frame-work; and as each contains about fifty eggs, should they all be hatched, two or three hundred caterpillars would at once be let loose, and, streaming down simultaneously upon the rose-tree beneath, would soon devour the greater number of its buds. As this window faces the east, the sudden appearance of the insects would make it appear not unplausible that they had been swept hither by an easterly wind.

We found, during the same winter, an extraordinary number of similar groups of the eggs of a leaf-roller (*Lozotænia Ribeana?*) on the branches of the gooseberry and red-currant, in a garden at Lee. On some small trees, from two to ten groups of eggs were discovered; and as each group consisted of from thirty to fifty, a caterpillar might have been hatched for every bud. After the severity of the season was over, we had the piece of bark cut off on which these eggs were attached; and though they had been exposed on the bare branches to the intense frosts of 1829-30, they were hatched in a few days after being brought into our study. As the currant-trees were not then come into leaf, we had no food to supply them with, and they refused the leaves of all other plants which we offered to them. Had they been permitted to remain on the trees till they were hatched, they would probably have not left a single leaf undevoured. For this spring, at least, these currant bushes will be safe from their attacks, and of *course will set at defiance the supposed blighting winds, which no doubt will, as usual, be accused of peopling the adjacent gardens with caterpillars. It may be well to remark, that these caterpillars, when hatched, are scarcely so thick as a thread of sewing silk, and being of a greenish colour, they are not readily found on the leaves, the opening buds of which they gnaw to the very core* *.

It does not seem to have ever occurred to those who thus speak of insect-bearing winds, that they get rid of no difficulty by the supposition; for where, we may ask, is the east or any other wind to take up the insects or eggs which it is said to drift along? The equally sudden disappearance of insects all at once, which is also popularly attributed to winds, arises from their having arrived at maturity, and fulfilled the designs of Providence, by depositing their eggs for the ensuing season, when they all die, some in a few hours, though others survive for several days, but rarely for weeks.

The sudden and simultaneous appearance of great numbers of frogs, snails, and other land animals, has given rise to the extravagant opinion that they have fallen in a shower from the clouds; and some goodly theories have been devised to account for the probable ascent of frog-spawn, and the eggs of snails, into the atmosphere by whirlwinds. The impossibility of this, in consequence of their specific gravity, is of course left out of consideration by the theorists. Our distinguished naturalist, Ray, when riding one afternoon in Berkshire, was much surprised at seeing an immense multitude of frogs crossing his path, and on looking into the adjacent fields he found that two or three acres of ground were nearly covered with them. They were all proceeding in the same direction towards some woods and ditches; and he traced

* J. R.

them back to the side of a very large pond, which, in spawning time, he was informed, swarmed with countless numbers of frogs. He naturally concluded, therefore, that, instead of having been precipitated from the clouds, they had been bred in the pond, from which they had been invited a short time before, by a refreshing shower, to go in quest of food *. Their great numbers will appear less marvellous, when we consider that a single frog spawns, as De Montbeillard informs us, about 1300 eggs †. Were it not, indeed, for their numerous enemies, and their not being fit to propagate till they are three years old, the country would soon be overrun with these reptiles. We have more than once seen a similar legion of hair-worms (*Gordii aquatici*, LINN.) in a garden at Lee, in Kent, every plant and spot of ground literally swarming with them. Their numbers, however, were easily accounted for, as a stream at the bottom of the garden abounds with them, and, like frogs, they appear to be amphibious ‡.

The errors of theory, as well as the mistakes of observers, swayed (unconsciously perhaps) by the influence of their theoretical opinions, may all be traced, we think, to the propensity of human nature to discover resemblances in things, which are afterwards magnified into close affinity, or even into identity. We are indebted to one of our best living entomologists, Mr. W. Mac Leay, for clearly pointing out the broad distinction between *analogy* and *affinity*§. The supposed floating of the eggs of insects in the air thus appears to have originated in drawing an analogy from the seeds of plants; though, from the facts we have stated, so far from there being any

* Ray's Wisdom of God in the Creation, p. 156.

† Dict. Classique d'Hist. Nat., vii., p. 495. ‡ J. R.

§ Horæ Entomologicæ, or Essays on Annulose Animals, 8vo. London, 1819-21.

analogy, there is no difference more marked than in this very point—that the eggs of insects are, in most cases, fixed by a glue at the moment of exclusion, while the seeds of plants are uniformly diffusable and free. The fertile seeds of plants, it is true, are heavy enough to sink in water, and consequently as much unfitted for floating in the air as the eggs of insects; but the contrivances to counteract this exemplify some of the most beautiful provisions of nature. The diffusion of the seeds of thistles, groundsel, dandelion, &c., by means of feathery down, attracts the notice of the most incurious. Another contrivance of nature for effecting the same purpose is not only curious in itself, but bears upon our present subject as illustrating an affinity which it may be supposed to have with the ovipositing of certain insects.

The seeds of the various species of violets are contained in a capsule of a single cell, or loculament, consisting, however, of three valves. To the inner part of each of these valves a seed is attached, and it remains so for some time after the valves, in the process of ripening, have separated and stood open. The influence of the sun's heat causes the sides of each valve to shrink and collapse; and in this state the edges press firmly upon the seed; which, it may be remarked, is not only extremely smooth, polished, and shining, but regularly egg-shaped. Thus, when the collapsing edge of the valve slides gradually and forcibly down over the sloping part of the seed, it is thrown with a jerk to a considerable distance. There is another part of the contrivance of nature for the same purpose, in the violaceæ, worthy of remark. Before the seed is ripe, the capsule hangs in a drooping position, with the persisting calyx spread over it like an umbrella, to guard it from the rain and dews, which would retard the process of ripening; but no sooner is the ripening completed, than the capsule becomes almost upright, with the calyx for a support. This position appears to be intended by nature to give more effect to the valvular mechanism for scattering the seeds, as the capsule thus gains a higher elevation (in some cases more than an inch) from which to project them. Some ripe capsules of a fine variety of heart's-ease (*Viola tricolor*), which I placed in a shallow pasteboard box, in a drawer, were found to have projected their seeds to the distance of two feet. From the elevation of a capsule, therefore, at the top of a tall plant, these seeds might be projected twice or thrice that distance *.

We may mention, as another very curious illustration of the power in plants of discharging their seeds, the remarkable instance of a minute fungus (*Sphærobolus stellatus*, Tode). This plant has the property of ejecting its seeds with great force and rapidity, and with a loud cracking noise; and yet it is no bigger than a pin's head†.

The circumstance alluded to as analogous in insects to this admirable contrivance, occurs in the forcible discharge of the eggs of some species to a distance. The ghost moth (*Hepialus humuli*), for example, ejects its minute black eggs with so much rapidity, that De Geer describes them as *running* from the oviduct; and they are sometimes forcibly thrown out like pellets from a pop-gun ‡. "A friend of mine," says Kirby, "who had observed with attention the proceedings of a common crane-fly (*Tipula*), assured me, that several females which he caught projected their eggs to the distance of more than ten inches §." Another instance is men-

* J. R. in Mag. of Nat. Hist., i. 380.

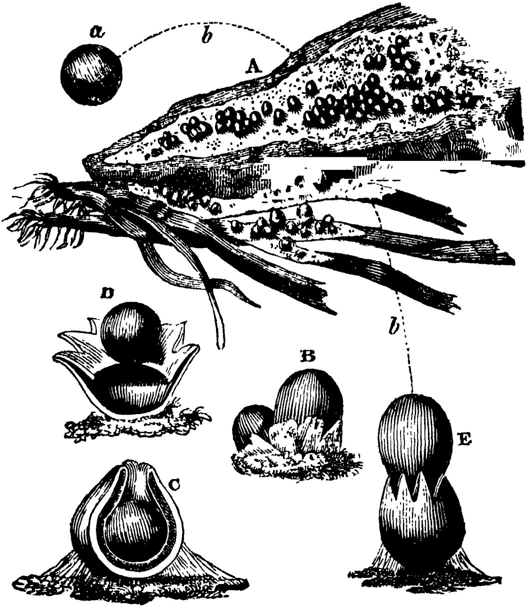
† For a minute account of this singular plant, see Greville's Scottish Cryptogamic Flora, No. xxxii.

‡ De Geer, Mém. des Insectes, iv., 494.

§ Kirby and Spence, Intr. iii. 66.

tioned by the Abbé Preaux, of a four-winged fly, called by him, *Mouche baliste*, which, when caught, jets out its eggs at intervals, as if by the jerk of a spring *.

The apparent analogy, however, between these in-



A, Plants of *Sphærobolus*, natural size. B, magnified view. C, sectional view, with the seed just previous to projection. D, the seed in the act of projection. E, a plant immediately after projection; *a*, the seed; *b b*, a line indicating its course.

* Dict. Classique d'Hist. Nat., Art. Mouches Balistes. The words are "Insecte à quatre ailes, qui lance ses œufs à diverses reprises, et comme par un ressort, *lorsqu'on le saisit.*"

sects and the plants which discharge their seeds, will disappear, when we consider that the scattering of the seeds is, in the plants, a regular and constant process of nature; whereas the insects only jet out their eggs from fear *when caught.* The power of throwing their eggs to a distance, indeed, could be of no possible use to insects, because they possess the more efficient power of locomotion.

The facts which we have thus stated with regard to the seeds of plants being diffused by the means of winged down, or by the more remarkable capacity of being projected, differ, as we have shewn, in some important circumstances from the nearly similar arrangement of Nature in the economy of insects. They constitute affinities, but not analogies. On the other hand, the more universal law of the continuance of insect life by every new generation being hatched from eggs, may be illustrated by an analogy, which is observed even in the most minute instances, in the generation of plants from seeds.

The diffusion of the seeds of an extensive order of plants (*Cryptogamiæ*, LINN., *Acotyledones*, JUSS., *Cellulares*, DE CANDOLLE) being so universal, and the seeds (*sporules*) themselves being so minute as to elude common observation, the phenomena thence arising have, like the sudden appearance of newly hatched insects, given some colour to the doctrine of spontaneous generation. We may see this exemplified every day on brick walls recently built, even if they be covered with a smooth coat of cement. The first indication of vegetable life on such a wall, particularly in parts exposed to the trickling down of rain water, is that of a green silky-looking substance, having somewhat the appearance of a coat of green paint. Mr. Drummond, of the Cork Botanic Garden, by accurately watching the progress of this green matter, which had been unsuccessfully investigated by Priestley, Ingenhouz, and Ellis, and had been mistaken by Linnæus for a crop of *byssi*, ascertained beyond question that it always consisted of the minute buds of common mosses, such as the wall screw moss (*Tortula muralis*) and the common hair-hood moss (*Polytrichum commune*)*. At Glasgow, we have repeatedly remarked, that on the walls of houses, built with freestone raised from a quarry more than a hundred feet under the surface of the soil, the whole exterior would, in the course of one month, appear as green as if painted, with these innumerable germinating mosses †.

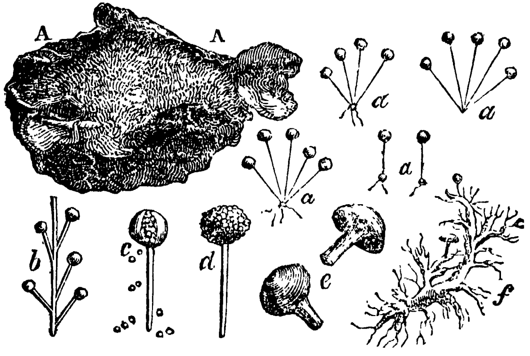
The germination of mosses on walls appears to arise from the seeds (*sporules*) being carried into the air. This process is facilitated by their extreme minuteness and their comparative lightness, for they do not sink in water like the seeds of phenogamous plants and the eggs of insects, as appears from their germinating on the surface of stagnant water as frequently as on walls. In low situations, the mode in which the seeds of cryptogamic plants are diffused is well exemplified in the puff-ball (*Lycoperdon*), which, when ripe, explodes its sporules in the form of a smoke-like cloud. Mosses again, which grow on trees and walls, if they do not thus explode their sporules, must drop them into the air; and, as they chiefly ripen early in spring, the winds which then prevail will scatter them to considerable distances. But we only state this as a highly probable inference from Drummond's discovery: to detect these all but invisible seeds floating in the atmosphere, and trace them in their passage from the parent plant to the wall or tree where they begin to germinate, we think is hardly possible.

If the doctrine be sound, that every plant arises from seed, we must either believe that innumerable

* Linn. Trans. † J. R.

mosses are wafted to the walls through the air, or adopt the hypothesis that they have existed for centuries in the interior of the rocks of the quarry. That it is not impossible the seeds may have existed in the rocks several curious facts would lead us to believe. Some seeds, for example, retain the power of germinating for an indefinite length of time; since the wheat usually wrapt up with Egyptian mummies will often germinate and grow, as well as if it had been gathered the preceding harvest. It also bears upon this subject, that when a piece of ground, which has never been tilled, is turned up by the spade or the plough, it immediately becomes covered with a crop of annuals, not one of which may grow within many miles of the spot; and a number of them, such as hedge mustard (*Sisymbrium officinale*) and chickweed (*Alsine media*), whose seeds are not winged. It is no less worthy of remark that all these annuals will again disappear as soon as the grass is suffered to spread over the spot which has been dug up. It is mentioned by Mr. James Jennings, in Time's Telescope for 1823, that the coltsfoot (*Tussilago farfara*) is usually the first plant which appears in England in such cases—a circumstance by no means remarkable, as the seeds of this plant are winged with down, and extremely light.

A still more minute family of cryptogamic plants, and consequently more difficult to trace, is well known by the popular name of mould or mouldiness (*Mucedines*, Linn.) This, Adolphe Brongniart justly remarks, is, in one of its groups, nearly allied to the puff-balls (*Lycoperda*), whose mode of diffusing their seeds we have just described. When mould is examined by the microscope it is seen to resemble these; and sometimes various fungi are, when mature, filled with a blackish dust, supposed to be the seed. Micheli, of Florence, an eminent botanist, resolved to try whether this supposed seed would grow if sown on vegetable substances, and found that it did so. On his experiments being repeated at Bologna, however, it was discovered that the mould grew equally well where none of the black powder had been sown; but Spallanzani, by more accurate attention, confirmed the conclusion of Micheli. He collected a great quantity of the dust, and, taking a number of pieces of moistened bread, apples, pears, gourds, &c., sowed some thickly, others sparingly, and others not at all. The result was, that on the unsown substances the mould did appear, but several days later, and then greatly less in quantity, than on the sown substances; while of these two, the pieces thickly sown had more than double the quantity of the pieces thinly sown, though, when it came up thick, it did not grow so tall.



Microscopic views of apple and pear mould. A A, Part of a shrivelled apple, covered with mould on the inside. *a a a a*, several of the individual mould plants highly magnified. *b*, a branched one. *c d*, seed-vessels, one bursting and scattering its seed. *e*, one mushroom-shaped. *f*, a portion of pear mould, of a branched form.

We were much struck last autumn (1829), upon cutting an apple asunder, to find in the seed-cells a copious growth of the mould with the slender stems and globular heads figured by Spallanzani. Mould upon an apple is not indeed wonderful; but the one in question was not only large, but apparently sound throughout. Whence, then, came the seeds of this mould in the very core of the apple? We have also met with mould of a different species, resembling the green mould on the rind of oranges (*Acrosporium fasciculatum*, GREVILLE), even on the kernels of nuts, when there was no opening save the minute pores in the shell. Through these pores, then, after being stripped of the husk that covered them, the seed of this nut-mould must have entered. This, however, will not account for the mould in the apple; the seed of which, we think, must have been introduced while it was in embryo, in some such way as the seeds of the subcortical fungi so abundant on dead leaves and branches of trees. This again may be illustrated by the curious facts respecting substances found in the interior wood of trees. Sir John Clark, for example, tells us that the horns of a large deer were discovered in the heart of an oak in Whinfield Park, Cumberland, fixed in the timber with large iron cramps, with which, of course, it had at first been fastened on the outside *. The eminent naturalist, Adanson, on visiting Cape Verd, was struck with the venerable aspect of a tree fifty feet in circumference; and recollecting having read in some old voyages that an inscription had been made upon such a tree, he was induced to search for this by cutting into the wood, and, marvellous to say, he actually found it under 300 layers of wood†! De Candolle, one of the greatest living botanists, remarked "a frost-bitten part in the wood of a tree, cut down in 1800, in the forest of

* Phil. Trans. vol. xli., p. 448.

† Adanson, Voyages à Senegal.

Fontainebleau. This being covered with 91 layers of wood, indicated that the accident occurred in 1709, so remarkable for a severe frost *." With these facts before us, we think the introduction of the seed of the mould into the centre of the apple by no means so unaccountable as at first view it appeared. Be this as it may, we tried, with the seed gathered from this apple-mould, similar experiments to those of Spallanzani, with results precisely similar to his; and being in this way able at pleasure to produce mould of the *same species* by sowing, we are entitled to conclude that all mould arises from seed, otherwise nature must produce the same effect from dissimilar causes, which is contrary to the first principles of sound philosophy †.

* Conv. on Veg. Physiol., i. 59.

† J. R.

Chapter II.

Physiology of Insects' Eggs.—Their Colour, Structure, Shape, Size, and Number.

It was a notion of Darwin's, (much more ingenious and plausible than his metamorphoses of shell-fish into birds,) that the variety in the colours of eggs, as well as the colours of many animals, is adapted to the purposes of concealment from their natural enemies. Thus, he says, the snake, the wild cat, and the leopard, are so coloured as to resemble dark leaves and their lighter interstices; birds resemble the colour of the brown ground or the green hedges which they frequent; while moths and butterflies are coloured like the flowers which they rob of their honey*. By following up this curious theory, Gloger, a German naturalist†, has remarked, that those birds whose eggs are of a bright or conspicuous colour instinctively conceal their nests in the hollows of trees, never quit them except during the night, or sit immediately after they have laid one or two eggs. On the other hand, in the case of birds who build an exposed nest, the colours of the eggs are less attractive. Amongst birds whose eggs are perfectly white—the most conspicuous of all colours,—he instances the kingfisher (*Alcedo*), which builds in a hole in a river's bank; the woodpecker (*Picus*), which builds in the hole of a tree; and the swallow (*Hirundo domestica*), whose

* Zoonomia, Sect. 39, p. 248, 3d. ed., and Botan. Garden, note on Rubia.

† Verhand. der Gesellsch. Naturforsch. Freunde. Berlin, 1824.

nest has a very small opening: while owls and hawks, which scarcely quit their nests in the day, and pigeons, which only lay one or two eggs and sit immediately after, have also white eggs. The bright-blue, or bright-green egg, again, belongs to birds which build in holes, as the starling (*Sturnus vulgaris*), or which construct their nests of green moss, or place them in the midst of grass, but always well covered. Almost all singing birds, he alleges, lay eggs of a dull or dark ground, and variously speckled; and they for the most part build open nests with materials similar in colour to the eggs, so that no evident contrast is presented which might lead to their discovery and destruction. We may add from Darwin the examples of the hedge-sparrow (*Accentor modularis*), whose eggs are greenish blue, as are those of magpies and crows, which are seen from beneath in wicker nests, between the eye and the blue of the firmament *.

As this theory is but indirectly connected with our subject, we cannot here spare room to examine it; but we may remark, that it appears to us much more beautiful and ingenious than true: for we could enumerate more instances in which the principle fails than holds good. Gloger's instances also are far from accurate; for though the king-fisher, for example, hides her shining white eggs in a hole, yet that will not conceal them from the piercing eyes of their chief enemy, the water rat, which, like all burrowing animals, can see with the least possible light. Many birds, also, which lay bright-coloured eggs, make open nests; the thrush, for example, whose clear-blue eggs, with a few black blotches, are far from being concealed by the plastering of clay and cow-dung upon which they are deposited. The green-finch (*Fringilla chloris*, Tem-

* See also St. Pierre, Studies of Nature, ii., 393; Note.

MINCK), again, which builds an open nest of green moss, lined with horsehair, black or white as it can be had, lays clear white eggs with red spots, precisely like those of the common wren and the willow wren (*Sylvia Trochilus*), which build covered nests with a small side-entrance ; while the house-sparrow (*Fringilla domestica*) lays eggs of a dull, dirty green, streaked with dull black, and always builds in holes or under cover. These objections will render it unnecessary for us to follow Darwin into his fanciful account of the origin of the colour of eggs, which he ascribes to the colour of the objects amongst which the mother bird chiefly lives acting upon the shell through the medium of the nerves of the eye ; for, if this were correct, we should have the greenfinch and the red-breast, instead of their white eggs, laying blue ones like the hedge-sparrow and the fire-tail.

Upon a partial view of the subject, we might bring many facts to support the theory from the colour of the eggs of insects. The nettle butterflies, for example, the small tortoise shell (*Vanessa Urticæ*), the peacock (*V. Io*), and the admirable (*V. Atalanta*), all lay eggs of a green colour, precisely similar in tint to the plant to which they are attached. On the contrary, the eggs of the miller moth (*Apatela Leporina*, STEPH.), which are deposited on the grey bark of the willow, are light purple ; another beautiful geometric moth (*Geometra illunaria*), which Sepp* calls *Herculesje*, lays its light pink eggs in the fissures of the bark of the elm ; the puss moth (*Cerura vinula*) lays shining brown eggs on the green leaf of the poplar ; and the garden white butterfly (*Pontia Brassicæ*) lays a group of yellow ones on a green cabbage or colewort leaf, but not of so bright a yellow as those of the seven-spot ladybird (*Coccinella Septempunctata*),

* Sepp, der Wonderen Gods, Tab. 35.

patches of which may be found on many sorts of leaves during the summer months.

The immediate origin of colour in the eggs of insects is in some cases the inclosed yolk shining through the transparent shell; but in others, the shell is not uniformly transparent, but ringed, banded, or dotted with opacities of various colours. In the eggs of the drinker moth (*Odonestis potatoria*), for example, there are two circular rings of a green colour, from the green yolk appearing through the shell; while the rest of the shell is white and opaque, as we have proved by dissection*. Certain ruddy spots on the white eggs of the small rhinoceros beetle (*Oryctes nasicornis*, ILLIGER) were discovered by Swammerdam to be the red mandibles and spiracles of the unhatched grub seen through the shell; and the white ground, we infer, was similarly caused by the body of the grub †. This, however, cannot be the origin of the bright red spots on the beautiful yellow egg of the brimstone moth (*Rumia cratægata*, DUPONCHEL), which may, perhaps, have a similar origin to those of birds.

With respect to the eggs of birds, it has been remarked by Mr. Knapp ‡, that in those "of one hue, the colouring matter resides in the calcareous part; but where there are markings, these are rather extraneous to it than mixed with it. The elegant blue that distinguishes the eggs of the fire-tail (*Sylvia phœnicurus*, LATH.), and of the hedge-sparrow, though corroded away, is not destroyed by muriatic acid. The blue calcareous coating of the thrush's egg is consumed; but the dark spots, like the markings on the eggs of the yellow-hammer, house-sparrow, magpie, &c., still preserve their stations on

* J. R.

† Swammerdam, Book of Nature, i. 13.

‡ Journal of a Naturalist, p. 230.

the film, though loosened and rendered mucilaginous by this rough process. Though this calcareous matter is partly taken up during incubation, the markings upon these eggs remain little injured even to the last, and are almost as strongly defined as when the eggs are first laid. These circumstances seem to imply, that the colouring matter on the shells of eggs does not contribute to the various hues of the plumage; but, it is reasonable to conclude, are designed to answer some particular object not obvious to us: for though the marks are so variable, yet the shadings and spottings of one species never wander so as to become exactly figured like those of another family, but preserve year after year a certain characteristic figuring."

Most of these remarks will apply to the colours of the eggs of insects: but though we can in most instances trace no connexion between the colours of eggs and the perfect insect, there is a striking exception in the egg of the brimstone moth mentioned above, which corresponds exactly in colour with the wings of the moth, though the caterpillar is of a dull brown.

The eggs of insects, like those of birds, have a shell enclosing the germ of the caterpillar with a peculiar matter for its nourishment, like the white and yolk of a bird's egg, provided for the nourishment of the contained chick. These several parts, however, are very different in substance from the eggs of birds. The shell of the bird's egg is brittle, opake, chiefly composed of chalk (*carbonate of lime*), and lined with a very thin tough membrane; while in the egg of an insect the shell is not brittle, is transparent, contains no lime (for it is not perceptibly acted upon by diluted sulphuric acid), and no lining membrane can be detected. It appears, indeed, very similar to the transparent portion of a goose-quill in the eggs of the drinker and other moths which we have dissected*; but in the eggs which are deposited in moist places, and in those of spiders, it is extremely thin†. The eggs of saw-flies, ants, &c., which grow larger, as we shall afterwards show, during the process of hatching, must possess an expansible shell to allow of their enlargement. The yolk and white in the eggs of birds are separated from each other by a very fine membranous bag in which each is contained; but in the eggs of insects, what answers to the yolk consists of distinct minute globules, which float in the white, if we may call it so, for it does not, as we have ascertained, coagulate in boiling water. The eggs of the gypsey moth (*Hypogymna dispar*), which we boiled, still continued partly fluid, though the brown matter answering to the yolk was considerably thickened. The portion which does not thicken by boiling most probably forms the first internal fluids of the caterpillar, answering to the blood of quadrupeds. The point where the caterpillar originates,—answering to the scar (*Cicatricula*) in the eggs of birds,—we can readily distinguish even by the naked eye in the larger species of eggs, as it lies always immediately under the shell*. "Having directed," says the younger Huber, "my close attention to the eggs of ants, I remarked that they were of different sizes, shades, and forms. The smallest were white, opaque, and cylindrical; the largest, transparent, and slightly arched at both ends; while those of a middle size were semi-transparent. On holding them up to the light I observed a sort of white oblong cloud; in some, a transparent point might be remarked at the superior extremity; in others, a clear zone above and underneath the little cloud. The largest presented a single opaque and whitish point

* J. R. † Kirby and Spence, Intr. 86.

in their interior. There were some whose whole body was so remarkably clear as to allow of my very distinctly observing the rings. On fixing attention more closely upon the latter, I observed the egg open, and the larva appear in its place. Having compared these eggs with those just laid, I constantly found the latter of a milky whiteness, completely opaque, and smaller by one-half, so that I had no reason to doubt of the eggs of ants receiving a very considerable increase in size; that in elongating they become transparent, but do not at this time disclose the form of the grub, which is always arched *."

The germ in the egg of the garden spider (*Epeira diadema*) is described by the accurate Heroldt, as appearing to the eye in form of a minute white point immediately under the shell, and in the centre of the circumference. On examining this point more narrowly, it is found to be of a lenticular shape, and composed of innumerable whitish granulations of a globular form, differing only from the globules of the yolk in being smaller and more opaque, as may be seen by squeezing out the contents of a spider's egg into a watch-glass. The most singular circumstance observed by Heroldt was, that in some species of spiders an egg appeared to have a considerable number dispersed upon different points of the surface; but all these ultimately united into a single germ †.

The eggs of the glow-worm (*Lampyris noctiluca*), as we ascertained from those deposited by one which we found in 1829, at Rudesheim, on the Rhine, are golden yellow, somewhat resembling cherry-tree gum, while the internal substance is similar in con-

* M. P. Huber on Ants, p. 68.

† Heroldt, Exercit. de Generat. Aranearum in Ovo, and his Unters. über die Bildung der Wizbellosen Thiere im Eie.

sistence to the wax of the ears, and in form of granules which are even externally apparent *.

We are accustomed to consider the form of eggs so nearly regular, that the epithet "egg-shaped" is frequently applied to other things, and is well understood; but the eggs of insects, though most commonly round, are seldom, like those of birds, smaller at one end than at the other, while they often exhibit forms never seen in the eggs of birds,—such as cylindric, flat, depressed, compressed, prismatic, angular, square, boat-shaped †, &c. These varieties of form are justly referred by Kirby and Spence to the "manifold wisdom" (πολυποικιλος σοφια) ‡ of the Creator; but we have some hesitation in admitting their limitation of this to his "will to vary forms, and so to glorify his wisdom and power independently of other considerations §," and think it would be more truly philosophic to confess our ignorance where we cannot explain what is above our comprehension. Paley, indeed, says, such facts "might induce us to believe that *variety* itself, distinct from every other consideration, was a motive in the mind of the Creator, or with the agents of his will;" but he immediately adds, "to this great variety in organized life the Deity has given, or perhaps there arises out of it, a corresponding variety of animal appetites, and did all animals covet the same element, retreat, or food, it is evident how much fewer could be supplied and accommodated, than what at present live conveniently together, and find a plentiful subsistence ||." The latter remark, we think, completely destroys the former, and it will lead us to what appears to be

* J. R.

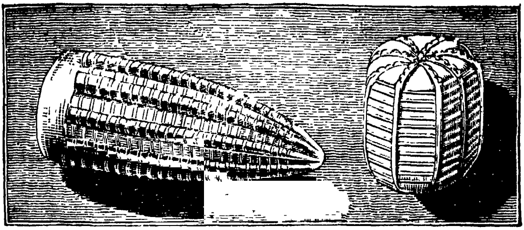
† Dumeril, Consider Générales, p. 49; and Insect Aichitecture, p. 19.

‡ Ephes. iii. 10.

§ Introd., iii. p. 95.

|| Natural Theology, p. 345, 14th ed.

the true cause of the varied forms of the eggs of insects.



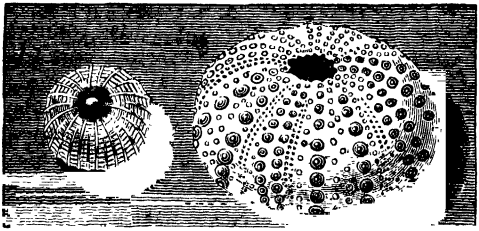
Eggs of a butterfly and of a moth, magnified.

The cause of the eggs of birds being nearly the same in shape, arises, we should say, from the similar forms of the animals themselves; while insects being much more varied in shape, require corresponding varieties in the forms of their eggs. The ostrich, the eagle, and the wren, for example, differ much more in size than in their general form; but the earwig, the garden-spider, butterflies, beetles, and grasshoppers, differ much more in form than in size, and consequently require eggs of varying forms to contain their progeny. We confess, however, that we cannot always trace the mathematical causes of these diversities of form in the eggs of insects; for though there prevails a general resemblance in those families and groups the most nearly allied, yet in others, even the species of the same genus exhibit differences which cannot be thus accounted for. In two species of *Vanessa*, for instance, the small and the great tortoise-shell butterflies, which differ in little but size, the egg of the small is cylindric with eight prominent ribs, while that of the great is shaped liked a Florence flask, and quite smooth and uniform *.

The ribbing of the eggs of the small tortoise-shell

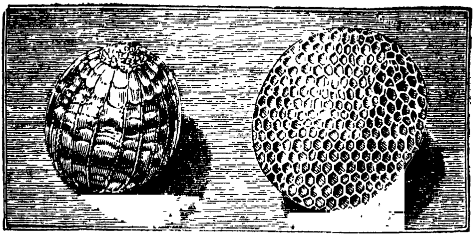
* Sepp, der Wonderen Gods, Tab. ii. and viii.

butterfly (*Vanessa urticæ*), which is also found on those of most of the species, leads us to remark that insect eggs are frequently sculptured in a very beautiful manner, far out-rivalling in elegance of design and delicacy of workmanship the engravings which we sometimes see on eggs brought from India and China. Some of them, when seen through a microscope, remind us of the fine crustaceous shells called sea-eggs,—a resemblance which is well exemplified in the egg of the angle-shades moth (*Phlogophora meticulosa*, STEPHENS), as compared with the *Clypeaster* of Parkinson.

a  b

a, magnified egg of the angle-shades moth (*Phlogophora meticulosa*); *b*, sea-egg (*Clypeaster*), natural size.

These channellings appear to correspond in most cases with the rings of the caterpillar to be hatched from the egg; but the design of the other sculptures on these eggs has not yet been discovered by the investigations of naturalists, and may, probably, for ever elude human penetration. But though we cannot tell why an insect's egg is so tastefully carved, we can admire the minute delicacy and extraordinary regularity of the markings. The egg of the meadow brown butterfly (*Hipparchia Jurtina*) is crowned at the upper end with sculptured work in the form of tiles or slates, as if to defend it from injury, while others are covered with a sort of net-work of extremely minute six-sided meshes.

a  b

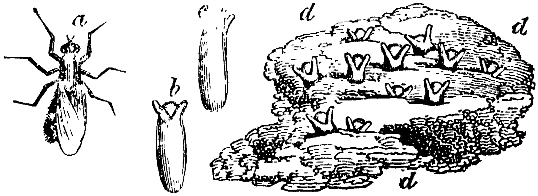
a, the egg of the meadow brown-butterfly, magnified; *b*, egg of the brimstone-moth (*Rumia Cratægata*), magnified.

The design of the appendages to some sort of eggs is much more apparent, and affords us some admirable illustrations of prospective contrivance. The eggs of the ephemeræ, for example, are smooth and oblong, resembling carraway comfits, a form which Swammerdam proved to be admirably adapted for diffusing them through the water, where, he says, they are dropt by the mother insect. For this purpose he placed " a few of them on the point of a knife, and letting them fall gently into water, they immediately separated of themselves in a very curious manner *." The same accurate observer describes a very remarkable appendage in the egg of the water scorpion (*Nepa cinerea*, Linn.), an insect by no means rare in Britain. This egg is furnished with a coronet of seven bristles disposed like the down on the seed of the blessed thistle, (*Centaurea benedicta*, Willdenow); and before they are deposited these bristles closely embrace the egg next to them in the ovary like a sort of sheath, as if a chain of thistle-seeds were formed, by placing each successively in the bosom of the down of the one next to it. As the mother insect deposits these eggs in the stems of aquatic plants, the bristles, which are partly left on the outside, are probably intended to

* Swamm. Book of Nature, i. 104.

prevent the aperture from being closed up by the rapid growth of the plant.

Réaumur gives an interesting description of a similar egg deposited by a common dung-fly, of a yellowish-orange colour, (*Scatophaga stercoraria*, MEIGEN). These eggs are furnished at the upper end with two divergent pegs, which prevent them from sinking into the dung where they are placed by the parent, while they are permitted to enter sufficiently far to preserve them moist. Both circumstances are indispensable to their hatching; for when Réaumur took them out of the dung, they shrivelled up in a few hours, and when he immersed them farther than the two pegs, they were suffocated, and could not afterwards be hatched *.

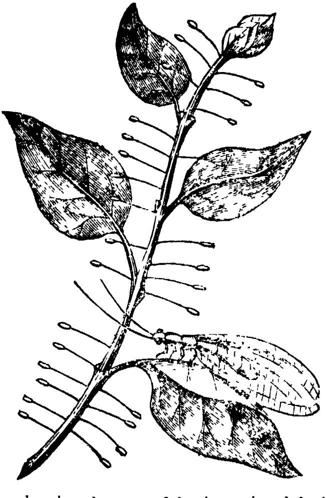


a, Dung-fly (*Scatophaga Stercoraria*); *b c*, front and side views of its eggs magnified; *d d d*, a number of these eggs deposited in cow-dung.

Before we began to study the habits of insects, we found upon a lilac-twig, in the neighbourhood of London, a singular production, which we took for a very delicate fungus, and supposing it not to be common, we carefully preserved the specimens; but we have since learned, with no little surprise, that these are the eggs of the lace-winged fly, (*Chrysopa reticulata*, LEACH). Réaumur says that several naturalists have described them as fungi, which is not to be wondered at; for they consist of a small oval greenish-white head, similar to the apple-mould,

* Réaumur, iv. 379.

with a white transparent stem, more than an inch high, not thicker than a human hair, but much more stiff and rigid. About a dozen of these eggs are deposited in a single and sometimes in a double line, upon the leaves and branches of elder or other trees and plants abounding with aphides, upon which the grubs feed when hatched. The footstalks of these eggs are formed by the mother-fly attaching a drop of gluten to the branch, and drawing it out (as a spider does its line) to the requisite length before the egg is deposited on its summit. As she uses her body for a measure, the footstalks are by consequence all nearly of equal length. It is evidently the design of these footstalks to place the eggs out of the reach of the grubs of lady-birds (*Coccinellæ*) and of aphidivorous flies (*Syrphi*), which



Twig of lilac, bearing the eggs of the lace-winged fly (*Chrysopa reticulata*, LEACH). The fly is seen resting on the lowest leaf.

frequent the same situations and might devour them. The footstalks are so smooth and slender that these grubs could not climb them, as we have proved by experiment *.

The ichneumon fly (*Ophion luteum*), whose larvæ feed upon the caterpillar of the puss-moth, also deposits eggs with a footstalk; and what is most singular, these larvæ, after they are hatched, during the first stage of their existence, continue attached to the shells of their eggs. It is not till the puss has formed her cocoon that they devour her, and spin their own cocoons under its cover †.

The eggs of insects do not seem to hold any regular proportion, so far as regards size, with their parent insects; for some large moths lay very small eggs, while others of a small size lay eggs considerably larger. Kirby and Spence think it probable that eggs which produce females are generally larger than male eggs; with the exception of the hive-bee, in which the reverse takes place. Huber, as we have seen above, found the eggs of ants of different sizes, from which he was led to discover that they increase in size after being deposited.

It has been remarked, that animals of prey are less prolific than those which live on vegetable food; and a similar principle appears to hold to a certain extent amongst insects, the most prolific families belonging, with few exceptions, to those which devour vegetable or animal substances beginning to decay and putrefy.

Thus it is that the eagle lays only two eggs, while the wren lays eight, and the pheasant twenty-four; and in the same way the dragon-flies (*Libellulina*, Mac Leay), do not lay above two dozen eggs, the lace-winged flies (*Hemerobidæ*) still fewer, and the noontide fly (*Mesembrina meridiana*, Meigen)

* J. R. † See Insect Architecture, pp. 195—325, 6.

only deposits two eggs; while a single plant-louse (*Aphis*), as we mentioned before from Réaumur, may be the living progenitor of 5,904,900,000 descendants, and the queen of the warrior white ants (*Termes bellicosus*, Smeathm.), produces 31,536,000 eggs in one year.

We may illustrate this subject by an extract exemplifying the proportionate fecundity of the animal kingdom in general. "Compared with the rest of animated nature," says Dalyell, "infusion animalcula are surely the most numerous: next are worms, insects, or fishes; amphibia and serpents, birds, quadrupeds; and last is man. The human female produces only one at a time, that after a considerable interval from birth, and but few during her whole existence. Many quadrupeds are subject to similar laws; some are more fertile, and their fecundity is little, if at all, inferior to that of certain birds, for they will produce ten or twenty at once. Several birds will breed frequently in a year, and have more than a single egg at a time. How prodigious is the difference, on descending to fishes, amphibia, reptiles, insects, and worms! Yet among them the numbers cannot be more different. According to naturalists, a scorpion will produce sixty-five young; a common fly will lay 144 eggs; a leech, 150; and a spider, 170. I have seen a hydrachna produce 600 eggs, and a female moth 1100. A tortoise, it is said, will lay 1000 eggs, and a frog 1100. A gall insect has laid 5000 eggs; a shrimp, 6000; and 10,000 have been found in the ovary, or what is supposed to be that part, of an ascarides. One naturalist found above 12,000 eggs in a lobster, and another above 21,000. An insect very similar to an ant (*Mutilla?*) has produced 80,000 in a single day; and Leeuwenhoeck seems to compute four millions in a crab. Many fishes, and those which in some countries seldom occur, produce incredible numbers of eggs. Above 36,000 have been counted in a herring; 38,000 in a smelt; 1,000,000 in a sole; 1,130,000 in a roach; 3,000,000 in a species of sturgeon; 342,000 in a carp; 383,000 in a tench; 546,000 in a mackerel; 992,000 in a perch; and 1,357,000 in a flounder. But of all fishes hitherto discovered, the cod seems the most fertile. One naturalist computes that it produces more than 3,686,000 eggs; another 9,000,000; and a third 9,444,000. Here, then, are eleven fishes, which probably, in the course of one season, will produce above thirteen millions of eggs; which is a number so astonishing and immense, that, without demonstration, we could never believe it true*."

The fecundity of insects is no less remarkable than that of fishes. In some instances, particularly in those already mentioned, the numbers produced from the eggs of a single female, far exceed the progeny of any other class of animals. It is this extraordinary fecundity which, under favourable circumstances, produces countless swarms of insects that give origin to the opinion of their being spontaneously generated by putrefaction, or brought in some mysterious way by blighting winds. The numerous accidents, however, to which insects are exposed from the deposition of the egg till their final transformation, tend to keep their numbers from becoming excessive, or to reduce them when they are at any time more than commonly numerous.

* Introd. Observ. to Spallanzani, xiv.

Chapter III.

Maternal Care of Insects in depositing their Eggs.—Solitary Bees.—Wasps.—Ichneumons.—Moths.—Butterflies.—Gnats.—Mistakes of Instinct.

Lord Kaimes, in his 'Gentleman Farmer,' mentions the singular fact that the female sheep, weeks before yeaning, selects some sheltered spot where she may drop her lamb with the most comfort and security; and when forcibly prevented from going there, she manifests the utmost uneasiness. But this instance of prospectively providing for a future progeny is exemplified much more strikingly in most insects, in consequence of the great difference of their economy compared with that of other animals. The sheep and other mammalian quadrupeds suckle their young, and watch over them with the most affectionate care during the earlier and more helpless stage of their existence. This, on the contrary, is only found in a few cases among insects, such as the social bees, wasps, and ants; for the greater number of species never live to see their descendants. The numerous families, indeed, of moths, butterflies, and other winged insects, seldom live more than a few days after they have deposited their eggs, though some other species probably live many months. The latter, however, are only exceptions to the general rule, that insects, after depositing their eggs, very soon die. The wisdom of Providence, therefore, has endowed female insects with the most wonderful acuteness and skill in anticipating the wants of their young, when they escape from the egg, and have no mother to direct or provide for them.

We have numerous beautiful instances of this in the solitary bees and wasps, which perform indefatigable labours in hewing out nests in wood and stone, and building structures of clay, leaves, cotton, and other materials, as we have elsewhere detailed at length*. But we recently met with an example of this, which we shall briefly notice. A small solitary bee, (*Chelostoma florisomne?*) not so large as the domestic fly, and more slender in the body, instead of digging into the ground like its congeners†, bores a hole in a tree about the diameter of a wheat straw, and, when empty, resembling externally the timber holes of the furniture beetle (*Anobium pertinax*), for which, indeed, we at first mistook them, till we were undeceived by seeing the little bees going in and out. When the work is completed, however, the hole can only be detected by a practised eye, for it is neatly covered with a substance, the nature of which remains to be discovered. It is a grey semi-transparent membrane, somewhat resembling the slime of a snail when dried; but whether it is secreted by the bee like wax, or gathered from plants like propolis, we cannot tell. As we had a whole colony of these little wood-boring bees in the stump of a growing poplar at Lee, we cut out several of the perforations, in order to examine the interior. These we found more than an inch deep, and filled to the brim with a thin whitish honey; but, like those of the larger carpenter bees of a different genus (*Xylocopa*), they were divided by several partitions of the same membranous material.

The circumstance, however, which induces us to give these details here, relates to the eggs deposited

* See Insect Architecture, pp. 24—64, &c. † Ibid. p. 43.

in these singular perforations. It is obvious, if the eggs were laid in the midst of the liquid honey, that they would either be prevented from hatching, or the grub would be suffocated in the first stage of its existence. Every chamber of the little nest is so full of honey, that it is difficult to divine how this is to be avoided, and it was only after repeated and anxious researches that we found a solution of the difficulty. It is this: the mother-bee, when she has filled a chamber with honey, glues a single egg, a hair's breadth or two above its surface, and at a similar minute distance she stretches the membranous partition, leaving between this and the surface of the honey just sufficient space, and no more, for the newly hatched grub to crawl all round. On opening one of these perforations after the grub had been some time hatched, we found it keeping aloof from the honey, and resting on the upper margin, from which it seemed to have stretched its head when feeding to the centre, instead of eating at the circumference. The honey was also then become thicker in consistence, and, in consequence of what had been consumed, formed a hollow cup*.

Réaumur describes the nest of a bee of the same family (*Andrena cineraria*, Fabr.), which is found in the neighbourhood of London, and differs from the preceding in making perforations, not in trees, but in the ground, and lining these with the membranaceous substance that composes the partitions and the outer covering. He takes no notice, however, of the prospective ingenuity with which the egg is placed above the surface of the fluid honey†.

The various species of nests thus prepared by the parent insects for depositing their eggs, are not merely intended for holding provisions and shel-

* J. R. † Reaumur, *Mem.*, vol. vi. p. 131.

tering the young grub from the inclemencies of the weather, or from being preyed upon by birds. There are more insidious and no less destructive enemies than these to guard against. This we shall immediately show from the economy of other families of the same order, whose proceedings also strictly illustrate the subject of maternal care. In popular works on natural history the insects alluded to are indiscriminately called *Ichneumons*, a name signifying *Pryers*, and first given by Aristotle to wasps. But recently this term has been considerably restricted, and therefore does not properly apply to many insects whose economy resembles the true ichneumons. It is the practice, then, of a very great number of insects, of different orders and families, to take advantage of the labours of other insects in providing for their progeny, in the same way as the common cuckoo and the cow-bunting of America (*Emberiza pecoris*, WILSON) lay their eggs in the nests of other birds. The venerable Dr. Jenner was the first to publish*, what had long been known to our peasants, that the young cuckoo, when hatched, soon ejects from the nest into which it has been surreptitiously introduced the eggs or young of its foster parent; but the insects under notice act still more ungratefully. They do not, indeed, live upon the honey or other provision stored up by the builder of the nest for the use of her own young, since, being all carnivorous, this is not to their taste; but they permit the rightful owner of the food to feast and fatten on it, that they may make of him a more substantial repast. The great numbers of different species of insects which are reared in this singular manner would appear almost incredible to one who had not studied their economy; but it cannot fail to meet the young entomologist at the very

* Phil. Trans. for 1788, p. 219.

outset of his studies; for it is scarcely possible for many broods of insects to be reared without observing it.

The insidious proceedings of these cuckoo insects, as we may not inappropriately call them, give rise to remarkable displays of ingenuity on the part of the mothers whose progeny is exposed to their felonious designs. It is the usual practice of the solitary bees and wasps to leave the whole task of constructing and provisioning the nest to the female, the male, like an American Indian, taking no part in those domestic concerns. In this case, though she is seldom absent from the spot for more than two or three minutes at a time, some prying *Chrysis* or *Tachina* often glides into her domicile, and finds time to deposit its egg and to escape before her return. Other solitary bees exhibit both more civilization and more cunning; for the male assists, at least, in watching and guarding the nest, if he does not lend a hand in its construction. The proceedings of one of these solitary bees (*Halictus fulvocinctus*, Steph.), indigenous in the vicinity of London, has frequently fallen under our observation. It constructs a gallery, having on the outside only a single perpendicular passage, but branching out into seven or eight, at the bottom of each of which is placed a globule of pollen kneaded up with honey about the size of a pea, where an egg is deposited. Walckenaër, who observed these insects with great care, remarks, that they only work during the night in making their galleries; and our observations so far agree with his, that though we have observed some dozens of their nests, we never saw them at work in the day. Instead of this, either the male or the female always remains at the entrance of the nest (which its head exactly fills) ready to give no friendly reception to any enemy that may venture to intrude. We have often seen, indeed, the ruby-tail fly (*Chrysis ignita*), on approaching this vigilant sentinel, fly off in all haste, with evident fear of the consequences. But, as Walckenaër justly remarks, should the partner of its cares return from a foraging excursion, and take two or three circular flights around the entrance to announce its arrival, the sentinel bee immediately makes way by withdrawing into the interior. Should the sentinel bee be absent through any cause from its post, and the forager enter without announcing its arrival, it is immediately driven back and punished for so unpardonable a breach of etiquette*.

Another circumstance worthy of notice in the manners of these bees (*Halicti*) is, that they fly directly into the entrance of their nests without ever alighting upon any contiguous object, a circumstance which is attributed by Walckenaër to their fear of enemies, numbers of which are always lurking about with evil intent. More than one species of spider and several sorts of wasps lie in wait to make prey of them, besides those we have mentioned as being on the alert to introduce their eggs into their nest. But their most formidable enemy is a solitary wasp (*Cerceris ornata*), numbers of which make their nests in the very midst of their colonies. The wasps surround the interior margin of their holes with a rampart of sand, agglutinated with a whitish mortar, and well polished. The gallery is five inches deep, somewhat in the form of an S, in which the female lays her eggs, with a store of provisions for her future young, consisting of the living bodies of her bee neighbours, the poor *Halicti*. It is only on fine days, between eleven and four o'clock, that the mother wasp engages in the chase of the bees, and may be seen flying with the most lively ardour around their nests. When an unfortu-

* Walck. Mem. des Abeilles Solit. Paris, 1817.

nate bee ventures at this time to approach its home, the wasp pounces upon it as a hawk would pounce upon a sparrow, seizes it by the back of the neck, carries it to the ground, and placing it by the side of a small stone or clod of earth, she turns it round upon its back. Then standing upon its belly in an attitude of conscious triumph, she darts her sting into the lower part of its head, in such a manner as to stupify it, but not to kill it outright. As soon as she has in this manner laid in a sufficient store of half-dead bees, she closes up the entrance *.

Several species of this family of wasps (*Cerceris aurita*, LATR., and *C. quadrifasciata*, BOSC) are of essential service to agriculturists by provisioning their nests with destructive weevils (*Curculionidæ*), so injurious to orchards and nurseries †. Other families of this order in a similar way provide for their progeny a supply of living insects of different species, of which interesting accounts have been given by more than one naturalist ‡.

The insects, however, of these marauding tribes are not permitted to carry on their depredations on their more peaceful neighbours with impunity; for nature has provided other races of animals to make prey of them. We do not allude merely to birds and reptiles, which devour as many of those carnivorous wasps as they can catch; for there is also a numerous tribe of insects who have the address to foil them at their own weapons. All the careful stratagems of the mason wasp (*Odynerus murarius*, LATR.), in rearing her turretted outworks to defend her premises while she excavates her galleries §, often prove ineffectual in guarding against the insi-

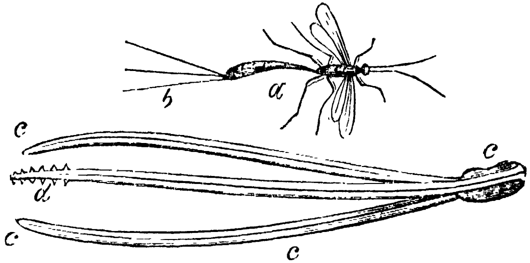
* Walck.; Latreille, Annales du Museum, tom. xiv.; and Bosc, Ann. de l'Agric., vol. liii.

† Bosc, Ann. de l'Agric., vol. liii.

‡ See Insect Architecture, pp. 26—33. § Ibid., pp. 30—32.

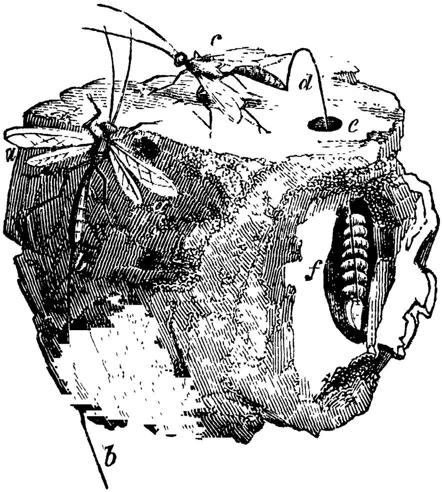
dious intrusion of a common ichneumon fly (*Pimpla manifestator*, Gravenhorst), easily known by its being black, with the legs red. This ichneumon sometimes pays a visit to the nest of the wasp before it is completed, for Réaumur has seen one peep into the entrance and then start back as if afraid of its depth; but, for the most part, she waits patiently till the wasp, having laid in a store of caterpillars for the young one, closes up the doorway with a barricado of kneaded clay. It is this very barricado which the ichneumon determines to assail in order to find a nest ready prepared and stocked with provisions for her own progeny. With this design she makes use of her ovipositor, which is as admirably adapted to the purpose as those of the saw-flies or the tree-hoppers (*Cicadæ*).

The ovipositor of all the true ichneumons (*Ichneumonidæ*) is similarly constructed, consisting of a borer enclosed in a sheath, which opens through its whole length like the legs of a pair of compasses. It is longer or shorter, and stronger or more slender, according to the substances which it may be necessary to penetrate when the eggs are deposited. The description, therefore, of the ovipositor of the one just alluded to (*P. manifestator*) will be sufficient to give the reader a distinct notion of the others. Being intended to penetrate into the deep holes dug by mason wasps, the ovipositor of this insect is nearly three inches long, and, as it is not concealed in the body like those of gall flies, it appears like a tail formed of a long black bristle. On examining this a little more narrowly, we find that what appears to be a single bristle is in reality three, two side ones forming a sheath, and the middle one a borer or brad-awl for piercing the clay barricado of the mason wasp's nest. The termination of the borer is not, however, smooth, like that of a brad-awl, but toothed like a saw, only the teeth, seven or eight, are not oblique, but perpendicular, a structure better fitted for acting upon clay, as the teeth will not become so readily clogged, and the instrument will be more easily retracted. The figures will make this more perspicuous than the best description.



a, the *Pimpla manifestator*; *b*, its ovipositor opened outwards; *c c c c*, magnified view of its ovipositor; *d*, the toothed point of the borer.

In order to study the economy of the mason wasps (*Odyneri*) more effectually, Réaumur made an artificial vespiary of sand and mortar upon a wall, which at the same time gave him an excellent opportunity of observing the manœuvres of the ichneumons. "I perceived," he tells us, "one of these ichneumons, at the instant it alighted on the spot under which so many of the little green caterpillars had been stored up by the wasps. Its long tail, which it carried horizontally, appeared to form but one bristle, though it was really composed of three; and though it carried it on a line with its body, it soon showed me that it was capable both of raising and lowering it, as well as of bending it in various directions, and in different proportions to its length. It moved its ovipositor so as to bring it into a bent position under its body, protruding it even beyond its own head; taking care to direct it into the barricadoed nest of the mason wasp. But although the insect appeared not to be disturbed by my observations, yet I was unable to perceive whether the toothed portion of the borer was pushed beyond the sides of the sheath. What I did see, however, convinced me that the instrument was worked in a manner well adapted to make its way through the mortar; for she turned it half round alternately from right to left and from left to right, as a carpenter would his brad-awl, and employed altogether more than a quarter of an hour before she succeeded in penetrating to a sufficient depth*."



Ichneumon flies ovipositing. *a a*, an ichneumon fly. *b b*, its ovipositor. *c*, an ichneumon, which has just bored through the closed substance of a sand wasp's nest at *e*, into which her ovipositor, *d*, descends to the coil of caterpillars at *f*, where the egg is laid.

* Réaumur, Mem. vi. p. 304.

Another parasite (*Pimpla strobilellæ*, FABR.) is armed with a long ovipositor, with which it deposits its eggs in larvæ that burrow in the fruit-cones of the fir.

The intrusion of these parasite eggs into the nests of insects is often an exceedingly puzzling circumstance to naturalists, in their earlier researches; and sometimes even deceives those of considerable experience and acuteness into the supposition that the insects ultimately produced are in reality those of the original builder of the nest. These deceptions frequently occur in the numerous species of vegetable galls, originating chiefly in the economy of a beautiful family of insects (*Chalcididæ*, WESTWOOD). When the gall-fly (*Cynips*) has deposited its eggs on the bud or the leaf of a plant in such a manner as to insure their being surrounded with a thick coating of vegetable substance, they are not on that account secure from the insects just alluded to; for the *Chalcis*, armed by nature with an instrument for the purpose, can penetrate in any direction the largest oak-apple or bedeguar of the rose*. The most obvious distinction between these parasites and the true gall-flies, is, that in the latter the ovipositor is partly concealed, while in the former it is altogether external, like the ichneumons in the preceding figure; but this distinction is of course wanting in the male insects. It was the observation of different species of insects, produced in this manner from the same sort of gall, which betrayed the illustrious Redi into the fanciful notion of their being generated by a vegetative and sensitive soul in the plant itself, to which also he attributed the generation of the grubs found in nuts, cherries, and other fruits. "There is nothing," as Réaumur justly remarks, "more fitted to humiliate the best reasoners, and to inspire them with a

* See Insect Architecture, pp. 375—384.

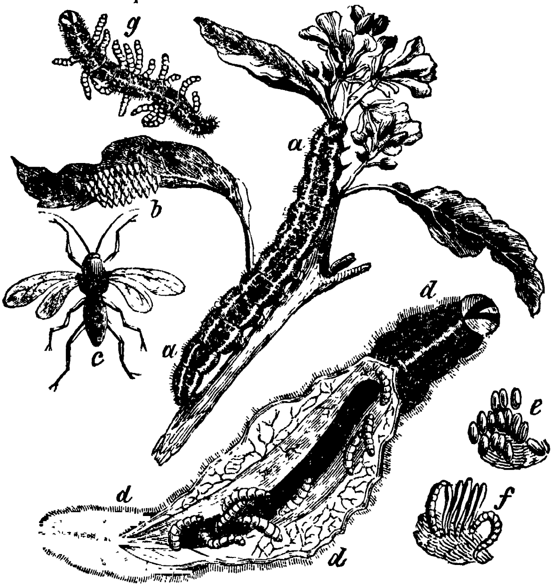
well-founded distrust of novel opinions, than to see a man like Redi, who had declared open war against popular prejudices, and successfully combated many of them, thus adopting a notion so improbable, or (to use a stronger term) so pitiable*." It was Redi's countryman, Malpighi, who first discovered the genuine history of gall-flies; but when we consider that from the bedeguar gall of the rose alone no less than three different species of insects may proceed, two of which (*Callimone bedeguaris*, and *Eurytoma stigma*, STEPHENS) are parasites, Redi had some cause for being puzzled to explain the phenomena.

Two other distinguished naturalists, Goedart and Ray, found no less difficulty in accounting for the progeny of ichneumons issuing from the caterpillars and chrysalides of butterflies. Ray, indeed, lived to ascertain the fact; but he was at one time inclined to believe, with Goedart, that when, from any defect or weakness, Nature could not bring a caterpillar to a butterfly, in order that her aim might not be entirely defeated, she stopped short, and formed them into insects of a smaller size, and less perfect structure †. M. Goedart even persuaded himself, says Réaumur sarcastically, that he had observed the caterpillar interesting itself for its infant progeny, by weaving for them an envelope of silk. It was also fancied that what was wanting in size in the parasite flies, when compared with the expected butterfly, was made up in their greater numbers ‡; with as much probability, says Réaumur, as that a cat would kitten a number of mice. The simple facts which we shall now state, will point out the origin of these strange mistakes.

* Réaumur, Mem. iii., p. 476.
† Ray, Hist. Ins., Pref. xv., and Cant. 137.
‡ Goedart, quoted by Réaumur, vol. ii., p. 415.

It must have occurred to the least attentive observers of the very common cabbage caterpillar (*Pontia Brassicæ*), that when it ceases to feed, and leaves its native cabbage to creep up walls and palings, it is often transformed into a group of little balls of silk, of a fine texture and a beautiful canary yellow colour; from each of which there issues, in process of time, a small four-winged fly (*Microgaster glomeratus*, SPINOLA), of a black colour, except the legs, which are yellow. By breeding these flies in a state of confinement, and introducing them to some cabbage caterpillars, their proceedings in depositing their eggs may be observed. We have more than once seen one of these little flies select a caterpillar, and perch upon its back, holding her ovipositor ready brandished to plunge between the rings which she seems to prefer. When she has thus begun laying her eggs, she does not readily take alarm; but, as Réaumur justly remarks, will permit an observer to approach her with a magnifying glass of a very short focus. Having deposited one egg, she withdraws her ovipositor, and again plunges it with another egg into a different part of the body of the caterpillar, till she has laid in all about thirty eggs. It is not a little remarkable, that the poor caterpillar, whose body is thus pierced with so many wounds, seems to bear it very patiently, and does not turn upon the fly, as he would be certain to do upon another caterpillar should it venture to pinch him; a circumstance by no means unusual. Sometimes, indeed, he gives a slight jerk, but the fly does not appear to be at all incommoded by the intimation that her presence is disagreeable.

The eggs, it may be remarked, are thrust sufficiently deep to prevent their being thrown off when the caterpillar casts its skin; and, being in due time hatched, the grubs feed in concert on the living body of the caterpillar. The most wonderful circumstance, indeed, of the whole phenomenon, is the instinct with which the grubs are evidently guided to avoid devouring any vital part, so that they may not kill the caterpillar, as in that case it would be useless to them for food. When full grown, they even eat their way through the skin of the caterpillar without killing it; though it generally dies in a few days without moving far from the place where the grubs have spun their group of silken cocoons in which to pass the winter.



Generation of Ichneumons. *a a*, the caterpillar of *Pontia Brassicæ*. *b*, the eggs of that butterfly glued to a leaf. *c*, *Microgaster glomeratus*, magnified. *d d d*, a magnified view of a dissected caterpillar, in whose body a number of ichneumon caterpillars have been hatched. *e*, silk cocoons spun by the ichneumons. *f*, grubs spinning cocoons. *g*, grubs eating their way out of the caterpillar.

But it is not only in the nests of bees and wasps, or in the bodies of caterpillars, that these provident mothers contrive to deposit their eggs; for many of them are so very minute, as to find in the eggs themselves of larger insects a sufficient magazine of food for their progeny; and accordingly, piercing the shell with their ovipositor, they thrust their own into the perforation. The most common instance of this which we have remarked, occurs in the eggs of spiders; patches of which may be found almost everywhere under the cross bars of palings, and the copings and corners of walls. Though spiders, for the most part, not only cover their eggs with a thick envelope of silk, but also remain near to protect them from enemies, yet a small four-winged fly (*Cryptus*, FABR.), and, if we are not mistaken, two-winged flies (*Muscidæ*, LEACH), also, outbrave the danger of being caught and immolated by the mother spider, and introduce their eggs either into or among those of their powerful enemy. These spider's eggs are subsequently feasted upon by the progeny of the flies,—a very natural reprisal for the ravages committed by this carnivorous race upon the whole generation of their fellows. That the mother flies actually pierce the eggs of other insects was observed before the year 1730, by the accurate Vallisnieri, who says, "I have seen with my own eyes a certain kind of wild flies deposit their eggs upon other eggs, and bore and pierce others with an ovipositor (*aculeus*), by means of which they have introduced the egg *." Count Zinanni, another Italian naturalist, told Réaumur, that, his attention being attracted by a small ichneumon fluttering about the eggs of butterflies, he soon observed it alight and fix upon one of these eggs; and, without being incommoded by his observing her proceedings through a strong magnifier,

* Vallisnieri, Lettere, 80.

she bent her ovipositor, and plunged it into the egg. She performed the same operation upon many other eggs, which he carefully put under cover; and in about three weeks had from them a brood of flies of the same species with the one whose remarkable proceedings he had watched*.

A writer in the Magazine of Natural History (Jan. 1830), gives an account of a numerous brood of a very minute species of ichneumon, supposed to be an egg parasite (*Platygaster ovulorum*? STEPHENS), which was produced from the caterpillars of the large white cabbage butterfly (*Pontia Brassicæ*). Having enclosed a number of these in a wire cage, five or six of them soon left off feeding, and crawled about the cage. "June 30," he proceeds, "I found them resting on large clusters of minute cocoons of an ovate form, the largest not exceeding two lines in length, and about the thickness of a caraway-seed. Each was enveloped with a fine yellow silk, resembling that of the common silkworm (*Bombyx Mori*). On these clusters the caterpillars remained the whole day without moving. Fresh leaves were given to the rest; but in the course of the day they all left off feeding, crawled about the cage, but underwent no other change. Early next day, I found they had, with the exception of two or three, all ejected the parasitical progeny they had been impregnated with; and, like the preceding caterpillars, continued resting on the clusters they had formed: the remaining three followed the example of the others; and the last operation of these devoted caterpillars was to envelope each cluster in a veil formed of the most delicate web†." It is not a little interesting to remark, that this circumstance corroborates the statement before given from

* Réaumur, Mem. vol. vi. p. 297.
† Loudon's Mag. Nat. Hist. iii. 51.

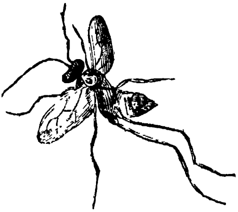
Goedart, and disbelieved by Réaumur and subsequent naturalists: but we think it so very extraordinary, that we are much inclined to think the observer (T. H. of Clapham) has unwittingly fallen into mistake. "Some of them," he continues, "executed the task; but the greater part were too feeble to complete it; and in the course of three days more they became motionless, and gradually, one after another, fell shrivelled and exhausted to the bottom of the cage." Some of the clusters contained upwards of a hundred cocoons, and others not more than sixty. By July 12, the perfect flies made their appearance by opening a sort of lid at the end of each cocoon. The flies seem to differ little, except in size, from the common ichneumon of the same caterpillar (*Microgaster glomeratus*); but, supposing them to be in the first instance egg parasites, they must have been deposited *among*, not *in* the eggs of the butterfly.

The minuteness of some of these parasite insects may be partly conceived from the fact mentioned by Bonnet,—that the egg of a butterfly, not bigger than a pin's head, is sufficient to nourish several of them; for out of twenty such eggs of butterflies, a prodigious number (*une quantité prodigieuse*) were evolved *. Few species of the plant-lice (*Aphides*) are a great deal larger than the butterfly's eggs described by Bonnet; yet these also have a parasitical enemy (*Microgaster Aphidum*, SPINOLA), which plunges its eggs in their bodies; but the larvæ, when hatched, are by no means safe, being liable to the attacks of another fly of the same family (*Gelis agilis*, THUNBERG), as Dr. Turton informs us †.

* Bonnet, Œuvres, 8vo. ii. 344. Kirby, referring to this passage, assigns, by mistake, only two to each egg. Introd. i. 342.

† Transl. of Linn. iii. 48.

It is not common, however, for the ichneumon flies to deposit their eggs in the bodies of perfect insects, as in most cases they prefer the eggs, larvæ, or pupæ; but instances are on record of their grubs having been found in the former. The troublesome cock-roach (*Blatta*) is selected by a parasite fly (*Evania apendigaster*, FABR.), as remarkable in form as it is rare in occurrence, in Britain at least. It has been found in the vicinity of London; but, were it abundant, it might tend to reduce the numbers of these black beetles, as they are incorrectly termed, the pests of the kitchen.



Magnified view of a parasite fly (*Evania apendigaster*).

An insect parasite, still more singular in form, and of still rarer occurrence, was discovered by Kirby, above thirty years ago, on the black bronze bee (*Andrena nigroænea*, STEPHENS). "I had previously," he remarks, "more than once observed upon other species something that I took to be a kind of *Acarus*, which appeared to be immoveably fixed just at the inosculations of the dorsal segments of the abdomen. At length, finding three or four upon a specimen of this bee, I determined not to lose the opportunity of taking one off to examine and describe; but what was my astonishment, when, upon my attempting to disengage it with a pin, I drew forth from the body of the bee a white fleshy larva, a quarter of an inch in length, the head of which I had mistaken for an acarus! (*bee-louse*). After I had examined one specimen, I attempted to extract a second; and the reader may imagine how greatly my astonishment was increased, when, after I had drawn it out but a little way, I saw its skin burst, and a head as black as ink, with large staring eyes and antennæ, consisting of two branches, break forth, and move itself briskly from side to side. It looked like a little imp of darkness just emerged from the infernal regions. My eagerness to set free from its confinement this extraordinary animal may be easily conjectured. Indeed I was impatient to become better acquainted with so singular a creature. When it was completely disengaged, and I had secured it from making its escape, I set myself to examine it as accurately as possible; and I found, after a careful inquiry, that I had got a nondescript, whose very class seemed dubious*." Of the manner in which this singular insect (*Stylops*) introduced its eggs into the body of a bee nothing is yet known, and its rarity puts it out of the reach of the most eager observers. Several species of the same genus have since been found near London, and an allied genus (*Xenos*) has since been discovered parasite in wasps by Professor Peck, in America.

Bee Parasite. (*Stylops Melittæ*, Kirby.)

De Geer was one day much surprised to observe a small white grub sucking the body of a young spider (*Epeira diadema*), having attached itself

* Monogr. Ap. Angl. ii. 113.

firmly to the abdomen. Having put it into a glass, he remarked a few days afterwards, that the spider had spun the outline of a vertical web, had stretched threads from the top to the bottom, and from one side to the other of the glass, together with the rays of a net, but without the circular threads. The most singular circumstance was, that the parasite grub was suspended in the centre of this web, where it spun its cocoon, while the exhausted spider had fallen dead to the bottom of the glass*.

These examples will suffice to prove the anxious care of the mother insects in depositing their eggs where their progeny may find abundance of food. The tact with which they discover this is one of those mysteries of nature which are apparently beyond the penetration of man ever to discover; for it is seldom that the mother insect herself feeds upon the same, or similar substances, as her larvæ, and yet she is well aware of what is appropriate for them. The ichneumon flies, whose history we have just been sketching, eat little, except, perhaps, a small quantity of honey from the nectary of a flower, and yet they know that their progeny must be fed by living insects; the butterflies and moths, whose scanty repast also consists solely of the honey of flowers, never make a provision of this for their caterpillars, but deposit their eggs on plants and trees where their young may eat abundantly of leaves or other parts "after their kind." In making these selections, each species exhibits some peculiarity well worthy of observation. Some confine themselves to one particular sort of plant, and never select any other; some make choice indifferently of two or three sorts; while others take a wider range, and fix upon plants of very different qualities. To exemplify this, we might mention some thousands of

* De Geer, Memoires, vol. ii. p. 863.

instances, but it will be sufficient to say, that we never find the eggs of the small tortoise-shell butterfly (*Vanessa urticæ*) on any plant but the nettle; its congener, the painted lady (*Cynthia cardui*, STEPHENS), though it prefers the spear-thistle, is sometimes found on the nettle, as is the comma (*Vanessa C. Album*), though it seems to prefer the hop; while we have found the eggs of the lackey moth (*Clisiocampa neustria*) on almost every bush and tree, from the sweetbriar to the oak, in woods, hedges, orchards, and gardens, without any apparent preference beyond the accident of the mother moth alighting on a particular branch. In the same way almost all those which deposit their eggs on salad plants, such as the great tiger (*Arctia Caja*, STEPHENS), will as readily select the nettle as the lettuce or dandelion *.

It is worthy of remark that our native insects frequently make choice of exotic plants, by means of the instinctive tact which enables them to discover such as suit their purpose. The death's-head hawk moth (*Acherontia Atropos*), for example, is now usually found on the potatoe and the jasmine, but previous to the introduction of these into Britain, it probably confined itself to the bitter sweet (*Solanum dulcamara*). We have known the moth taken in Ayrshire, where this plant is abundant. An instance in point has just occurred to us in one of the minute leaf-miners. Upon the leaf of an exotic plant (*Cineraria cruenta*) kept in a garden-pot in our study, we were not a little surprised to observe the tortuous windings of a miner, considerably different in the outline from any we had before examined. Though it was so late as December, also, the grub seemed very active, and would sometimes mine nearly half an inch of the leaf in the course of the day. It

* J. R.

was transformed within the leaf, in a few days, into a pupa, and being put under a bell-glass, a small two-winged fly (*Tephritis Serratulæ ?*) made its appearance in about a fortnight. In some garden-pots, in another room of the same house, were exotic plants of the American groundsel (*Senecio elegans*), the leaves of which were crowded with miners, whose paths, however, were so very different as to indicate a different species; but upon their transformation into perfect insects, they turned out exactly the same. They proved, indeed, to be the same with the leaf-miners of the swine-thistle (*Sonchus oleraceus*),

Leaf-mining maggots. *a*, the fly (*Tephritis Serratulæ ?*) *b*, mined leaf of sow-thistle (*Sonchus oleraceus*). *c*, mined leaf of *Senecio elegans*. *d d*, mined leaf of *Cineraria cruenta*.

numerous specimens of which we collected in the immediate vicinity; but the flies of these, from their previous exposure to the cold out of doors, did not appear till a month later. It is worthy of remark, that the two exotic plants are of the same natural family (*Compositæ*); yet, notwithstanding the similarity of the common groundsel (*Senecio vulgaris*) to the American, not one leaf of the former was found mined, though it is an abundant native plant *.

It is no less remarkable, that the mother insects of the larvæ which live solitary and those which live in society take care to deposit their eggs with regard to the respective destinations of their progeny. In our earlier studies we remember being much interested with Harris's description of the admirable butterfly (*Vanessa Atalanta*), flitting rapidly and stealthily from field to field, and depositing only a single egg on a single nettle in each, as if she were afraid of overstocking one place and leaving others uninhabited by her descendants †. Our subsequent observation of the manners of the insect itself has led us to doubt the accuracy of Harris; for we think it will hold as a pretty general principle, that the mothers of solitary caterpillars, for the most part, deposit several eggs on the same plant, often at no great distance, and sometimes on the same leaf. No class of caterpillars could well be considered more solitary than those of the hawk moths (*Sphingidæ*, Leach), yet we have found from two to three eggs of that of the poplar hawk (*Smerinthus Populi*) upon the same leaf, and a similar number of the eggs of the puss moth, the larva of which is also solitary, on one leaf ‡; while of the admirable butterfly above alluded to, we found, in 1825, as many as from three to six on every plant in a small patch of about a dozen

* J. R. † See Harris's Aurelian, vi. fol. Lond. 1778.
‡ See Insect Architecture, p. 192.

nettles, in Copenhagen-fields, Islington. A similar deposition of eggs is made by several of the mothers of the subsolitary caterpillars which live in the wood of trees. Of this we had a good example in the clear under-wing (*Ægeria asiliformis*), above a score of the small black eggs of which we found deposited in a scattered manner on the trunk of a single poplar at Lee *.

The most singular disposal of eggs with which we are acquainted in the economy of insects, is exemplified in the common gnat (*Culex pipiens*, LINN.). It is admirably described by Réaumur, though it seems first to have been discovered by Langallo, who mentions it in a letter addressed to Redi, printed at Florence in 1679; and by Alloa, who actually saw the eggs laid, and afterwards sketched a figure of them. Those who wish to witness this singular operation, must repair before five or six o'clock in the morning to a pond or a bucket of stagnant water frequented by gnats; when Réaumur went later in the day he was always disappointed.

The facts of this disposal of her eggs by the common gnat, are sufficiently curious to excite attention to them; and, therefore, it is not easily to be understood how the following erroneous and fanciful account originated. " The manner," says Goldsmith, " in which the insect lays its eggs is particularly curious; after having laid the proper number on the surface of the water, it surrounds them with a kind of unctuous matter, which prevents them from sinking, but at the same time *fastens them with a thread to the bottom*, to prevent their floating away, at the mercy of every breeze, from a place the warmth of which is proper for their production, to any other where the water may be too cold, or the animals, its enemies, too numerous. Thus the insects, in their

* J. R.

egg state, resemble a buoy which is fixed by an anchor. As they come to maturity, they *sink deeper*, and at last, when they leave the egg as worms, *creep to the bottom* *." This fable, which was first mentioned by Pliny, is repeated verbatim by Bingley †. The impossibility of a gnat spinning a thread, and plunging into the water to fix it at the bottom, never struck these writers.

We are the more anxious to expose these erroneous accounts, from a persuasion that a taste for natural history has been more injured by numerous similar statements, which could not be verified by a student, in many popular works, than by the driest skeleton descriptions of those who have merely pursued Natural History as a science of names.

The problem of the gnat is to construct a boat-shaped raft, which will float, of eggs heavy enough to sink in water if dropped into it one by one. The eggs are nearly of the pyramidal form of a pocket gunpowder-flask, rather pointed at the upper and broad at the under end, with a projection like the mouth of a bottle. The first operation of the mother gnat is to fix herself by the four fore-legs to the side of a bucket, or upon a floating leaf, with her body level with and resting upon the surface of the water, excepting the last ring of the tail, which is a little raised; she then crosses her two hind legs in form of an X, the inner opening of which is intended to form the scaffolding of her structure. She accordingly brings the inner angle of her crossed legs close to the the raised part of her body and places in it an egg, covered, as is usual among insects, with a glutinous fluid. On each side of this egg she places another, all which adhere firmly together by means of their glue, and form a triangular figure thus ⁎⁎⁎, which is the stern

* Goldsmith, Animated Nature, vi. 337.

† Bingley, Animal Biography, iii. 439, 3d ed.

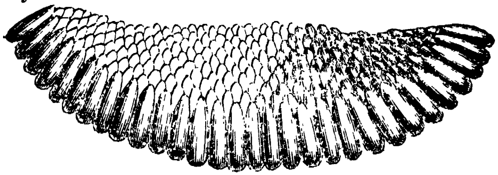
of the raft. She proceeds in the same manner to add egg after egg in a vertical (not a horizontal) position, carefully regulating the shape by her crossed legs; and as her raft increases in magnitude, she pushes the whole gradually to a greater distance, and when she has about half-finished she uncrosses her legs and places them parallel, the angle being no longer necessary for shaping the boat. Each raft consists of from two hundred and fifty to three hundred and fifty eggs, which, when all laid, float on the water secure from sinking, and are finally abandoned by the mother. They are hatched in a few days, the grubs issuing from the lower end; but the boat, now composed of the empty shells, continues to float till it is destroyed by the weather*.

Gnats forming their egg boats. *a*, represents the commencement of the boat of eggs; *b*, the boat about two-thirds completed; *c*, the perfect boat resting on the surface of the water.

Kirby justly describes this little vessel as resembling a London wherry, being sharp and higher, as sailors say, *fore* and *aft*, convex below and concave above, and always floating on its keel. "The most violent agitation of the water," he adds, "cannot sink it, and what is more extraordinary, and a property still a desideratum in our life-boats, though hollow, it never becomes

* Réaumur, Mem. iv. p. 621.

filled with water, even though exposed. To put this to the test, I placed half a dozen of these boats upon the surface of a tumbler half-full of water: I then poured upon them a stream of that element from the mouth of a quart bottle held a foot above them. Yet after this treatment, which was so rough as actually to project one out of the glass, I found them floating as before upon their bottoms, and not a drop of water within their cavity*." We have repeatedly pushed them to the bottom of a glass of water; but they always came up immediately to the surface apparently unwetted.



Magnified view of the boat of gnats' eggs.

We have contented ourselves with giving here only a few examples of the maternal care which is displayed by insects in depositing their eggs, though we could have filled the volume with similar details. The instincts which are thus displayed are of the most interesting description; and they cannot fail to impress the most careless observer with a deep reverence of that providential wisdom by which they are implanted in these small and feeble creatures for the maintenance of their race. But it is not essential, in order to produce this reverence, to exaggerate the circumstances under which these remarkable peculiarities are displayed. The infallibility of the instinct of insects in such cases is, in most books of natural history, maintained to be without exception. "Led by an instinct," say Kirby and Spence, "far more un-

* Introd. iii. p. 32.

erring than the practised eye of the botanist, she recognizes the plant the moment she approaches it *." And again, they talk of "the *unerring* foresight with which the female deposits her eggs in the precise place where the larvæ when excluded are sure to find suitable food †." This unconditional position requires, however, to be considerably modified to make it correspond with the facts. The experiment we gave from Redi in our first chapter, in which the carnivorous flies laid their eggs on the silk and paper covering tainted meat, will occur to every reader as one striking exception; and we can mention several others still more marked. When Dr. Arnold discovered that most singular parasitic plant, the krubut, of Sumatra, (*Rafflesia Arnoldii*, Brown,) which consists of a flower only, without leaf or stem, and of the extraordinary diameter of three feet, he perceived a swarm of flies hovering over the nectary, and apparently laying their eggs in its substance, mistaking it most probably for carrion, as it smelt like tainted beef ‡. A similar mistake is committed in our own country, when the common blow-fly (*Musca vomitoria*) lays its eggs in the fœtid funguses (*Phalli*, *Agarici*, &c.), apparently under the notion that these are genuine carrion §. This may be more particularly observed on the singular class of plants, *stapelias*, which are so common in our hot-houses: whole families of maggots are constantly born to starve in their fœtid flowers.

These are instances of the mistakes of instinct in circumstances where it depends upon the information of the senses; and similar mistakes frequently occur where the higher powers of human rationality are deceived by analogous phenomena. The fine nutty flavour of cherry laurel water and of prussic acid

* Introd. i. p. 340. † Ibid. iii. p. 65.
‡ R. Brown, Linn. Trans. vol. xiii. § Smellie, Philos. of Nat. Hist.

would be certain to deceive the inexperienced; and Majendie's servant actually fell an immediate victim to her desire of tasting the prussic acid which she found in his laboratory. This would be considered perhaps a mistake arising from the artificial habits acquired in society, by those who maintain that animals, guided by instinct, never mistake poison for food. But we may add another curious instance or two of similar mistakes in the inferior races.

The common earth-worm (*Lumbricus terrestris*) is instinctively afraid of moles; and no sooner does it hear any subterranean noise, or feel any shaking of the ground, similar to those indicative of the approaching movements of its enemy, than it makes a speedy escape to the surface. Every boy knows how to take advantage of this to procure fish-baits, by thrusting a spade or a stake into the ground, and moving it backwards and forwards, to imitate the advance of a mole burrowing in search of prey. The worm, unable from its instinct to discriminate between its subterranean enemy and the spade, darts into day-light, and is instantly captured for the boy's bait-bag. The lapwing (*Vanellus cristatus*, MEYER), it is stated by Dr. Anderson in his 'Bee,' is aware of this instinctive fear in the earth-worm of subterranean concussions or noises; and when it cannot find sufficiency of slugs *, &c. above ground, it pats with its feet, till the earth-worms, mistaking it for an advancing mole, come forth to be feasted upon.

It is well known that, whenever a hawk appears, he is immediately surrounded by a host of small birds, particularly swallows, which dart at him and tease him, for the purpose, as may be supposed, of distracting his attention, on the principle that

* "Nourriture;—insectes, araignées, vers, et petits limaçons." TEMMINCK, Manuel d'Ornithologie, p. 552, 2d. edit.

'wealth makes wit waver.' Be this as it may, the cuckoo, which bears a strong resemblance to a hawk when on the wing, is certain to be accompanied by a similar retinue of small birds wherever it flies. In the north this is so commonly observed, that the cuckoo is popularly believed to be always attended by a *titling* or pippet (*Anthus pratensis*, BECHSTEIN), which, it is further imagined, has been its stepmother and nurse from the egg: this, indeed, is the bird whose nest the cuckoo most frequently selects to deposit the eggs which she so strangely and unnaturally abandons; though it is more probable that it is not on this account, but because she appears to be a hawk, that the pippet and other small birds persecute her.

Linnæus records in his 'Lachesis Lapponica,' that at Tornea there is a meadow, or bog, full of water-hemlock (*Cicuta virosa*), which annually destroys from fifty to a hundred head of cattle. It seems that they eat most of it in spring, when first turned into the pasture, partly from their eagerness for fresh pasture, and partly from their long fasting and greediness, the herbage being then short. Besides, from the immersion of the hemlock under water, it may not have the proper scent to deter them. A similar destruction of cattle from the same cause occurs in the wide meadows of Leinings*.

* J. R., in Mag. of Nat. Hist., i. 374.

CHAPTER IV.

Hybernation of Insect Eggs.—Ingenuity of Moths.—Singularities of Cochenille Insects and of Spiders.—Experiments of Spallanzani and John Hunter.

THE assertion of Paley that "the *human* animal is the only one which can clothe itself *," though it accords with what is known of quadrupeds, birds, and fishes, by no means holds good in the insect world, in which it may be disproved by the most superficial observer †. Men, indeed, proceed by means of reasoning and experiment to the discovery of such materials as are best fitted for protecting their bodies against the vicissitudes of temperature, and other changes of weather; while insects are taught by the Governor of the Universe to select instinctively the best materials for their clothing. This is exemplified in a very remarkable manner in the coverings made by different families for protecting their eggs, as we shall now describe.

The maternal affection of the eider duck (*Anas mollissima*, LINN.) has frequently been celebrated by naturalists, from her stripping the down from her own breast to form her nest, a circumstance which is also exemplified in the common rabbit; but both of these animals are outrivalled by more than one moth:— for the latter, not contented with a nest made of their own down, take pains to cover with it each individual egg. The provision which nature has made for this purpose is worthy of attention. The female, for example, of the gypsey moth (*Hypogymna dispar*) has the hinder parts of her body thickly clothed with a

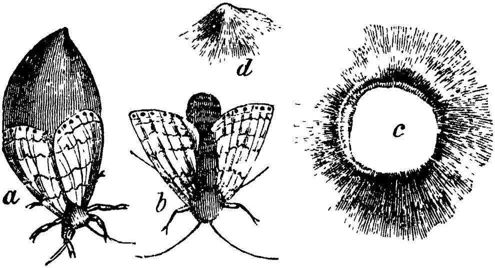
* Natural Theology, p. 230. 11th edit.

† See "Insect Architecture," chaps. x., xii., &c.

soft down of a hair-brown colour, which is wanting in the male, evidently because to him it would be of no use. As a covering for her own body, it can be of but small service, since she emerges from her pupa-case during the hot days of August, and does not usually live more than a week or a fortnight. Its chief or sole purpose, therefore, is to furnish a covering for her eggs.

When about to lay, the mother gypsey moth places herself on the trunk of an oak or an elm, invariably with her head downwards, the reason of which position will be immediately explained. Without the aid of her legs, which are too short to be used like those of the gnat by way of rule and compass, she contrives to place her eggs in the form of an inverted cone. She first makes a little bed of this down, into which she thrusts the egg intended for the point of her cone; and this egg, being covered with adhesive gluten, attaches around it all the hairs of the down with which it comes in contact, and also sticks to the bark of the tree, from its being pushed home. Proceeding in the same manner, she continues for several hours adding to the mass; but she does not in general finish the operation in less than two days, indulging in occasional rests when fatigued with her labour. At intervals, also, she takes care to protect the eggs placed in the cone with an exterior covering of the same down. There is one part of these operations not a little remarkable. In the bed which she first makes for the eggs, the hairs of the down either point at right angles to the bark of the tree, or at least are tossed down with little regularity; but in the external coping, which is designed to keep out the winter rains, the hairs are carefully placed in a sloping direction, like the tiles on a house, or the pile of a well brushed hat, pointing downwards towards the base of the cone. The latter is usually concave, because, when the moth takes her occasional rests, she never moves from the spot, but remains with her tail thrust in amongst the eggs. We have given these details from observations made in the Parc at Brussels, in August, 1829* ; and our entomological readers will perceive, that though they do not disagree with the facts observed by the accurate Réaumur, we have added several particulars not mentioned by him †.

In order to preserve some specimens of the gypsey moth, which abounds in the Netherlands, but is rare in most parts of Britain, we inclosed two or three in chip boxes. Upon opening these, a short time afterwards, we found that one of the moths had deposited a patch of eggs; but, instead of the conical form which the insect would have chosen had she been at liberty, she had disposed them in the form of a wheel, of which her body was the radius. This, of course, was not so much to be wondered at, as it no doubt arose from her want of space to proceed in the usual manner; but we deem it worthy of notice that this wheel, which was about a quarter of an inch broad in the rim, was sloped with



a, female gypsey moth, one-third the natural size, just finishing her group of eggs. *b*, female gypsey moth, with its body covered with down. *c*, circle of eggs covered with hair, and *d*, conical mound of eggs covered with hair, laid by gypsey moths in confinement.

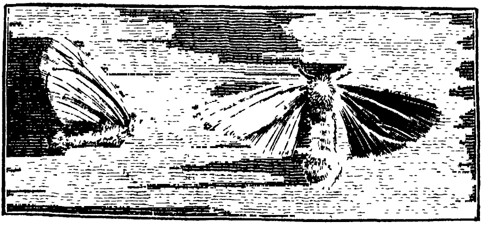
* J. R. † Réaumur, Mem. ii., 101.

the greatest regularity, after the manner of a candle shade, and the down tiled upon it all round. Another of our prisoners, though precisely in the same circumstances as to space, instead of forming a wheel, piled up her eggs in form of a circular mound ; but as the number of her eggs was not a sixth part of those of the other, (probably from her having deposited part before we caught her,) this may have induced her to vary the shape of the group. Like the others, however, the regular slope and tiling of the down was carefully preserved *. We have now (April, 1830) a numerous brood of caterpillars from these very eggs.

The eggs, which are thus deposited with so much care, are destined to abide all the pitiless pelting of the storms of winter; for, although they are laid in August, they are not hatched till the elm comes into leaf in the following spring. The covering of down, accordingly, from the manner in which it is tiled and brushed smooth by the mother moth, not only protects them from wet, but from severe cold, being one of the best non-conductors of heat. The experiments of modern chemical philosophers have proved beyond a doubt, that the warmest material for clothing is not what imparts most heat to the body, but what best prevents the escape of the heat generated there. The feeling of cold, therefore, does not, as might be supposed, arise from anything positively cold, but solely from a deficiency of heat. On putting the hand, for example, on a piece of ice, the feeling of cold does not arise from cold given out by the ice to the hand, but from the heat which the ice takes from the hand, which heat can be actually traced in the water formed by the melting of the ice. But when the hand is laid upon wool, feathers, or down, these do not feel cold, because they do not carry off the heat of the skin so rapidly as the ice.

* J. R.

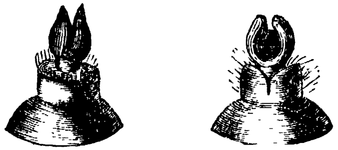
It may appear a little paradoxical, though the doctrine is sound, to assert that down and similar materials are nearly as well calculated for protecting an animal from excessive outward heat as from severe cold. This, however, has been long well known as a fact to the Neapolitan peasantry, who convey snow from Mount Vesuvius to Naples in the summer for the purposes of luxury: they preserve it from melting by covering it with chaff and wool. It may not be out of place to remark that instances of this occur among insects, precisely similar to what we have just detailed respecting the gypsey moth. The brown-tail and the golden-tail moths (*Porthesia auriflua*, and *P. Chrysorrhœa*, STEPHENS), whose caterpillars spin themselves a warm nest before the setting-in of the winter colds*, seem no less careful to protect their eggs from the summer heats of July and August, at which time they are deposited. The down with which they are furnished for this purpose grows upon the tail of the female moth, in form of a thick tuft or brush, of a shining silky gloss, and of a different colour from the short hair on the body. It may be remarked that moths have only a mouth tube for sucking honey, and



Females of the brown and gold-tailed moths, showing the bunch of down on the tails.

* See "Insect Architecture," p. 329.

no mandibles or jaws *, like bees, wasps, and beetles, for performing any mechanical labour; but the moths in question have an organ admirably contrived for covering their eggs with down. This consists of an extensile instrument, situated in the tail, not unlike the points of a pair of sugar-tongs, and intended to perform the part of tweezers in pulling off the down, and placing it upon the eggs. Having reared numerous broods of the moths alluded to, we can testify to the minute accuracy of Réaumur in detailing their proceedings. He remarks, that though the mother moth is exceedingly sluggish (*lourde*) in her general movements, she employs her tweezers with surprising quickness, on all sides, first, to pull off a pinch of down, and spread it out, and then to place the egg upon it, and cover it neatly over, and smooth the down in the proper direction. The nature of the instrument will be better understood by the following figures.

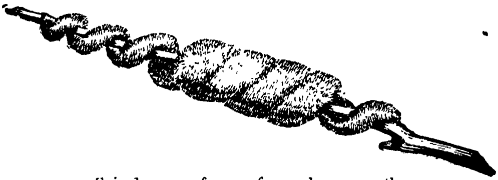


Tweezers of the brown and gold-tailed moths, magnified.

Réaumur has figured the deposition of the eggs of an insect, the species of which is not ascertained, sent him by a physician of Luçon, which are covered, like the preceding, with down, but are arranged in an elegant spiral form, as if a lady would wind one of the ends of her fur tippet spirally round a branch.

* Savigny, however, has displayed much acumen in shewing how the suckers of moths, &c., are analogous to mandibles.—*Mémoires sur les Anim. sans Verteb.*

These eggs were extremely small, and the down very fine, like the short fur of the beaver, and of a pretty squirrel-grey colour. The eggs were oblong, and placed on end, at right angles to the branch ; as was also their downy envelope, which differed in this respect from the imbricated and smoothly brushed coping of the moths above described. There is nothing of this kind, says Réaumur, which we ought to consider it difficult for an insect to execute, when we are acquainted with the admirable instruments with which nature has furnished them *.



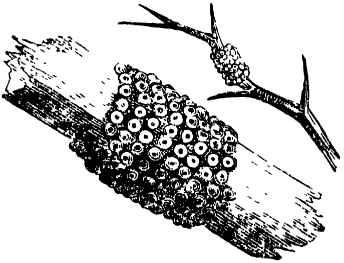
Spiral group of eggs of an unknown moth.

The spiral form of eggs deposited upon a branch may, in particular years, be seen in almost every orchard and every hedge, being the method followed by the lackey moth (*Clisiocampa neustria*, STEPHENS) and its congeners. The precise manner in which the mother lackey proceeds has not, so far as we know, been witnessed by any naturalist ; and though Réaumur reared a great number on purpose to discover it, all his efforts proved unsuccessful. An examination, however, of the arrangement of the eggs themselves, shews that they are placed in a manner excellently adapted to secure their adhesion to the branch, and to prevent their sustaining injury. The egg is somewhat of the form of a funnel-shaped wine-glass—broader at top than at bottom †; and it

* Réaumur, Mem. ii. 107.

† See two of these eggs figured in "Insect Architecture," p. 19.

is worthy of remark, that this is the precise form of the arch-stones of a bridge. They are, in fact, built together in the arched form. This, together with the strong cement employed in uniting them, renders it difficult to crush them, though considerable force be used for that purpose; and this even when they are slipped off the branch, round which they are set like pearls on a bracelet, which is the name given them by the French peasantry. The cement, also, is so hard, that when pressed it resists the nail, though it may be pierced with the point of a sharp knife; and not being soluble in water, "nor in any other liquid," says Swammerdam, "which I have tried," the heaviest rain dashes upon the eggs without injury.



Eggs of the lackey moth, wound spirally round a twig of hawthorn; natural size, and magnified.

It may be a question with some, when they compare these naked eggs of the lackey moth, exposed on a bare branch, with the warm downy covering of those of the gypsey moth, how the former are protected from the colds of winter. This is a question which previous researches cannot fully answer, but one circumstance is obvious—the lackey's eggs are many degrees harder than those of the gypsey, which may be easily crushed. Probably also, this may be connected with their electrical state; and that has always an intimate connection with heat in animated bodies. The living principle, to which we shall by and bye advert, must also be taken into account.

In consequence of the minuteness of insect eggs, notwithstanding the researches of enthusiastic entomologists, we are still unacquainted with by far the greater number. The hybernation of eggs is, therefore, a subject upon which little is known. In the egg state insect life is, perhaps, less liable to accidents, than in a more advanced stage of existence; and it is most probable that the greater number remain unhatched during the cold season. Different modes of depositing eggs are resorted to by different species of the same genus, as may be exemplified in the plant lice (*Aphides*). It was observed by De Geer, that those of the birch and the blackthorn (*Aphis Alni*, and *A. Pruni*) covered each egg individually with a white cottony down, detached from their bodies by means of their hind legs, and placed by the same means over the eggs*. But the greater number of this family lay their eggs in an exposed situation, upon the plants where the young, when hatched, may find food. Thus Kirby found the small black eggs of a large species on the buds of birch-trees; and we have just discovered (Jan. 1830) a numerous deposit of the eggs of the magpie plant-louse (*Aphis Sambuci*) on an elder tree, where the insect was abundant the preceding summer†. These eggs are exceedingly minute, but easily observed on account of their shining black colour. They are placed in an irregular patch upon a part of the trunk from which the bark has been stripped off, and are entirely unprotected.

The cochenille insects (*Coccidæ* LEACH), so called from one of the species furnishing the well-known valuable dye-stuff, protect their eggs in a still more

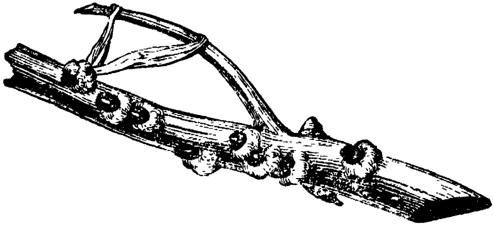
* De Geer, Mem. sur les Insectes, iii. 48, 51. † J. R.

remarkable manner. The mother deposits her eggs under her body, which becomes glued to the spot; she then dies, and her body becomes a covering for the eggs. In this state the insects appear on the bark of trees like small warts, some species in the form of a boat, some kidney-shaped, and others globular; and, before their history was understood, they were with some plausibility supposed to be vegetable galls,—whence they were termed *Gall Insects* by the French.

Though the mother insect is seldom larger than a peppercorn, the number of eggs which she lays amounts to several thousands, and in fact fills the greater portion of her body. Those which are found on our green-house plants, and which are the pest of the grape-vines in the neighbourhood of London, both in and out of doors, secrete a sort of white silky gum, very like gossamer, as the first bed of their eggs. Réaumur could not discover that the mother insect was furnished with any organ similar to those of spiders and caterpillars for spinning this gossamer; and in an allied genus (*Dorthesia*), Kirby and Spence talk of it as "wire-drawn through numerous pores in certain oval plates in the skin*." Having minutely observed, during several successive summers, some thousands of the female cocci found on vines in the open air, we have satisfied ourselves that this cottony matter is precisely similar to the gluten which envelopes the eggs of most insects; and that it is neither spun like the threads of caterpillars, or the webs of spiders, nor wire-drawn through numerous pores,—but is simply excluded along with the eggs. We may remark, also, that the covering formed by the body of the mother coccus prevents this substance from drying, as the webs of spiders do; and, consequently, it can at any time be

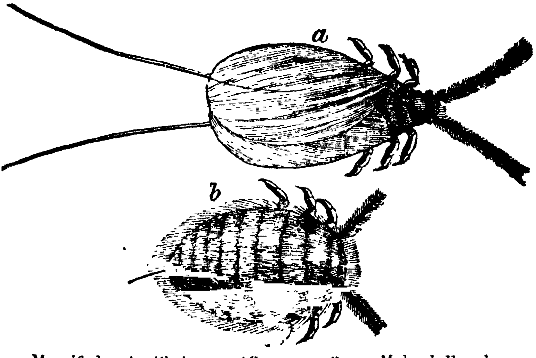
* Introd. iii., p. 183.

drawn out into extended threads, by detaching a few of the eggs from the mass.



Eggs of the Coccus covered with down, and with the bodies of the mothers,

An account, which appears to us altogether apocryphal, has been given of the migrations of the species which produces the cochenille (*Coccus Cacti*, LINN). From the females remaining stationary, it is said, their numerous progeny would not find sufficient nutriment on their native tree; and they are, at the same time, so delicate, that they could not travel along the ground from one plant to another;



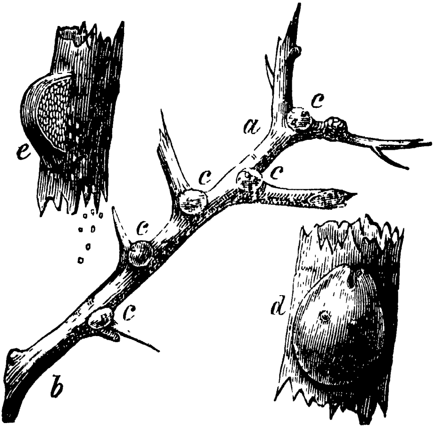
Magnified cochenille insects, (*Coccus cacti*). *a*, Male. *b*, Female.

but nature, it is alleged, provides for them admirable means of emigration, since, at the period of their birth, a multitude of spiders fasten their nets to the leaves of the nopal, and along these, which serve them for bridges, the young cocci emigrate to the adjacent trees *. We have little doubt that this story has originated in the inaccurate observations of some fanciful traveller, who mistook the threads accidentally drawn out from the mass of eggs, for those of a spider.

The gossamer envelope, however, which we have just described as covering the eggs of the coccus that is common on our British vines, is not intended as a defence against the cold of winter; for this species hybernates, according to Réaumur, in the larva state, though we have frequently searched for these larvæ in vain during winter, on vines where they swarmed in myriads during summer. But the British species of coccus of the hawthorn, &c., on account of which we introduced the subject here, assuredly hybernates in the egg state; and may be seen at the off-goings of the branchlets in an oval form, like that of a minute wood-louse (*Oniscus*), of a silvery grey colour, differing, indeed, but little from the tint of the bark. On raising up with the point of a penknife what appeared to be the body of the insect, we found that it was hard, dry, and dead,—the mere skin, in a word, of the mother coccus, while underneath was a multitude of eggs of a deep orange colour. It is worthy of notice, also, that there is, then, no envelope of gossamer, though there is mixed up with the eggs a small quantity of a greyish white powder, which, we are inclined to conjecture, may be the dried remains of it; and, the more so, that Réaumur figures the gossamer as abundant in the coccus of the hawthorn. Unfortunately he has not

* St. Pierre, Studies of Nature, vol. i.

mentioned at what season he procured these, and we have no means of ascertaining whether our species is the same with his*.



a b c, Eggs of the hawthorn coccus, covered by the body of the dead mother. *d*, one of those magnified. *e*, a section, shewing the eggs within.

We have found the eggs just mentioned most abundant on the hawthorn in the hedges around London; but as the size, the colours, and the forms of the crust are very different, there can be no doubt of there being different species even on the same tree. "In July, 1812," says Kirby, "I saw a currant-bush miserably ravaged by a species of coccus very much resembling the coccus of the vine. The eggs were of a beautiful pink, and enveloped in a large mass of cotton-like web, which could be drawn out to a considerable length †." From the manner in which this justly popular author speaks, it would appear he had not elsewhere met with this coccus; but

* J. R. † Intr. i. 197.

it is by no means of rare occurrence, and may be found on most currant-bushes, and often on hawthorns, &c. around London. The envelope of the eggs is of a chestnut-brown colour.

A much more singular species occurs in company with the preceding, and abounds on the currant-bushes at Lee. From their resemblance to the form of one of the valves of a mussel-shell, Réaumur named this species *en coquille* (*Coccus conchiformis*, Gmelin). He says, it imposed upon him for several years, as he supposed it to be the cocoon of some minute insect about to go into the pupa state; but he was undeceived by finding them full of eggs. We were more disposed, at first, to look upon them as a subcortical fungus (such as *Cucurbitaria Berberidis*, Grev. or *Cryptosphæria Pteridis*, Sowerb.), for, during the winter, when we first observed them, they appeared exactly like a little slip of the bark elevated by the growth of a fungus below it. Then they were so crowded on some branches, that not a hair's breadth of the bark remained uncovered. When, however, we found these minute bark-like scales full of eggs, we were inclined to conjecture that they had been deposited by saw-flies cutting into the bark; but this was instantly disproved by removing them, and finding the bark below sound and uncut. Réaumur put the matter beyond dispute by actually hatching the eggs, when insects were produced similar to other cocci. But our species, found on the currant-bush, seems to differ from his of the elm, not in form and colour, but in habit, being gregarious, while his was subsolitary *.

During the severe frost of 1829-30, we observed several small birds, such as the long-tailed titmouse (*Parus caudatus*), and the gold-crested wren (*Regu-*

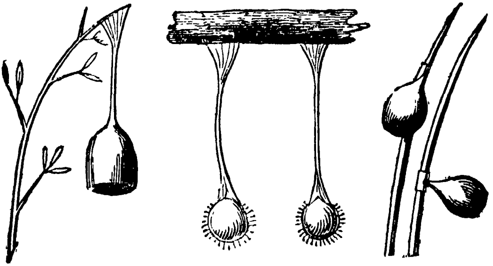
* J. R.

lus cristàtus, RAY), busily pecking the eggs of the cocci in the hedges *.

The resemblance of these singular insects to the wood-louse (*Oniscus*), which is not properly an insect, but a crustaceous animal, may be traced farther than mere external appearance; for the body of the mother, in the latter, also becomes a covering for the egg, though she does not die immediately after laying as the coccus does, but carries her eggs under her breast in small four-valved cells.

One of the most easily discovered depositions of eggs during the winter months are those made by various species of spiders, particularly that of the large garden-spider (*Epeira diadema*), which may be found in the angles of walls, in form of a ball, about the size of a cherry, of beautiful yellow silk, and much stronger than the common materials of the same spider's geometric web. This substance Réaumur endeavoured to bring into use as a substitute for silk; but he was unsuccessful in procuring it in quantity, owing to the ferocious habits of the spiders, which devoured one another when he reared them gregariously. As the eggs of spiders have usually a thin soft shell, a thick warm envelope of silk is, no doubt, essential to their weathering the colds of winter, notwithstanding the sheltered corners where they are usually placed. Some species weave these little silken nests in a very elegant form. We possess one of the pyriform shape of a balloon, the texture of which is close and netted with diagonal meshes. One, somewhat in form of a drinking-glass, is figured in Loudon's Magazine of Natural History, as having been found near Wandsworth, attached to the stem of a rush growing in water.

There was a deposition of eggs at the bottom, the rest of the space being vacant. De Geer describes similar spiders' nests attached to the stems of grass*; and we once found a large one of an elongated shape, and composed of very white silk, on a spike of grass at Compton-Basset, Wiltshire†.



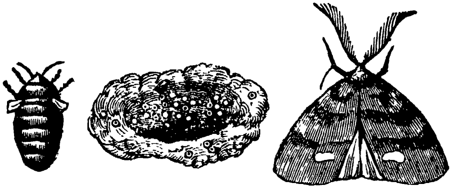
Spiders' nests.

The vapourer (*Orgyia antiqua*, OCHSENH.), a common moth, takes advantage of the warm silken envelope of the pupa-case, from which she has escaped a few days before, to form a bed for her eggs. In our earlier studies of insect economy we were inclined to ascribe to accident the deposition of the eggs in this particular situation, but we have found so many instances of it as to reject the explanation. Swammerdam also observes, that "this custom of fastening the eggs to the web in a constant method, and by the immutable law of nature, is so peculiar to this species of insects, that I have never observed it in any other kind whatsoever. This female," he subjoins, "like a most prudent housewife, never leaves her habitation, but is always fixing her eggs to the surface of the web out of which she has herself crept, thus affording a beautiful instance of industrious housewifery‡." One

* De Geer, Mem., vol. vii. pp. 227—9. † J. R.

‡ Swammerdam, pt. ii. page 7.

reason for this is, that the female of this moth having only the rudiments of wings, a peculiarity remarkable in several other moths, she cannot shift so readily about. But whatever may be the real cause, there can be no doubt that the web serves to keep the eggs warm during winter; for though they are placed on the outside of the web, the whole is usually under some projection of a wall or arm of a tree, and the non-conducting property of the silk, both with regard to heat and electricity, must be of great benefit to the eggs in preserving them in an equable temperature, and of course promoting their early hatching.



Vapourer Moth (*Orgyia antiqua*), male and female, the latter without wings; with the eggs laid upon the silken cocoon from which the mother has issued.

We cannot better conclude these imperfect sketches of the hybernation of insect eggs, than by an account of the ingenious experiments made by Spallanzani and John Hunter, by exposing several species of these to great degrees of cold as well as of heat. It results from these experiments that "intense cold," to use the words of Spallanzani, "does not destroy the eggs of insects. The year 1709, when Fahrenheit's thermometer fell to 1°, is celebrated for its rigour and its fatal effects on plants and animals. Who can believe, exclaims Boerhaave, that the severity of this winter did not destroy the eggs of insects, especially those exposed to its influence in the open fields, on the naked earth, or on the branches of trees? Yet, when the spring had tempered the air, these eggs produced as they usually did after the mildest winters. Since that period there have been winters more severe. In France, during December, 1788, the thermometer fell considerably lower, and in several other temperate European climates.

"I have exposed eggs to a more rigorous trial than the winter of 1709. Those of several insects, and among others the silk-worm, moth, and elm butterfly (*Vanessa polychloros?*) were inclosed in a glass vessel and buried five hours in a mixture of ice and sal gem (*rock salt*); the thermometer fell 6° below zero. In the middle of the following spring, however, caterpillars came from all the eggs, and at the same time as from those that had suffered no cold. In the following year, I submitted them to an experiment still more hazardous. A mixture of ice and sal gem with the fuming spirit of nitre (*Nitrate of Ammonia*), reduced the thermometer 22° below zero, that is 23° lower than the cold of 1709. They were not injured, as I had evident proof by their being hatched.

"Combining all these facts, we conclude that cold is less noxious to germs and eggs, than to animalcula and insects. Germs in general can support 2° below zero; whereas of animalcula some die at the freezing point, and some at about 20°. The eggs of many insects continue fertile after being subjected to a temperature of 22° below zero, while insects themselves die at 16° and 14°. This I have ascertained in the eggs of the silk-worm moth and of the elm butterfly; and although there are caterpillars and chrysalides able to resist great cold, I have uniformly found it to be in a less degree than what can be resisted by their eggs. What can be the cause of so great a difference? Insects killed at 16° and 14°

are so penetrated and frozen by the cold, that their members do not yield to the pressure of the finger, and seem perfect ice under the knife. This does not happen to eggs, though subjected to cold of much greater intensity. Their contents remain fluid, even at the greatest cold, as may be seen by crushing them with the nail. Perhaps this is derived from constituent spirituous or oleaginous parts, or from some principle adapted to abate the power of cold*. If eggs do not freeze, it is probable the included embryos do not freeze. Is there anything wonderful, therefore, that they then survive cold which is fatal to them when produced? Probably for the same reason (and I see no objection that can apply), animalcula, concentrated in the germ, can support a degree of cold they are incapable of when developed.

"As the temperature of freezing still retains a portion of heat, why, it may be asked, should it not develope the germs of the most minute animalcula? Had we never seen any eggs hatched but those of birds, which require 104°, we should have concluded that all others require the same. A little initiation into the study of minute animals teaches how many kinds produce at a temperature infinitely less. Such are the eggs of butterflies and many other insects, of frogs, lizards, tortoises, down to some, as those of toads, which I have seen produce at 45°. If these eggs hatch at 59° less than is required by those of birds, what repugnance will there be to suppose that at 13° less, or the freezing point, the eggs of other animals may be hatched? Nor should it surprise me to be told of animals whose eggs would produce at much greater cold, after knowing that there are plants, beings so similar to animals, and many of them,

* In plain language, Spallanzani did not know what to make of the facts.

which amidst the rigours of winter flourish and fructify*."

It is remarked by John Hunter that an egg will freeze by a great degree of cold; at the same time there seems to be a living principle which enables it to support cold without destruction, and when once that principle is destroyed, cold more easily operates. An egg was thus frozen by the cold of zero; after thawing and again exposing it to the same degree of cold, it froze seven minutes and a half sooner. A new-laid egg took an hour to freeze in 15° and 17°, but when thawed, it froze at 25° in half the time†.

The principle of vitality, therefore, whatever may be the cause, is evidently less easily destroyed in the egg state than in the perfect animal; and therefore the inference that a rigorous winter promises a diminution of insects in the summer succeeding commonly proves erroneous. On the contrary, recorded facts prove that they are sometimes even more abundant than usual after severe frosts. During the present spring of 1830, accordingly, notwithstanding the severe frosts of the preceding winter, we have observed a much greater number of insects, even of the smaller and more delicate kinds (*Aleyrodes*, *Corethra*, *Alucita*, &c.) as well as of larvæ, both those just hatched, and those which have lived through the winter, than last year, when the frost was not so severe. We were particularly struck with the larvæ of some small tipula (*Boletophila?*), which we found in abundance in Birch Wood, Kent, feeding on a fungus (*Boletus fomentarius*, FRIES), and which were so beautifully transparent and soft, that we could not understand how they had escaped being frozen. It is not a little remarkable, in connexion with this, that the

* Spallanzani's Tracts, transl. by Dalyell, vol. i. p. 63.
† Hunter on the Animal Economy.

migratory birds seem to have been aware of this abundance of insects by their appearing earlier than usual. We saw a pair of nightingales at Greenhithe on the 21st of March, and a number of swallows the same week at Lee,—which is two or three weeks before their average time*.

* J. R.

Chapter V.

Hatching of Insect Eggs.

The contents of an egg principally consist of nutriment adapted to the different parts of the germ which it contains—the yolk for nourishing the soft parts; the white, for the blood and other fluids; and the shell, for the bones. In the case of insects, as well as of birds, fishes, and reptiles, the embryo is placed in the most advantageous position for partaking of the repast,—namely, in a particular corner where it may breathe fresh air always communicated to the chamber of the egg by ventilatory passages in the shell; if these be shut up, by covering the egg with grease, varnish, or chalk, it is suffocated and dies. In the case of birds, according to Malpighi and the older physiologists*, the rudiment of the chick, while still a minute point, is lodged on the film that envelopes the yolk, near the centre of the egg; and,—as the floating wick of a mariner's lamp is constantly preserved upon a level with the surface by the mobility of the slings and the weight of the oil-vessel tending downwards, however the ship move,—there is an ingenious natural mechanism, which prevents the embryo chick from being upset when the egg is stirred. The yolk is sustained by two membranous ribbons, visible at the aperture of the egg, and fastening it on each side to the common membrane glued to the shell. These suspensory bands being fixed above the centre of the

* Malpighi, de Ovo incubato; Leeuwenhoeck, Epist. phys. xl.; and Harvey, in Willoughby's Ornithol. c. iii.

yolk, of course the more weighty part always descends, in every position of the egg, as far as they will permit, and the chick being thence prevented from sliding down, nourishes itself in security.

We cannot, on account of their minuteness, ascertain whether there is any similar mechanical contrivance in the eggs of insects; but we have in several instances distinctly observed the speck where the embryo insect was placed just within the shell of the egg. In order to stimulate it to feast and fatten on the good things stored up in his egg-shell chamber, it appears that a certain degree of heat is indispensably requisite; for cold, though it does not usually, as we have seen, kill the embryo, almost always renders it torpid. But the stimulus of heat produces activity in the living principle, causes the embryo to devour all the nutritive contents of the egg, and thence to increase proportionably in size. It is worthy of remark, however, that the stimulus of light, contrary to that of heat, acts unfavourably upon the hatching of eggs. Both of these positions may be illustrated by numerous facts and experiments.

Most birds, so far as has been ascertained, supply the heat necessary for hatching their eggs by sitting constantly upon them during a certain number of days; but reptiles, such as the crocodile, bury their eggs in the warm sand upon the banks of rivers. Insects, again, seldom, if ever, sit upon their eggs, as birds do, in order to hatch them. This, indeed, would be impossible, as the greater number of insects die in a few days after depositing their eggs, the continuation of the species being apparently their only business in their last or perfect stage; since, as they then generally cease to feed, they cannot possibly live long. A few instances, however, have been observed, of insects performing something very similar to the incubation of birds, though we have the high authority of Fabricius, that "insects never sit upon their eggs *."

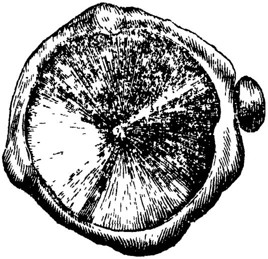
Upon the incontestable statements of two distinguished observers of insects, Frisch † and De Geer, the female of the common earwig (*Forficula auricularia*, Linn.) sits upon her eggs. This circumstance, however, seems to have escaped the notice of other naturalists, though her attentions to her young ones is often witnessed. De Geer discovered a female earwig in the beginning of April under some stones, and brooding over a number of eggs, of whose safety she appeared to be not a little jealous. In order to study her proceedings the better, he placed her in a nurse-box filled with fresh earth, and scattered the eggs in it at random. She was not long, however, in collecting them with all care into one spot, carrying them one by one in her mandibles, and placing herself over them. She never left them for a moment, sitting as assiduously as a bird does while hatching. In about five or six weeks the grubs were hatched, and were then of a whitish colour ‡. At another time, in the beginning of June, De Geer found under a stone a female earwig accompanied with a numerous brood of young, to all appearance newly hatched, and nestling under their mother like chickens under a hen. These he likewise placed in a nurse-box with fresh earth; but instead of burrowing into the mould, as he had expected, they crowded under the bosom and between the legs of their mother, who remained quiet and evidently pleased, suffering them to continue there for an hour or more at a time. He fed both this brood and the one first mentioned with bits of ripe apple; and perceived that

* Fabricius, Philosoph. Entomol. lxxvi.

† Insecten in Deutschland, 4to. 1766.

‡ De Geer, Mem., vol. iii. p. 548.

they grew from day to day, and cast their skins, as caterpillars do, more than once. The mother did not live long, probably in consequence of confinement; and her progeny devoured nearly the whole of her body, as they also did the bodies of their brethren, when any of these chanced to die. We may remark, in passing, that it is an unfounded popular prejudice that earwigs get into the brain by creeping into the ear; for though, from being night insects, and disliking exposure to the light, they may, by chance, attempt to take shelter in the ear, the disagreeable odour of the wax will soon drive them out: at all events they could never get farther than the drum, which completely shuts the passage to the brain. We have known, indeed, a small beetle, get into the ear; but it did no further injury than produce a strange tingling sensation by crawling about the drum, and soon made its exit*. A little red insect (the harvest-bug?) sometimes gets into the ear in bed, and produces wonderful commotion, but no real injury.



Drum of the ear, shewing that there is no passage through it to the brain.

Kirby and Spence are inclined to infer that a tree bug (*Acanthosoma grisea*, STEPHENS) may also sit

* J. R.

upon its eggs *, because De Geer found a mother of this species surrounded with a brood of thirty or forty young ones following her as chickens follow a hen. She never leaves her family; but as soon as she moves, all the young ones closely follow, and assemble around her in a cluster wherever she makes a halt. De Geer once cut a branch of birch, upon which a family of these bugs had assembled, and the mother shewed every symptom of fear and distress. Had she not had a family to protect, she would have taken immediate flight; but instead of this, she kept beating her wings rapidly and incessantly, and never stirred from her young. But even all this, affectionately maternal as it must be considered, is far from authorizing the conclusion that she sits upon her eggs; though it is certain she must remain near them till they are hatched, unless she belong to those mentioned by Busch as ovo-viviparous †.

One of the most common instances of something similar to birds hatching their eggs occurs in several species of spiders, which may be seen sitting near or upon the silken bag in which they have inclosed their eggs. Many of these mothers, however, die before their young are hatched,—all of them, perhaps, when the eggs are laid late in autumn. During the winter of 1829-30, we watched a considerable number of the geometric spiders (*Epeiræ*) brooding over their eggs for several weeks; but though the weather before Christmas was little more than an average degree of coldness, every one of them died, some living a longer time, and others a shorter ‡. But this is not the case with a very common wandering spider called by Dr. Lister the wolf (*Lycosa saccata*, LATR.), and first observed, we believe, by the celebrated Harvey §. "In order," says Swammerdam, "to

* Intro. i. 358, and iii. 101.

† Schneider, Europäische Schmetterlinge, i. 206. ‡ J. R.

§ Harvey, De Generatione.

hatch her eggs the better, she carries them about as it were in a case, with wonderful solicitude and affection; insomuch, that when the skin forming this case, which hangs to the hinder part of her body, is by any accident broken off, the little insect seeks after it with as much earnestness and industry as a hen for her lost chickens, and when found fastens it again to its place with the greatest marks of joy *."

Bonnet has given a more detailed account of the manners of this spider, which, though no less fierce and ferocious in aspect than her congeners, manifests an extraordinary change of mien when forcibly deprived of her eggs. Then she instantly appears tame, stops to look around her, and begins to walk at a slow pace, and search on every side for what she has lost, nor will she even fly when one threatens to seize her. But should the experimenter, moved with compassion, restore her bag of eggs, she catches it up with all haste, and darts away in a moment; or, when left undisturbed, will leisurely attach it again to her body.

"With a view," continues Bonnet, "to put this singular attachment to a novel test, I one day threw a spider with her eggs into the pit-fall of an ant-lion (*Myrmelion formicarium*) †. The spider endeavoured to escape, and was eagerly remounting the side of the pit, when I again tumbled her to the bottom, and the ant-lion, more nimble than the first time, seized the bag of eggs with its mandibles, and attempted to drag it under the sand. The spider, on the other hand, made the most strenuous efforts to keep her hold, and struggled hard to defeat the aim of the concealed depredator; but the gum which fastened her bag, not being calculated to withstand such violence, at length gave way, and the ant-lion

* Book of Nature, pt. i. p. 24.

† See Insect Architecture, p. 209.

was about to carry off the prize in triumph. The spider, however, instantly regained it with her mandibles, and redoubled her endeavours to snatch the bag from her enemy; but her efforts were vain, for the ant-lion, being the stronger, succeeded in dragging it under the sand. The unfortunate mother, now robbed of her eggs, might have at least saved her own life, as she could easily have escaped out of the pit-fall; but, wonderful to tell, she chose rather to be buried alive along with her eggs. As the sand concealed from my view what was passing below, I laid hold of the spider, leaving the bag in the power of the ant-lion. But the affectionate mother, deprived of her bag, would not quit the spot where she had lost them, though I repeatedly pushed her with a twig. Life itself seemed to have become a burden to her since all her hopes and pleasures were gone for ever*."

That some portion of heat may be communicated to the eggs of the spider, which are thus carried so assiduously under her body, is highly probable; and it is also, no doubt, advantageous to the young, when hatched, to have the assistance of their mother to open the bag for them, as was remarked by De Geer†; "without which," say Kirby and Spence, "they could never escape‡." But that neither of these are indispensable conditions we have ascertained by repeated experiments. We have taken a considerable number of these egg-bags from their mothers, and put them under inverted wine-glasses and into pill-boxes, and in every instance the young have been duly hatched, and made their way *without* assistance out of the bag. In all these experiments, the young spiders joined in concert in making a web across their prison; a circumstance at variance with the assertion,

* Bonnet, Œuvres, vol. ii. p. 435.

† De Geer, Mem. vol. vii. p. 194. ‡ Introd. i. p. 361.

copied from Lister into most subsequent works on natural history, that this species never spins a web. They might not indeed have done so if they had been left at liberty*.

A spider of the same species, which Bonnet kept under an inverted glass, at first was so exceedingly attached to her bag of eggs, that he could not beat her away from it after it was detached. "By and bye," he continues, "I observed with surprise that she had abandoned and kept aloof from the very bag which she had previously defended with so much courage and address; and I marvelled still more to see her run away from it when I placed it near her. I remarked at the same time that she had become less agile, seemingly in consequence of sickness. By more close observation, I discovered that several of the young ones were hatched, and their numbers increased by degrees, while all ran towards their mother and climbed upon her body. Some placed themselves on her back, some on her head, and some on her limbs, so that she was literally covered with them, and appeared to bend under the weight, not so much from being over-loaded, as from her feeble condition; and indeed she soon afterwards died. The young spiders remained in a group upon the body of their mother, which they did not abandon for some time, and for the purpose, as I was half inclined (pardon the odious supposition) to think, of sucking the juices of her body†."

In order to prove whether a spider of this species could distinguish her own egg-bag from that of a stranger, we interchanged the bags of two individuals, which we had put under inverted wine-glasses; but both manifested great uneasiness, and would not touch the strange bags. We then introduced one of the mothers into the glass containing her eggs and

* J. R.

† Bonnet, Œuvres, vol. ii. p. 440.

the other spider; but even then she did not take to them, which we attributed to the presence of the other, as all spiders nourish mutual enmity. Upon removing the stranger, however, she shewed the same indifference to her eggs as before, and we concluded that, after having lost sight of them for a short time, she was no longer able to recognize them*.

A more extraordinary method of hatching eggs occurs in several insects, thence termed ovo-viviparous, which retain the eggs within their bodies till they are hatched; and in this way they appear, like larger animals, to produce young instead of eggs. We do not here allude to the cochenille insects formerly mentioned; for though these cover their eggs with their bodies, it is after they are laid and imbedded in gossamer. Neither can these singular insects be properly said to sit upon their eggs, inasmuch as the mother always dies when she has finished laying.

The guffer (*Blennius ovo-viviparus*, LACEPEDE), a British sea-fish, common under stones at low-water mark, affords an instance of this singular mode of the eggs being hatched in the body of the mother; and it is remarkable that when the young are ready to appear, she leaves her usual haunts on the coast, and goes farther out to sea, that they may be out of the reach of their natural enemies†. Our common viper (*Coluber berus*, LINN.) is also ovo-viviparous, as are several other reptiles; though it is an exception to the general rule in this class. We caught a female of the nimble lizard (*Lacerta agilis*, LINN.) on a heath near Sorn, Ayrshire, in July, and kept it for some time under a glass, where it produced six young ones; but in consequence of improper food, or of confinement, they all soon died‡. This lizard is said to be sometimes oviparous. The observations also of the elder

* J. R. † Lacepède, Poissons, ii. p. 497. ‡ J. R.

naturalists with respect to the scorpion's being ovo-viviparous, have been recently verified by Leon Dufour*, a living French naturalist, distinguished for acuteness and accuracy.

In the case of insects, it was first discovered by Redi, the father of experimental entomology, that, though the greater number of flies lay eggs, some also bring forth their young alive; and he was thence led to put the question, whether such flies, under different circumstances of temperature, do not sometimes produce young, and at other times deposit eggs†. He might as well, says Réaumur, have asked whether, in certain circumstances, a hen, instead of laying eggs, should bring forth chickens. The fact, on the contrary, has been ascertained by Réaumur, and recently confirmed by Dufour‡, that the ovo-viviparous insects are furnished with an abdominal pouch, in which the eggs are deposited by the mother previous to their being hatched. In this respect they afford a striking analogy with the kangaroo, the opossum, and other marsupial quadrupeds, which are furnished with a similar pouch for protecting their young in the first stage of their existence. One of our most common flies exemplifies this.

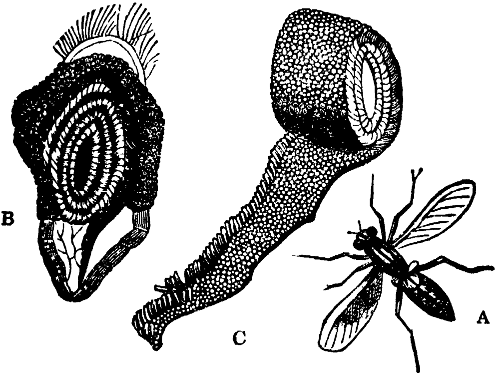
It may not have occurred to many of our readers that there are more sorts than one of the large flies usually ca. ed blow-flies and flesh flies. One of these, distinguishe‹ by its brilliant shining green colour and black legs (*Musca Cæsar*, LINN.), we have adverted to§ in recounting the experiments of Redi; another, frequently called the blue-bottle (*Musca vomitoria*, LINN.), is easily distinguished by the abdomen being of a shining blue, the shoulders black, and the forehead fox-coloured. The insect, however, to which we wish to call attention at present, though nearly the size of the

* Nouv. Dict. d'Hist. Nat., xxx. 426.

† Redi, Esperienze intorno alla Gen. degl' Insetti, 4to. 1668.

‡ Annales des Sciences Naturelles. § Page 3.

blue-bottle, rather longer and more slender, and black, with lighter stripes on the shoulders, is not blue in the abdomen, but greyish black, and all over chequered with squares of a lighter colour. This chequered blow-fly (*Sarcophaga carnaria*, MEIGEN) does not even belong to the same genus as the preceding, and differs from it in the remarkable circumstance of hatching its eggs in an abdominal pouch, and instead of eggs depositing maggots upon dead carcasses. The eggs of all the flesh flies are in sultry weather hatched with great rapidity; but in the case of the chequered blow-fly, nature has provided the means of still more rapid destruction for removing the offensive parts of carcasses. The arrangement of the numerous minute larvæ in the pouch is very remarkable, and resembles the coil of a watch-spring, or a roll of ribbon. Réaumur had the patience and perseverance to uncoil this multitudinous assemblage of flies in embryo, and found it about two inches and a half in length, though the body of the mother-fly herself was only about one-



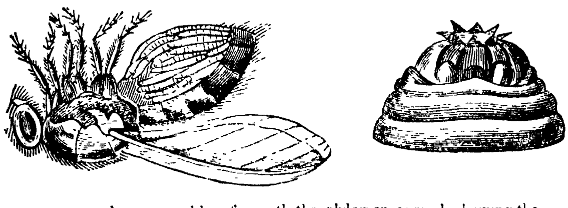
A, the chequered blow-fly. B, the abdomen of the chequered blow fly, opened and magnified, shewing the coil of young larvæ. C, the coil of larvæ partly unwound.

third of an inch, and he computed that there were about 20,000 young in the coil*. When this extraordinary fecundity is considered, we need not wonder at the countless swarms which appear as if by magic upon a joint of meat during hot weather.

Like most female insects, the mother-fly dies in a few days after giving birth to her numerous brood; but, unlike the oviparous flies, she seems to take a considerable time to deposit the whole. It would be impossible indeed for her pouch to contain the larvæ if they were all hatched at the same time; and therefore it has been so ordered by Providence that they should arrive at maturity in succession. From the early death of the mother, Réaumur conjectured that they did not scruple to eat their way through her bowels; but he disproved his supposition by a most decisive experiment. He took a fly which had already deposited a few larvæ, and closed the natural opening of the pouch with sealing-wax, so that it was impossible any more could make their exit there. The mother lived several days longer than she would have done, had she been left at liberty to produce her young; but not one of them attempted to force a passage, after being shut up for ten days.

Another large grey fly with brick-red eyes (species

A B



A, large grey blow fly, with the abdomen opened, shewing the young maggots. B, breathing apparatus of the maggot of a large grey blow-fly.

* Réaumur, Mem. iv. 417.

not ascertained) was discovered by Réaumur to be ovo-viviparous; but the embryo flies were not arranged in the pouch in the same spiral form as the preceding, but longitudinally. These did not appear to be quite so numerous; and they had a peculiar breathing apparatus, which, when shut, as it could be at pleasure, appeared in the form of a crown.

Amongst several other ovo-viviparous flies discovered by Réaumur, there was a very minute tipulidan gnat (species not ascertained) with a jet-black body, white wings, and beaded antennæ, not larger than the head of an ordinary pin, which was bred in great numbers from some cows' dung put into one of his nurse-boxes for another purpose. He justly remarks upon this circumstance, that "the minute and the grand are nothing, or rather are the same, to the Author of nature."

The numerous genus *Aphis* presents the singular anomaly of producing eggs in the autumn and living young during summer, and, as Curtis tells us, even during winter in green-houses. De Geer, however, ascertained that it was not the *same individual* aphides which at one season produced young and at another eggs, but *different generations**. By a series of very careful and troublesome experiments Bonnet also ascertained the curious fact, that in three months nine generations of these insects may be produced in succession, though the males be rigorously excluded from the nurse-boxes where the females are isolated. In fact all the aphides produced in spring from the eggs laid in autumn appear to be females; and no males are produced till the end of summer, a short time before the eggs are deposited for winter. Among both males and females are some with and some without wings,—the nature of which distinction does not appear to be yet ascertained.

* De Geer, Mem. des Insectes, iii. 70.

Bonnet, however, whose opinion is entitled to considerable authority, seems to think that the eggs of aphides which are destined to survive the winter are very different from other eggs; and he supposes that the insect, in a state nearly perfect, quits the body of its mother in that covering which shelters it from the cold in winter, and that it is not, as other germs are in the egg, surrounded by food, by means of which it is developed and supported. It is nothing more, he conjectures, than an asylum of which the aphides appearing at another season have no need; and it is for this reason that some are produced naked and others enveloped in a covering. If this be correct, the mothers are not then truly oviparous, even in autumn, when they deposit these pseudo-eggs; since their young are almost as perfect as they ever will be, in the asylum in which they are naturally placed at birth. It was in vain that Bonnet endeavoured to preserve eggs of this sort in his chamber till spring, in consequence, he imagines, of the want of a certain degree of moisture which they would have had out of doors. We have been more successful, through the precaution of not taking the eggs from their native tree till February, and in 1830 we had a brood of several hundreds produced of the oak aphis (*Aphis Quercus*)*.

The failure on the part of Bonnet leads us to remark, with the younger Huber, that ants are more skilful in this respect than naturalists, and anxiously nurse, during winter, the eggs of aphides, which they collect with great care in the autumn. The interesting narrative of the discovery of this we shall give in Huber's own words.

"One day in November," says he, "anxious to know if the yellow ants (*Formica flava*) began to bury themselves in their subterranean chambers, I destroyed, with care, one of their habitations, story by

* J. R.

story. I had not advanced far in this attempt, when I discovered an apartment containing an assemblage of little eggs, which were for the most part of the colour of ebony. Several ants surrounded and appeared to take great care of them, and endeavoured, as quickly as possible, to convey them from my sight. I seized upon this chamber, its inhabitants, and the treasure it contained.

"The ants did not abandon these eggs to make their escape; a stronger instinct retained them: they hastened to conceal them under the small dwelling which I held in my hand, and when I reached home, I drew them from it, to observe them more attentively. Viewed with a microscope, they appeared nearly of the form of ants' eggs, but their colour was entirely different; the greater part were black; others were of a cloudy yellow. I found them in several ant-hills, and obtained them of different degrees in shade; they were not all black and yellow; some were brown, of a slight and also of a brilliant red and white; others were of a colour less distinct, as straw colour, greyish, and I remarked that they were not the same colour at both extremities.

"To observe them more closely, I placed them in the corner of a box faced with glass; they were collected in a heap like the eggs of ants; their guardians seemed to value them highly; after having visited them, they placed one part in the earth, but I witnessed the attention they bestowed upon the rest; they approached them, slightly separating their mandibles; passed their tongue between each, extended them, then walked alternately over them, depositing, I believe, a liquid substance as they proceeded. They appeared to treat them exactly as if they were eggs of their own species; they touched them with their antennæ, and frequently carried them in their mouths; they did not quit these eggs a single instant; they took them up, turned them, and after having surveyed them with affectionate regard, conveyed them with extreme tenderness to the little chamber of earth I had placed at their disposal. They were not, however, the eggs of ants; we know that these are extremely white, becoming transparent as they increase in age, but never acquire a colour essentially different. I was, for a long time, unacquainted with the origin of those of which I have just spoken, and by chance discovered they contained little aphides; but it was not these individual eggs I saw them quit; it was other eggs which were a little larger, found in the nests of yellow ants, and of a particular species. On opening an ant-hill, I discovered several chambers containing a great number of brown eggs, of which the ants were extremely jealous, carrying them with the utmost expedition to the bottom of the nest, disputing and contending for them with a zeal which left me no doubt of the strong attachment with which they regard them.

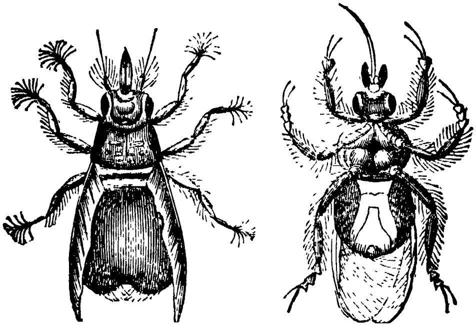
" Desirous of conciliating their interests, as well as my own, I took the ants and their treasure, and placed them in such a manner that I might easily observe them. These eggs were never abandoned. The ants took the same care of them as the former. The following day I saw one of these eggs open, and an aphis fully formed, having a large trunk, quit it. I knew it to be a puceron of the oak: the others were disclosed a few days after, and the greater number in my presence. They set immediately about sucking the juice from some branches of the tree I gave them, and the ants now found, within their reach, a recompense for their care and attention. The ant-hill whence these eggs had been taken was situated at the foot of an oak, which readily accounts for their existence in that place. I discovered them in the spring; the pucerons which quitted them were very large for insects just born, but they had not yet obtained their full size*."

It is not, however, the aphides themselves who select the snug winter retreat of an ant-hill, or who know how to secure the careful nursing of the ants. All this is the sole concern of the latter, to secure for themselves a supply of the honey-dew, as it is erroneously called, secreted by the aphides in spring. The ants, it may be proper to remark, take similar care of their own eggs (as well as of their cocoons, popularly supposed to be their eggs), as was remarked by Sir E. King, in the reign of Charles II. He informs us that they diligently gather together in a heap their true eggs, which are small and white like the granules of lump sugar, and upon these eggs they lie in multitudes, "I suppose," says Derham, "by way of incubation†." "I have observed," adds Sir E. King, "in summer, that in the morning they bring up those of their young called ant-eggs (*cocoons*) towards the top of the bank, so that you may, from ten o'clock till five or six in the afternoon, find them near the top,— for the most part on the south side. But towards seven or eight at night, if it be cool, or likely to rain, you may dig a foot deep before you can find them‡."

An interesting family of two-winged flies (*Hippoboscidæ*, LEACH) resemble the aphides in some points of their economy, though in others they are singularly peculiar. Réaumur discovered, what has been recently confirmed by Dufour and others, that the mothers not only hatch their eggs within the body, but retain them there till they are changed into chrysalides. Réaumur gives a lively narrative of his discovery, and the solicitude of his servants to find him female flies ready to deposit what he at first took for

* M. P. Huber on Ants, p. 245.
† Derham, Phys. Theol. ii. 207. 11th ed.
‡ Phil. Trans. No. xxiii.

eggs. He was so anxious to hatch those supposed eggs that he carried them in his pocket by day and took them to bed with him at night, (as Bonnet afterwards did with the eggs of aphides,) for several weeks successively; but instead of grubs, as he had expected, perfect flies were evolved exactly similar to their parents. He calls them spider flies, from their resemblance to spiders; and in some parts of France the species which infests horses (*Hippobosca equina*) is called the Spaniard or Breton: in England it is too well known under the name of the forest fly.



Spider flies (*Hippoboscidæ*, Leach.)

We have the more willingly introduced this subject here, that another fly (*Craterina Hirundinis*, Olfers), of the same family, has the instinct to deposit its egg-like cocoons in the warm feathery nest of swallows, where they have all the necessary heat which Réaumur, in his experiments, was so careful to maintain. In return for the warmth which the young has thus received, the perfect fly, during its brief existence, lives by sucking the blood of the swallows, as the one first mentioned sucks the blood of horses, horned cattle, and, it is also said, of man.

The effect of heat upon the eggs of insects has been carried much farther than in the experiments just alluded to of Réaumur and Bonnet*. Spallanzani was desirous of ascertaining what degree of heat the eggs of insects and other animals, as well as the seeds of plants, would bear when compared with their larvæ; and he found that below 93° Fahr. silk-worms did not appear affected, but at 95°, and still more at 97°, they became restless, while at 99° they ceased to move, and all died at 108°. The eggs of these, on the other hand, long resisted the influence of heat. At 80° they were the most productive; at 99° many still appeared, but with considerable diminution, and as the heat was increased their fertility decreased, till at 144° not one was fertile. The eggs and caterpillars of the elm butterfly (*Vanessa polychloros*?) perfectly corresponded with those of the silk-worm. In the case of the eggs of the blow-fly (*Musca vomitoria*) a great many produced maggots at 124°; but at 135° and 138° very few, and all were sterile at 140°. The maggots produced from these eggs became restless at 88°, and endeavoured to escape, and as this heat was increased they became proportionably more agitated till it arose to 108°, when they all perished. Full-grown maggots of the same kind all died at 108°; but when changed into flies they died when the heat was so low as 99°; though their pupæ were productive at 104° and 106°, but not at 111°†.

If these experiments may, as we believe they may, be relied on, we have some reason to doubt that "the eggs of the *musca vomitoria*, our common blow-fly, are often," as Dr. Good affirms, "deposited in the heat of summer upon putrescent meat, and broiled with such meat over a gridiron in the form of steaks, in a heat not merely of 212°, but of three or four times 212°; and yet, instead of being hereby destroyed, we

* See Insect Architecture, p. 24.

† Spallanzani, Tracts by Dalyell, vol. i. p. 35.

sometimes find them quickened by this very exposure into their larva or grub state*." It would have been well if some more accurate authority had been given for so miraculous a fact than this general statement: the appearance of maggots on broiled meat, from which the inference is apparently made, seems rather to indicate that eggs, or more probably ovo-viviparous larvæ, had been deposited there, not *before*, but *after* the broiling.

One certain result of all such experiments is, that eggs are more capable of withstanding heat than the animals producing them; and from similar experiments the same law appears to hold with the seeds of plants, which also withstand more heat than eggs. Water increases the destructive influence of heat. The causes upon which these curious facts depend do not appear to be well understood. It is certain, however, that the life of an animal in the egg is feeble, or at least lethargic, in comparison with that of the animal produced; and that animals, when in a state of very feeble animation, resist external injuries with more impunity than when very vivacious. We once saw a very delicate young girl, emaciated with scrofula, have her leg amputated without even heaving a sigh; while a robust Irish labourer, who underwent the same operation immediately after her, roared like a bull.

Experiments prove that the fluids of eggs, and consequently of their germs, are more abundant than in vegetable seeds; and this excess of fluid may tend to destroy the germ more readily, from heat expanding the fluids, and thus putting them in motion: for then they must strike violently against the tender parts of the germs, and rupture and destroy them. Hence seeds exposed to heat are killed at lower degrees in water, than if dry, in the same way as ice will melt sooner in warm water than in air of equal temperature†.

* Good's Book of Nature, vol. i. p. 221. 1st edit.

† Spallanzani, Tracts by Dalyell, vol. i. p. 43.

In the practical management of the eggs of the silk-worm Count Dandolo directs the temperature of the stove-room to be 64° when they are first put in. "The third day the temperature should be raised to 66°; the fourth day to 68°; the fifth day to 71°; the sixth day to 73°; the seventh day to 75°; the eighth day to 77°; the ninth day to 80°; the tenth, eleventh, and twelfth days to 82°. When the temperature of the stove-room is raised to 75°, it is advantageous to have two dishes, in which water may be poured, so as to offer a surface of nearly four inches diameter. In four days there will have taken place an evaporation of nearly twelve ounces of water; the vapour, which rises very slowly, moderates the dryness which might occur in the stove-house, particularly during a northerly wind: very dry air is not favourable to the development of the silk-worm*." Damp or stagnant air, or sudden changes of temperature, either high or low, are exceedingly injurious to the hatching of eggs.

From some very curious experiments of Michelotti, it appears that exposure to light is by no means favourable to the hatching of eggs. This ingenious naturalist inclosed a number of eggs in glass vessels, admitting the light to one series and excluding it from another, similar in every other particular. The result was, that few or none of the eggs exposed to light were hatched, while those in the dark were almost all fertile. He arrived at the same results in his experiments upon vegetable seeds†. Kirby and Spence justly remark, that these curious facts may account for so many insects fastening their eggs to the under sides of leaves, and may be the final cause of the opaque horny texture of those exposed in full day‡.

Among the singular circumstances in which insects differ from the larger animals, we may reckon that

* Count Dandolo, on Silk-Worms, Eng. trans., p. 55.
† Philosophical Mag. vol. ix. p. 244. ‡ Introduc. iii. p. 77.

of the eggs of some increasing in size during the process of hatching. The fact appears to have first been noticed by the celebrated Vallisnieri in his observations on saw flies (*Tenthredinidæ*, LEACH)*. Other instances were subsequently discovered by Réaumur, De Geer, Derham, Rösel, and the younger Huber. "It ought not," says Réaumur, speaking of gall flies (*Cynipidæ*, WESTWOOD), "to be passed in silence, that the egg which I found in the gall appeared to me considerably larger than the eggs of the same species when they proceed from the body of the fly, or even when they are taken from the mother fly near the time of their being laid. The whole of those I took from the mother flies which I killed were

Generation of a water-mite (*Hydrachna abstergens*).
a a, the water scorpion, in whose body the mite fixes her eggs. *b b*, a magnified view of one of its claws. *c*, a tooth-like process for restraining the motion of the joint. *d*, the water-mite. *e*, a greatly magnified view of one of its eggs. *f*, the hook by which it is inserted into the body of the scorpion.

* See Insect Architecture, pp. 157-8.

remarkably small; and I thence inferred that the egg would have, and indeed had, increased in the gall*."

Rösel made a similar observation on the red eggs of a water-mite (*Hydrachna abstergens*); and he was induced to suppose (justly, as we think) that, as they are deposited upon the bodies of water-scorpions (*Nepidæ*, LEACH), they derive their means of increase from them†. De Geer remarked that the water-scorpions, when much infested with them, became gradually weakened as the eggs increased in size

Huber the younger, in the course of his experiments, discovered that the eggs of ants, from being small and opaque, became comparatively large and transparent. "To be convinced of the truth of this," he says, "I viewed those eggs with the microscope. I also measured them, and having separated them from each other, found the longest to be those only in which the grubs were hatched in my presence. If I removed them from the workers, before they attained their full length and transparency, they dried up, and the grubs never quitted them." Huber is inclined to attribute this remarkable increase and transparency to the humidity imparted to them by the working ants who so assiduously pass them through their mouths. "For," he adds, "if they be not surrounded with a liquid, or preserved from the influence of the external air, their pellicle, moistened every instant by the workers, may preserve a certain degree of suppleness and expansibility, according to the development of the included grub§."

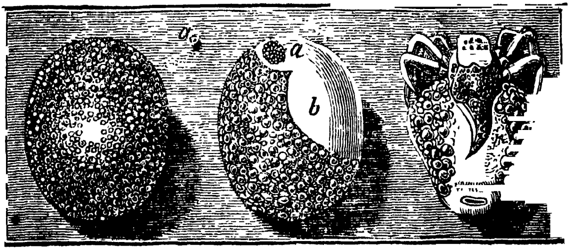
The most minute observations, however, of this kind, which have hitherto been published, were made

* Réaumur, Mem. vol. iii. p. 479.
† Rosel, Insecten. vol. iii. p. 152.
‡ De Geer, Mem. des Insectes, vol. vii. p. 145.
§ M. P. Huber on Ants, p. 72.

by Heroldt on the eggs of the garden spider (*Epeira diadema*), to which we formerly alluded. He divides the process of hatching into twelve periods, according to the progress of development. This progress is not measured by time, as has been done in experimenting on the eggs of birds. The germ, or cicatricula, which is composed of minute granules, when placed in a due temperature, begins to expand towards the extremity of the egg, till it takes the form of a comet, whose nucleus is the centre of the germ, and whose tail consists of transparent globules. On continuing to expand, or rather to disperse its granules, they appear to be decomposed into imperceptible molecules, producing a sort of translucent cloud, through which the globules of the yolk may be distinguished. The place which the germ previously occupied appears as a single transparent point. The cloudy matter next accumulates round the centre of the germ, assumes a pearly aspect, and becomes solid and opaque. This is the rudiment of the embryo spider, the outline of whose head and body becomes apparent, occupying a little more than a fourth of the egg. At first this embryo appears homogeneous, but by and bye four little archlets are seen, which are the rudiments of the legs, and at the same time the outlines of the mandibles are formed. The whole seems to derive nourishment from the yolk, in which it is rooted as a parasite plant upon a tree. When the embryo spider is near its exclusion, it completely fills the interior of the egg, the shell of which moulds itself closely around the body, and it looks like the nymph of a beetle*. When sufficiently developed, it makes a rent in the shell, as was first observed by De Geer, opposite the breast, through which it pushes its head, and successively disengages its body; but the shell still envelopes the legs and feet, and it is not without a

* Heroldt, Exercit. de Gener. Aranearum in Ovo.

great deal of trouble, by alternately stretching out and contracting them, that it succeeds in rending this, and sets itself at liberty*. Even then the young spider can neither spin a web nor catch prey; for it is still enveloped in an extremely delicate membrane, which it does not moult unless the weather is favourable and fine†.



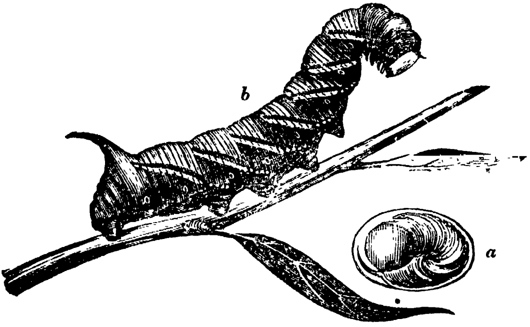
Hatching of the egg of the garden spider (*Epeira diadema*). *a*, natural size. *b*, egg magnified, the cicatricula (a white spot) in the front. C, the germ enlarged; *a*, the head, and *b*, the body of the embryo. *d*, the embryo spider ready to cast off its first skin.

The latter circumstance will enable us to explain some experiments made by Redi, who kept spiders newly hatched for many months without food‡. In the experiments made by us upon the eggs of the wolf spider (*Lycosa saccata*), we more than once kept the young in boxes, where they were forgotten and without food; and we uniformly found that they remained lively and well so long as they did not cast their embryo skin; but when they did moult, they could not long survive the want of sustenance§.

In the eggs of moths, the embryo, previous to exclusion, may be seen through the shell, snugly coiled

* De Geer, Mem. vii., p. 196.
† Dict. Classique d'Hist. Nat. xii. 141.
‡ Redi, Esperienze, 99. J. R.

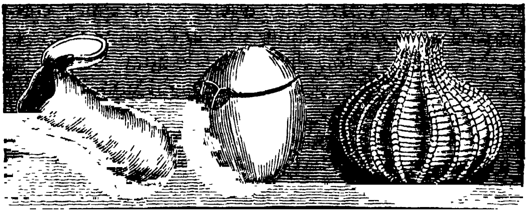
up in a ring, as is distinctly shewn in many of the beautiful and accurate figures of Sepp*.



a, egg of the privet hawk moth (*Sphinx Ligustri*) magnified, shewing the inclosed embryo. *b*, the caterpillar, when grown.

In the case of the eggs of birds, the chick, when fully developed, breaks the shell with its bill, the point of which is then furnished with a hard scale. This is evidently contrived by providential wisdom for this very purpose, for it drops off in a few days after the chick is excluded. It is probable that the larvæ of many insects which are furnished with strong mandibles gnaw their way through the egg-shell; but we know that there are others which, like the spider, rupture their envelope, since the edges appear ragged and irregular. Others, again, seem to have an opening provided for them, in a door, which only requires them to push it open. This is the case with the louse (*Pediculus humanus*), and with the bird-louse (*Nirmus*), found on the neck feathers of the golden pheasant. A still more ingenious contrivance was discovered by the Rev. R. Sheppard, in the egg of a field bug (*Pentatoma*, Latr.), which is not only fur-

* Der Wonderen Gods, *passim*.



a *b* *c*

Doors in eggs for the escape of the larvæ.

a, egg of the louse (*Pediculus humanus*). *b*, egg of the pentatoma. *c*, shell of a moth's egg found upon the dew-berry, all magnified.

nished with a convex lid, but with a lever of a horny texture, and in the form of a cross-bow, for opening it, the handle being fixed to the lower part of the egg by a membrane, and the bow part to the lid*. On the leaf of a dew-berry (*Rubus cæsius*) we found a beautifully ribbed egg of some moth, which, having been brought into our study in January, 1830, was hatched by the warmth, and exhibited an opening similar to the elastic cocoon of the emperor-moth; each of the ribs having expanded to allow of the escape of the caterpillar.

The period at which the eggs of insects are hatched after deposition depends mainly upon temperature; for by keeping them in an ice-house in summer, the hatching may be retarded †, as it may be hastened (witness the instance in the preceding paragraph) by heat in winter; but there are many other circumstances unknown to us which often hasten or retard the process. The eggs of the blow-fly (*Musca vomitoria*) are said to hatch within two hours‡, while those of several moths, and numerous other insects, remain unhatched for six or nine months; perhaps, in some cases, even for one or more years It is worthy of re-

* Kirby and Spence, iii. 104. † Réaumur, Mem.
‡ Nouv. Dict. d'Hist. Nat. xii. 564.

mark, however, that the periods of hatching correspond in a striking manner with the leafing of trees, and the appearance of other materials fitted for the food of the young. We observed a good example of this in the spring of 1829. A lackey moth had deposited during autumn a spiral ring of her eggs on the branch of a sweet-briar planted in a garden-pot out of doors. We removed this into our study during the winter. Here the warmth caused the tree to bud, and at the same time hatched the lackeys about a month sooner than those out of doors. Owing to the same cause, several colonies of the caterpillars of the brown-tail moth revived from their torpidity, and came forth from their winter nests before the hawthorns were in leaf, a circumstance which would not have happened to them out of doors*. Kirby and Spence give an instance precisely similar, of the eggs of an aphis found on the birch, and hatched in-doors a full month before those in the open air†.

It is a remarkable circumstance, long observed by collectors, that the male broods of insects appear earlier than the female broods; and it would appear from the following fact, that there is a similar retardation in the hatching of female eggs. "Upon the leaf of a poplar tree were found three eggs of the puss moth (*Cerura vinula*), two of which were hatched about two weeks before the other. The first were males, the last a female. As they were on the same leaf, and presumed, therefore, to have been laid by the same parent, at the same time, the difference of hatching could not have arisen from difference of weather, exposure, &c.‡" In the case of the lackeys on the sweet-briar above-mentioned, some were hatched several days before others, but whether these were of different sexes we did not ascertain.

* J. R. † Kirby and Spence, Intr. ii. 434.
‡ J. Rennie, in Mag. of Nat. Hist., vol. i. p. 373.

SECTION II.—LARVÆ *

Chapter VI.

Structure of Caterpillars, Grubs, and Maggots.

It is reported by Boerhaave, in his life of Swammerdam, that when the Grand Duke of Tuscany was visiting the curiosities of Holland, in 1668, he found nothing more worthy of his admiration than the naturalist's account of the structure of caterpillars,—for Swammerdam, by the skilful management of instruments of wonderful delicacy and fineness, shewed the prince in what manner the future butterfly lies neatly folded up in the caterpillar, like a flower in the unexpanded bud. He was, indeed, so struck with this and other wonders of the insect world, disclosed to him by the great naturalist, that he made him a princely offer to induce him to reside at his court; but Swammerdam, from feelings of independence, modestly declined to accept it, preferring to continue his delightful studies at home. The facts which thus struck the Duke with admiration, we shall now endeavour, with the aid of Swammerdam, to trace. But, before we proceed, it may not be out of place to advert to some very novel views which have

* It may be proper to repeat here, that an insect, when hatched from the egg, is called by naturalists *larva;* and in popular language, a *caterpillar* or *grub*, if furnished with feet, and a *maggot, worm,* or *gentle,* if without feet.

been recently started by continental naturalists, who maintain that vegetables are actually converted into animals, and these again into vegetables.

It must be obvious, we think, from the details we have already given, that the doctrine of *transmutation*, so far as regards insects, is equally absurd and impossible with the pretended alchemical transmutation of lead and other inferior metals into gold and silver; which doctrine was, indeed, supported upon the supposed fact of insects being thus transmuted *. But visionary as either of these may appear, they have both been supported by men of talent and distinguished reputation. It does not, perhaps, at first sight seem more impossible, that water should be transmuted into diamonds, or brass into gold, than that an egg should disclose a chick or a caterpillar, or that a caterpillar should change into a butterfly or a beetle; but by adhering rigidly to facts, and rejecting as rigidly all fancies and analogies, how plausible soever they may appear, we are certain that the latter changes are of common occurrence, whereas the former are contrary to all experience, and to the best experiments. We say the *best;* because observations, if not experiments, have been made for the express purpose of proving such improbable transmutations.

" I have shewn to a great number of persons," says Professor Agardh, " the changeable crow-silk (*Conferva mutabilis*, ROTH ; *Draparnaldia m.* BORY ST. V.) in its state of a plant, the 3d of August, change by the 5th into molecules endowed with locomobility, reunite by the 6th into simple articulations, and reconstituted by the 10th into the primitive form of the plant †." Previous to this (in 1814) Professor Nees von Esenbeck, of Bonn, published similar obser-

* Sir Theodore Mayerne, Epist. Dedicat ad Theatrum Insect. Mouffetii.

† Agardh, Diss. de Metamorph. Algarum. 1820.

vations, in which he remarks, that "as the phenomena in question appear to contradict certain principles admitted into the reigning systems, we often prefer rather to deny the conclusions of candid and experienced observers, than to receive what has hitherto been regarded as untenable by generally admitted authority. In this situation are placed all observations upon the transition or metamorphosis of vegetable life (characterised by immobility) into animal life (characterised by mobility);—the moment when a being, arrived at the period of its existence, continues itself, as it were, by a new creation, and the animated embryo developes itself into a motionless vegetable*." Agardh, in his account of another allied family (*Ocillatoriæ*), has even given figures, first of the plant, and then of the animalcules into which its filaments are converted†, which induced Bory St. Vincent to remark sarcastically, that "all nature appears, to the Professor of Lund, to be nothing but confervæ travestied‡."

Passing over what has been published on this strange doctrine by Vaucher, Girod-Chantrans, Treviranus, Carus, and others, we shall only stop to mention the more recent observations of Francis Unger. The plant he selected was the *Conferva dilatata β* of Roth. "Within the space of one hour," says he, "I succeeded in tracing, not only the diminution of vitality and death of the animalcules, but also the subsequent development of the dead animals into germinating plants, in such a manner as to establish the truth of the fact." He adds with great simplicity, "I could scarcely believe my own eyes§." Like Agardh, he has given figures of these miracu-

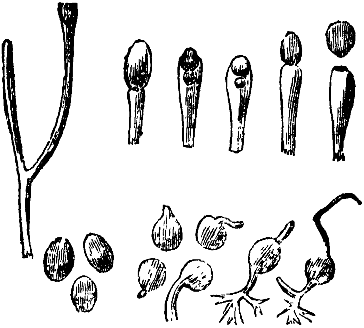
* Quoted in "Annales des Sciences Naturelles" for 1828.

† Agardh, Icones Alg. ined. i. 10.

‡ Dict. Classique d'Hist. Nat, x. 469.

§ Annales des Sciences Nat., 1828.

lous changes, which our readers may be curious to see.



Supposed animal and vegetable metamorphoses.

Since the only proof of these plants being transmuted (as is alleged) into animals, appears to be their acquiring motion*, and, as Unger says, " swimming freely about;" we think we should be equally entitled to infer that camphor is animated because it moves spontaneously when thrown into water. This property in camphor has not hitherto been satisfactorily explained; and it would undoubtedly be better to leave the phenomena described by our advocates for transmutation likewise unexplained, than to leap at once to their startling conclusions. " We might as well," says Bory St. Vincent, " astonish the world with the discovery of a fig-tree transmuted into a mulberry tree, because the *Broussonetia*, when young, has the leaves of the one, and when old of the other; and by such a system of observing we shall end in looking upon the oak and the mistletoe as the same plant: the wand of Circe could not produce more astounding consequences

* Nees von Esenbeck.

than the microscope does in the hands of such observers*."

It is apparently a branch of the same untenable theory, which maintains that the fluid termed by Heroldt the *blood* of caterpillars is the only original portion of them, which, being endowed with a formative power†, produces an envelope for itself of mucous net-work (*rete mucosum*), and this again, by means of a similar power, is successively transmuted into the caterpillar, the pupa, and the perfect insect‡; in some similar way, we suppose, to the formative power displayed by water, when, during frost, it shoots into crystals of ice. But the framers of such theories seem to forget that living blood is a very different thing from inanimate water, and the growth and nutrition of animals from the chemical formation of crystals. Kirby and Spence very justly remark, that Heroldt's formative power is only an apology for ignorance, and that his denying the existence of what he cannot trace, is no proof of his doctrine, but of his mistake in supposing the first appearance of the organs of the butterfly in his microscope to be literally their first existence. To suppose the blood, we may also remark, endowed with the power of creating insects, gets rid of no difficulty and explains no phenomenon, while it is altogether a gratuitous assumption, unproved and improbable. "Admirable discovery," exclaims Virey; "as if you should affirm that a stone falls because it falls§!" We think it is St. Pierre who remarks, that Nature seldom permits philosophers to peep to the bottom of her basket; and we have already

* Dict. Class. d' Hist. Nat. x. 468.

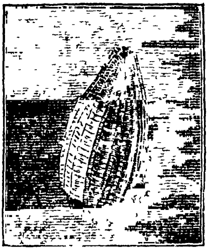
† The German term is "Bildende Kraft," i. e. *Vis formatrix*, or *Nisus formativus*.

‡ Heroldt, quoted by Kirby and Spence, iii. 83.

§ Quoted by Kirby and Spence.

recorded many instances, besides the one under consideration, of their strange mistakes in guessing at what they cannot fathom. We prefer following Swammerdam, Réaumur, and Bonnet, in recording what can be actually seen on examining the structure of caterpillars.

In a chapter of Swammerdam's Book of Nature, quaintly headed "An animal in an animal, or the butterfly hidden in the caterpillar," we find the following details respecting the caterpillar of the large cabbage butterfly (*Pontia brassicæ*). The egg of this insect is of a yellow colour, flask shaped, and marked with fifteen ribs, converging towards the smaller end, and extending a little beyond it. The



Egg of the large cabbage butterfly (*Pontia brassicæ*), magnified.

caterpillar, but too well known from its ravages, has sixteen feet, a yellow line along the back, and another on each side, the rest of the body being bluish grey, spotted with black; and the whole surface sprinkled with thin, short, whitish hairs*.

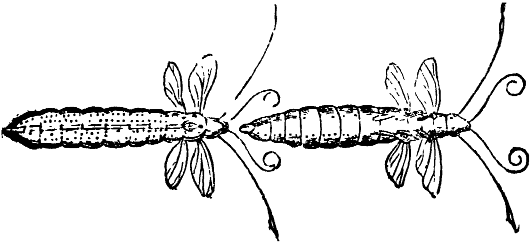
"In order," continues Swammerdam, "to discover plainly that a butterfly is inclosed and hidden in the

* Ray, Cat. Cantab., quoted by Swammerdam. See fig. *a*, page 62.

skin of this caterpillar, the following operation must be used. One must kill a full-grown caterpillar, tie a thread to its body, and dip it for a minute or two into boiling water. The outer skin will, after this, easily separate, because the fluids, between the two skins, are by this means rarefied and dilated, and therefore they break and detach both the vessels and the fibres wherewith they were united together. By this means the outer skin of the caterpillar, being separated, may be easily drawn off from the butterfly which is contained and folded up in it. This done, it is clearly and distinctly seen, that, within this skin of the caterpillar, a perfect and real butterfly was hidden, and therefore the skin of the caterpillar must be considered only as an outer garment, containing in it parts belonging to the nature of a butterfly, which have grown under its defence by slow degrees, in like manner as other sensitive bodies increase by accretion.

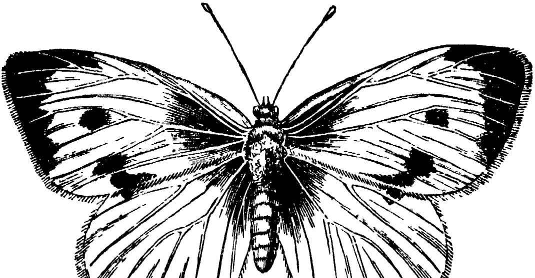
"But as these limbs of the butterfly which lie under the skin of the caterpillar cannot, without great difficulty, be discovered in the full-grown caterpillar, unless by a person accustomed to such experiments,—because they are then very soft, tender, and small, and are moreover complicated or folded together, and inclosed in some membranaceous coverings,—it is, therefore, necessary to defer the operation just now proposed, until the several parts of the butterfly become somewhat more conspicuous than at first, and are more increased and swelled under the skin by the force of the intruded blood and aqueous humour. This is known to be the case when the caterpillar ceases to eat, and its skin on each side of the thorax, near under the head, is then observed to be more and more elevated by the increasing and swelling limbs, and shews the appearance of two pairs of prominent tubercles *."

* Swammerdam, Book of Nature, ii. 26.



Embryo butterflies (*Pontiæ Brassicæ*), as they appear in the bodies of caterpillars. The wings, antennæ, and trunks in the figures are spread out to shew them.

By similar dissections, Malpighi both actually discovered the moth in the body of a silk worm, and also the eggs of it *; and Réaumur made a similar discovery in the caterpillar of the gypsey moth (*Hypogymna dispar*) †.



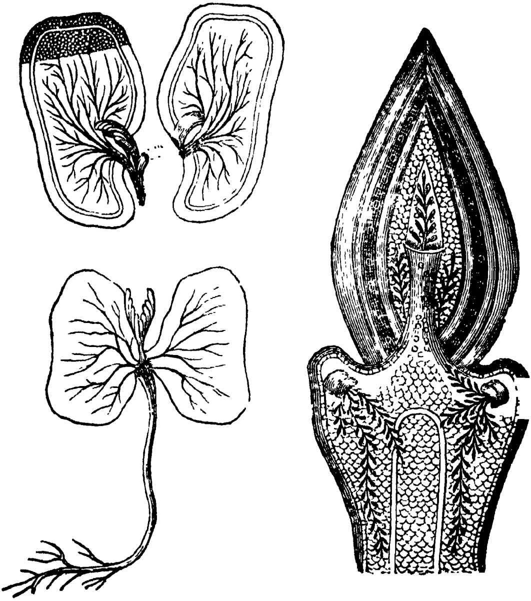
Female of the perfect cabbage butterfly (*Pontia brassicæ*).

In order to harden the parts of the incipient butterfly that are soft, Swammerdam immersed the caterpillar in a phial filled with equal parts of vinegar and spirit of wine for sixteen hours, when he found it would

* Malpighi de Bombyce, 29. † Réaumur, Mem. i. 359.

better bear handling. It may be necessary to remark, that though all the parts of the butterfly are in this manner discoverable in the caterpillar, they are only in the bud, if we may use the expression, and appear to be out of proportion from being so closely folded up and unexpanded. The whole, indeed, bears so much analogy to the embryo of a plant in the seed, or the rudi-

b



c *a*

a, greatly magnified view of a section of the bud of the laburnum. It exhibits the nascent flowers, arranged in regular order, previously to their bursting into perfect existence. *b*, section of a bean seed. *c*, seed-leaves, root, and the first true leaf of the beech.

ments of a leaf or of a flower in the bud, that Swammerdam has given figures of the parallel developments of larvæ and of a carnation. His selection of this flower was not perhaps the most happy; but our readers may readily obtain examples by carefully dividing the unexpanded buds of the rose, the lilac, the horse-chesnut, the American walnut, or beans, and other large seeds after they have been planted in moist earth, but not left long enough to shoot into a plant. The preceding figures will illustrate this better than description. Dr. Grew proved in this manner that flowers which blow in spring are formed in the preceding year *; and Du Hamel, on dissecting, in January, the bud of a pear-tree, found under an envelope of about thirty leaf scales eight or ten embryo flowers resembling rose-buds bestudded with hairs †.

The butterfly and the flower-bud, however, differ remarkably in the manner in which they are nourished,—the latter receiving sap from the enveloping leaf scales, the former taking food into the stomach through the mouth of the caterpillar. The stomach, indeed, of the inclosed butterfly is so capacious, that it fills the greater portion of its body; and requires the caterpillar to occupy almost its whole time in eating in order to satisfy its cravings. When the food is digested in the stomach of the insect, it passes, as in the larger animals, into the small intestines ‡; but it is not, as in them, collected by innumerable little vessels which afterwards run into one, (as brooks unite to form a river,) and go to the lungs to be exposed to the air, supplied by breathing, in order to be there oxygenated and formed into red blood. Insects, on the contrary, do not

* Grew. Phys. Veg., ii. 60.

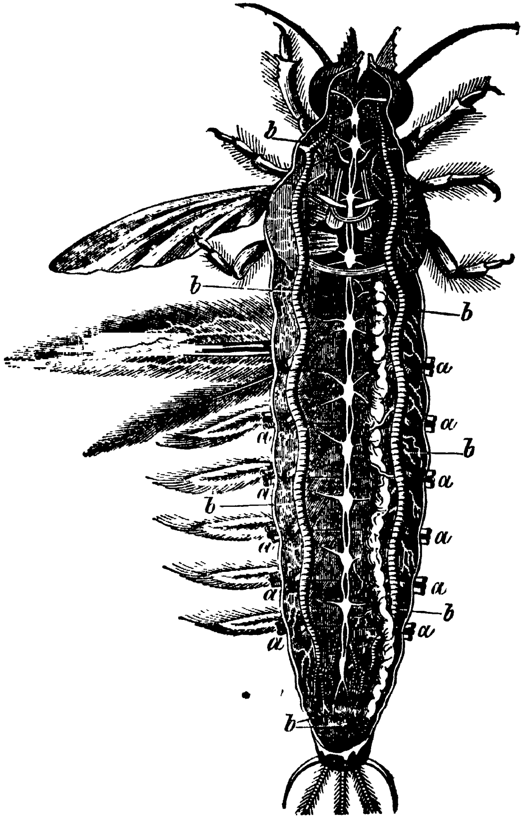
† Du Hamel, Physique des Arbres, iii., 1.

‡ See "Insect Architecture," p. 309, D, D.; and this vol. p. 198.

breathe by the mouth, and are not furnished with lungs; for though good air is no less essential to their nutrition and existence, it is brought to act on the digested food in a different manner. In caterpillars, and in most perfect insects, the air is respired by breathing-tubes—usually eighteen in number—placed along the sides *, the mouths of which may be seen moving, as the air passes in and out, from ten to thirty times in a minute. When these are covered with oil, or any other matter preventing the entrance of the air, the insect, being unable to breathe, is suffocated and dies, as was observed two thousand years ago by Aristotle †. The breathing-tubes all run into what may be called a wind-pipe, one of which lies along each side of the insect; and these two wind-pipes send off innumerable small branches with air to the vessels containing the digested food, supplying it with oxygen for the purposes of nourishment. A fluid is thus prepared analogous to the blood of the larger animals, and stored up in a large dorsal vessel; but this is not at all like a heart, for though it has been observed to beat, its motions do not seem to be constant or regular, and no blood-vessels go off from it. The fluid analogous to blood may perhaps pass through this singular reservoir, as water does through blotting paper; but as yet this process has not been accurately investigated. A more distinct notion, however, of the process of insect breathing may be obtained from Swammerdam's sketch of the interior of the water-grub of a May-fly (*Ephemera*).

It is further conjectured that the portion of the blood not immediately wanted for nourishing the organs already formed, goes to form a mass of thickish mucilage, contained in floating membranes of a white,

* Insect Archi. p. 308. † Aristotle, Hist. Animal., viii. 27.



Dissection of the water grub of a May fly (*Ephemera*). The back is laid open, and the nerves, intestines, and respiratory apparatus exhibited. *a a a a a a*, six clusters of short tubes, opening on both sides, through which the creat re breathes: the air contained in the water, passing through hese, enters two wind-pipes, *b b b b*, running from head to t il, and circulates through every part of the body. The eight fin ., and a portion of the tail bristle. have been omitted, to give th of the figure on a larger scale. The central white lines are he nerves.

yellow, or green colour, and apparently analogous to fat in the larger animals *. This furnishes, as is further supposed, a store of nutriment for promoting the growth of the butterfly †.

This brief sketch will serve to give the reader a tolerable notion of the internal structure of caterpillars, and the manner in which their food is elaborated into nutriment; but when we know that Lyonnet wrote a large quarto volume on the structure of a single caterpillar, and that Malpighi, Heroldt, Ramdohr, Sprengel, and Marcel de Serres, are little less voluminous, it will be understood that we give it merely as a sketch which we could easily have extended, had it appeared, as it does not, to be suitable to our plan. It will prove more interesting, we think, to pass now to the external structure and appearance.

It will be obvious from what we have said respecting the colours of eggs, that we are not inclined to adopt in all its extent the theory of many naturalists, which maintains the peculiar colours and forms of animals to be given them by nature for the purpose of concealment from their enemies. As in the instance of caterpillars this theory meets us again in full force, we shall mention a few facts which appear not only to be at variance with it, but shew, we think, that the facts of the theorists may stand as appropriately for exceptions as for a general rule. Since caterpillars form the staple food of soft-billed birds and of the young of most hard-billed birds, not to mention the parasite grubs of ichneumon flies which destroy great numbers, nature has provided an immense abundance of them beyond what is requisite for continuing the race. Were it maintained, therefore, that they were all by design so formed and coloured as to deceive the eyes of birds and ichneu-

* Lyonnet, Anat. de la Chenille, 106.

† Réaumur, Mem. i. 145.

mons, the purpose of their superabundant production would be frustrated. We have no doubt, indeed, that insectivorous animals can instinctively detect their prey, in all the usual modes of concealment, as acutely as the practised eye of a naturalist, who can with ease perceive what escapes the observation of the inexperienced. When a woodpecker is taught by nature to detect a wood-boring caterpillar, by the bark sounding hollow when tapped with his bill, and when an ichneumon fly can detect a chrysalis closely rolled up in a leaf *, we should be strongly inclined to doubt that colour or form could afford very effectual concealment from enemies, though we readily grant that many probable instances of this have been adduced. Of these instances it may be well to give a few examples.

The caterpillar of a nocturnal moth (*Noctua algæ*, Fabr.) is said to assume the colour of the lichens upon which it feeds, being grey when it feeds on a grey one (*Parmelia saxatilis*, Ach.), and always yellow when it feeds on a yellow one (*Cetraria juniperina*, Ach.†); the change of colour being (it is alleged) intended by Providence to conceal it from its enemies, as it becomes difficult to distinguish it from the lichens. The caterpillar of the coronet moth (*Acronycta Ligustri*, Ochsenheim.), which feeds upon the privet, is so exactly of the colour of the underside of the leaf, to which it usually clings during the day, that a person may have the leaf in his hand without discovering the caterpillar ‡; a circumstance explained upon the same principle. This, indeed, is no uncommon circumstance, as many caterpillars very nearly resemble the colour of the leaves upon which they feed; and the wonder rather is, that so

* See "Insect Architecture," p. 174-5.

† Fabr. Vorlesung. in Kirby and Spence, ii. 220.

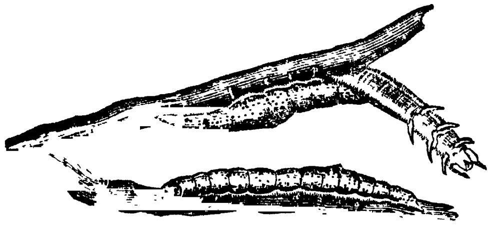
‡ Brahm, Insecten, in ibid. p. 221.

many others should not be similarly coloured, when we consider that their stomachs occupy the greater portion of their bodies, and are generally gorged with food. It would be no difficult matter, therefore, to enumerate several hundred examples of caterpillars resembling in colour the substances upon which they feed. It strikes us as more singular to find a great many which, though they feed on green leaves, resemble in colour the grey or brown bark of the branches where they usually rest when not feeding.

Caterpillars of the Clifden nonpareil feeding on the grey poplar.

A marked instance of this occurs in the caterpillar of one of our largest and most beautiful moths, the Clifden nonpareil (*Catocala fraxini*, SCHRANK), which feeds on the ash and the poplar, and is so similar to a stripe of brown lichen dotted with black, that it would not be readily discovered by any person but a naturalist*.

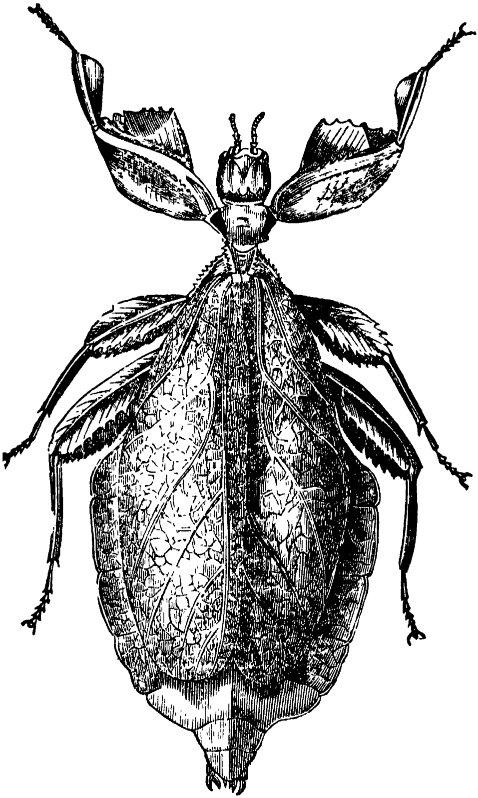
* J. R.



Caterpillars of the Clifden nonpareil in a more advanced stage of growth.

Of the extraordinary tropical insects popularly termed Walking-leaves, belonging to several orders and families (*Locusta*, *Mantis*, *Phasma*, &c.), the wing-cases, not only in colour, but in texture, and even in veining, are so exactly like leaves, from the fresh green of those newly expanded to the faded brown of those withered and fallen, that botanists themselves might be deceived if they were detached from the insects and exhibited as real leaves. Among the locusts of Fabricius (*Pterophylla*, KIRBY) alone, we find the various species with wing-cases resembling in this manner the leaves of the laurel, the myrtle, the citron, the lily, the sage, the olive, the camellia, thyme, and grass.

The Spectres (*Phasmatæ*, LICHTENSTEIN), on the other hand, resemble the smaller branches of trees with their spray; and so minutely detailed is this mimicry that the very snags and knobs, as Kirby and Spence remark, are accurately imitated. Those who are curious in such matters may readily find similar instances in some of our native caterpillars, by no means uncommon. In the latter part of summer, for example, by beating the bushes of a hawthorn hedge while an umbrella is held under, the caterpillar of the brimstone moth (*Rumia Cratægata*? DUPONCHET) may often be found, appearing, as it stalks along the



Walking-leaf insect (*Phyllia foliata*, DUMERIL), magnified.

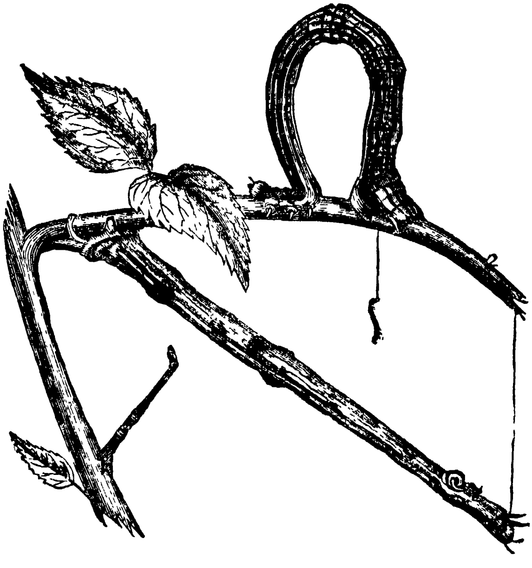
whalebones of the umbrella, like a self-moving withered branch, the skin being wrinkled and furrowed like the bark, while the bulgings of the rings and a notched protuberance on the back add much to the resemblance.

Transformations of the brimstone moth (*Rumia Cratægata*). *a*, the caterpillar in its resting position. *b*, the moth. *c*, the eggs. *d*, the young caterpillar.

We found during last summer, on an elder, at Lee, several specimens of a similar walking-branch caterpillar, that of the swallow-tail moth (*Ourapteryx Sambucaria*, LEACH), not so common as the preceding, but equally remarkable; for the ringed bulgings on the body are precisely like those of an elder branch, while the longitudinal stripes are like the cracks in the bark*. It is likewise worthy of remark that these caterpillars, when not feeding, rest upon their prolegs, with their body stretched out at various angles from the branch, their only support being a thread of

* J. R.

silk, from which the head hangs, in order that they may always be ready to drop down in safety, by extending this thread, on the sudden approach of enemies. As they feed chiefly in the night, they may be seen continuing in this stiff and singular attitude for a whole day without moving, "So that, doubtless," say Kirby and Spence, "the sparrows and other birds are frequently deceived by this manœuvre, and thus baulked of their prey. Rösel's gardener, mistaking one of these caterpillars for a dead twig, started back in great alarm, when upon attempting to break it he found it was a living animal*." We are well



Caterpillars of the swallow-tailed moth, resembling the twigs on which they rest.

* Intr. ii. 236; Rösel, Insecten, i. v. 27.

persuaded, however, that neither a bird, an ichneumon, nor a naturalist, would have been apt to fall into such a mistake.

This family of caterpillars (*Geometridæ*, STEPHENS) have been by collectors not inappropriately named surveyors, loopers, and geometers, from their peculiar manner of moving, which may readily be conceived by those who have not seen them, when we mention that at the commencement of each step their bodies present a pretty exact figure of the Greek letter Ω. In this position, laying hold with their hinder prolegs, they stretch out their heads to the full extent of their body, laying hold with their fore legs while they bring forward their body into the Ω form again.

Such are among the most prominent examples adduced by naturalists who advocate the theory that these resemblances to inanimate objects are intended to conceal insects from their enemies*. We shall now give a few instances which have suggested themselves as no less corroborative of the opposite doctrine. The first which occurs to us is one of the surveyor caterpillars, whose movements we have just been describing, found very commonly on the currant, the gooseberry, and the black thorn, and called by collectors the magpie (*Abraxas Grossulariata*, LEACH). This caterpillar is very conspicuous from being spotted, somewhat like the perfect insect, with black upon a bright yellow ground, and contrasting strongly both with the deep green of the leaves upon which it feeds, and the dark-coloured bark upon which it usually rests. The caterpillars of the water betony moth (*Cucullia Scrophulariæ*, HUBNER), and of the burnet moth (*Euclidia Glyphica*, OCHSENHEIM.), are similarly marked with deep black on a yellow ground, which must render them very conspicuous. The caterpillars of the small tortoise-shell

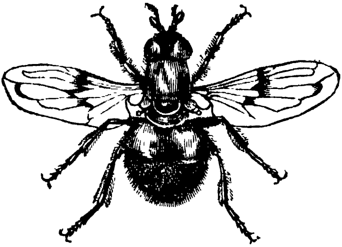
* See Kirby and Spence, Intr. ii. 219-237.

butterfly (*Vanessa Urticæ*), are, we admit, very similar in colour to the nettles they are found on; but we cannot, surely, say the same of the dark black ones of the peacock (*V. Io*), also nettle feeders, particularly as these are not only large, but keep together in numerous companies; which also applies to the caterpillar of the Camberwell beauty (*V. Antiopa*), as well as to the conspicuous caterpillar of the buff tip (*Pygæra bucephala*, OCHSENH.), so very destructive in certain years to beeches, oaks, limes, filberts, and other trees*. Some of those just mentioned, indeed, are provided, as we shall afterwards see, with better means of defence than their colours; but if peculiar colours be given by nature for the purpose of concealment, as in the instance of the caterpillars of the small tortoise-shell, why are these studded with thorns in the same way as the conspicuous caterpillars of the peacock and the Camberwell beauty? In this, as in many other instances, the theory evidently proves too much.

To the examples which we have here given of conspicuous caterpillars, we could easily add some hundreds more; but thinking these sufficient, we may be permitted, by way of farther illustration, to allude to the instances remarkable in perfect insects. Kirby and Spence mention a different kind of imitation of form and colour, which they think "affords a beautiful instance of the wisdom of Providence in adapting means to their end." One of those two-winged flies (*Volucellæ*, GEOFFROI), which bear a considerable resemblance to humble bees, lives during the larva state in the hives of the latter; and it is inferred, that as the flies "strikingly resemble those bees in shape, clothing, and colour, the Author of nature has provided that they may enter these nests

* All these caterpillars are figured in this volume: see contents of the engravings.

and deposit their eggs undiscovered;" for "did they venture themselves amongst the humble bees in a less kindred form, their lives would probably pay the forfeit of their presumption *."



A two-winged fly (*Volucella plumata*, MEIGEN).

We do not conceive that any dissent from this doctrine has a tendency to weaken or destroy the smallest link in the beautiful chain of causes which leads us upwards to the admirable superintendence of the great First Cause; and, therefore, we state that, in the case before us, our justly eminent authors surely forgot, that bees well know strange individuals of their own species, and beat them off when they attempt to plunder their hives; and these robber bees are not only like but identical with themselves in shape, clothing, and colour. Indeed, when it is considered that in the designs of Providence, as evidenced by the economy of nature, the nourishment of the stronger species of carnivorous animals is as much regarded as the means which the weaker have of escaping from them, such general rules cannot be but of very limited application.

Darwin, as we formerly mentioned, maintained that butterflies resembled the colours of the flowers which they frequent; and many of them may be granted to do so without leading us to adopt the

* Intr. ii. 223.

inference of the theorists that they are thus coloured to conceal them from their enemies. Were this, indeed, the true cause of these colours, the butterflies ought to remain stationary on the flowers, without sporting about in the sunshine, as if on purpose to show the birds and the dragon flies that they are living insects, and not inanimate flowers. In the instance of many moths which fly by twilight, this is no less obvious; for instead of being of dark dusky colours, which would have effectually concealed them from the bats and the fern-owls, they are frequently white, or at least of such light colours as show well in the dusk. There is but small need of enumerating examples of this, and it will be sufficient to name the white-ghost moth (*Hepialus Humuli*), which may often be seen, where hops or burdocks grow, hovering on the wing for hours together; the satin moth (*Leucoma Salicis*, STEPHENS), which floats about the air like an animated flake of snow-white down, or flits conspicuously from tree to tree among the higher branches of a row of poplars; and the magpie moth (*Abraxas grossulariata*), usually abundant in every garden, though liberally sprinkled with black spots, has enough of white to distinguish it in its heavy, lumbering flight, even when the last rays of the twilight are disappearing. That these are not strained examples of insects so coloured as to be conspicuous to their enemies, will farther be obvious from a common contrivance of schoolboys to catch bats. They chalk the seed-heads of burdocks in such a manner as to resemble the white moths alluded to; and throwing these up where a bat is observed flying, he fails not to dart upon the supposed moth, and the bur adhering to his wings, brings him down to pay the penalty of his mistake*.

If we leave colouring out of consideration, and

* J. R.

look merely at the forms of caterpillars, we think it must be apparent to the most indifferent observer, that, though they have often a rather ungainly, repulsive, and sometimes a formidable aspect, yet this renders them in numerous instances very conspicuous. The forms, also, we may remark, which appear disagreeable or threatening to us, may not seem so to birds and ichneumons which make them their prey. One of the most singular of these forms of caterpillars occurs in that of the pebble moth (*Notodonta Ziczac*, STEPHENS *), the form being such that it is not easy for one unacquainted with it to tell which is the head and which the tail. The puss (*Cerura Vinula*) is another whose form and attitudes cannot fail to attract the notice of the most indifferent observer. Dr. Shaw, in his Zoological Lectures, quotes from a country newspaper a most ludicrous account of this "monster," as it is there called, having a head like a lion, jaws like a shark, a horn like a unicorn, and two tremendous stings in its tail. The gross exaggeration of this description will be obvious from the following accurate figures; yet how formidable soever this caterpillar may appear to us (even Rösel, the entomologist, was afraid of it at first), we know that no one is more readily pounced upon by at least two species of ichneumons, which seem, therefore, not to be afraid to deposit their eggs in its body †; and it is no doubt often made prey of by birds, at least in its young state; for when full grown, being about as thick as a man's thumb, it may prove rather too bulky a morsel ‡.

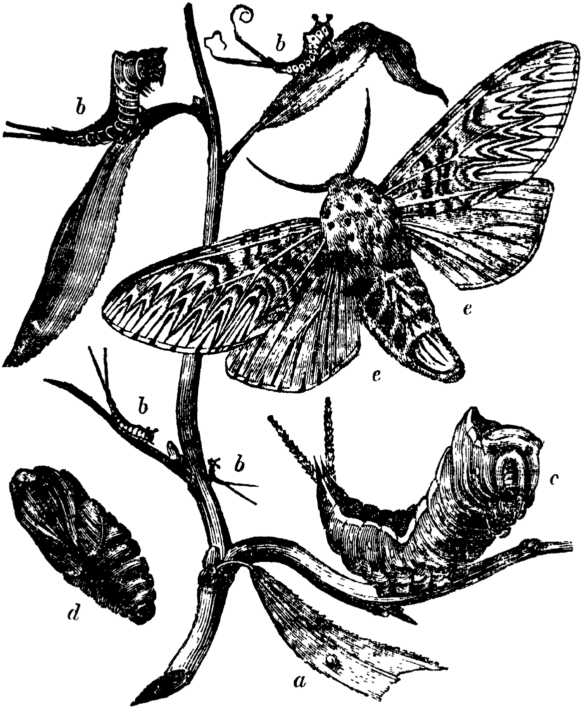
Our readers may like to see, by way of contrast to the exaggerated account quoted by Shaw, the excellent description of the puss caterpillar given by old Isaac Walton. "The very colours of caterpil-

* Figured in Insect Architecture, p. 172.

† See ibid., pp. 195 and 325-6.

‡ J. R.

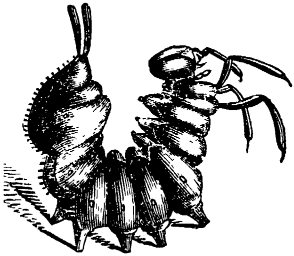
lars," says he, "as one has observed, are elegant and beautiful. I shall, for a taste of the rest, describe one of them; which I will, some time the next month, shew you feeding on a willow tree; and you shall find him punctually to answer this very description: his lips and mouth somewhat yellow; his eyes



Transformations of the puss moth (*Cerura Vinula*). *a*, the egg. *b b b*, young larvæ. *c*, full-grown larva. *d*, the pupa. *e*, the moth.

black as jet; his forehead purple; his feet and hinder parts green; his tail two-forked and black; the whole body stained with a kind of red spots, which run along the neck and shoulder-blade, not unlike the form of St. Andrew's cross, or the letter X made thus crosswise, and a white line drawn down his back to his tail; all which add much beauty to his whole body. And it is to me observable, that at a fixed age this caterpillar gives over to eat, and towards winter comes to be covered over with a strange shell or crust, called an *aurelia**; and so lives a kind of dead life without eating all the winter. And as others of several kinds turn to be several kinds of flies and vermin the spring following; so this caterpillar then turns to be a painted butterfly†."

Another caterpillar, called by collectors the lobster (*Stauropus Fagi*, GERMAR.), which is rarely met with, has not only very long legs, a circumstance uncommon among caterpillars, but assumes an attitude similar to the puss just figured, though the shape of the creature renders it much more strange. This caterpillar was known to Mouffet, and is indifferently figured by him, as well as by



Lobster caterpillar (*Stauropus Fagi*, GERMAR.)

* See Insect Architecture, p. 194.
† Walton's Angler, chap. v

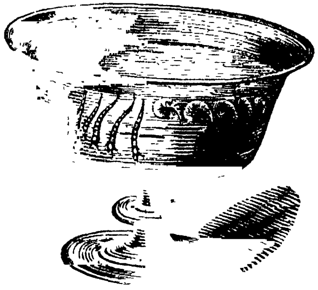
Albin and Donovan; but Rösel's figure, which we here copy, is more accurate.

Looking at these very singular forms of caterpillars, we could not anticipate, without previous knowledge, that all of them produced insects of nearly the same shape, though differing considerably in size and colour. It is not a little remarkable, also, that the colours of caterpillars, with a few exceptions, such as the magpie-moth (*Abraxas grossulariata*), are very different indeed from the insects into which they are transformed. Plain and inconspicuous caterpillars will sometimes give splendidly coloured insects, as in the case of the *Vanessa* butterflies; while finely marked caterpillars will give plain insects, as the one whose gaudy stripes of sky-blue, scarlet, and black, has obtained it the appropriate name of the lackey (*Clisiocampa neustria*, Curtis), though the moth is of a dull brownish yellow. Two of our finest native insects, however, the swallow-tailed butterfly and the emperor-moth, are produced from beautifully coloured caterpillars; but neither the colours nor the markings of these have any resemblance.

A more extraordinary difference, however, between the first and the last stage of insect life occurs in the case of those insects whose larvæ are aquatic. One of our commonest families of insects, the gnats (*Culicidæ*, Latr.), whose ingenious mode of constructing a floating raft of eggs we have already described, affords a very striking illustration of our position. When these eggs are hatched, the grubs appear; but they do not, as is said by older naturalists, " make themselves little lodgments of glue, which they fasten to some solid body at the very bottom of the water, unless they meet with chalk, whose softness permits them to burrow into its substance*." On the contrary, they

* Spectacle de la Nature, i. 123.

usually swim near the surface of the water, with their heads downwards and their tails in the air, for a purpose which will presently be obvious. These grubs, called *scurrs* in the north, may be met with in abundance during the summer in ditches or in water-butts*, appearing like minute, whitish, semi-transparent shrimps or fishes, when their bodies are a little bent, as they frequently are.

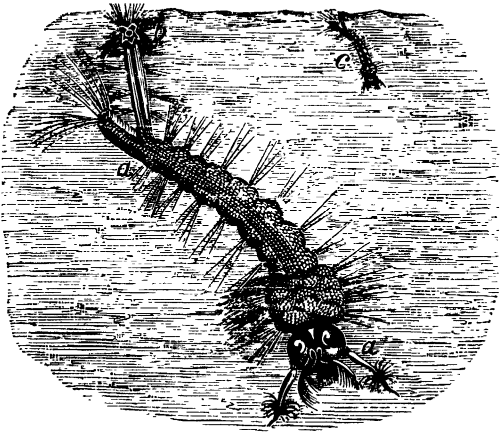


Aquatic grubs of gnats in a glass vessel of water.

The organs for breathing, which are very remarkable in the grub of the gnat, are not situated along the sides, as in caterpillars, but in the tail. A tube for the purpose of respiration goes off from the terminal ring of the body at an angle. Its main buoys, also, are its tail and its breathing-tube, both of which end in a sort of funnel, composed of hairs, in form of a star, anointed with oil, so as to repel water. Swammerdam remarks that when, by handling it too roughly, this oil is removed, the grub "can no longer suspend itself on the surface of the water; I have, on these occasions, observed it put its tail in its mouth, and afterwards draw it back, as a water-fowl will draw its feathers through its bill to prepare them for resist-

* See Insect Architecture, p. 20, bottom figure, on the right.

ing water*." The air, which enters through several openings in the breathing-tube, passes onwards to two lateral wind-pipes, very similar to those of caterpillars, as above described. When it wishes to descend to the bottom of the water, it folds up the hairs of the funnel, but by means of its oil retains at their ends a globule of air; and when it wishes to re-ascend, it has only to open its hair funnel again.

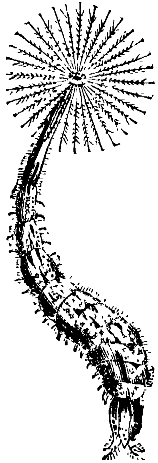


Larva of the common gnat (*Culex pipiens?*) floating in water, greatly magnified, *a a*, the body and head of the larva. *b*, the respiratory apparatus, situated in the tail. *c*, the larva, not magnified.

A similar but more elegant apparatus for the same purpose occurs in the water-grub of a two-winged fly, which Goedart called the chameleon fly (*Stratiomys chamæleon*, MEIGEN), because he found it could live nine months without food. The terminal ring of this grub is extended to a considerable length, and fringed at the end with a beautiful star-like funnel of thirty feathered hairs. Whether the creature oils these,

* Biblia, Naturæ, i. 154.

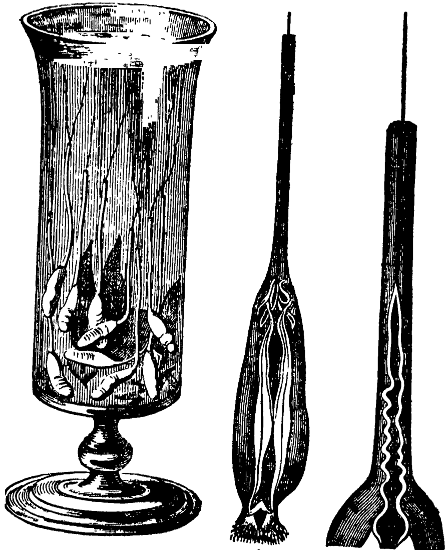
like the grub of the gnat, we know not, but they perfectly repel water; and at the point where the insect hangs suspended, a small dimple may be observed on the surface. When it wishes to dive to the bottom, it has the power of bringing the ends of the hairs together, without diminishing the capacity of the funnel below; and a globule of air, for the purpose of breathing under water, is thus enclosed and carried down, appearing, as Swammerdam says, like a brilliant pearl or polished silver. "As for my part," he adds, "I dare boldly affirm, that the incomprehensible greatness of the Deity manifests itself in these mysterious operations in a particular manner, and affords us an opportunity of examining, as it were, with our senses, the divine nature*."



Buoy-like structure in the tail of a water-grub of a two-winged fly (*Stratiomys Chamæleon*).

* Swammerdam, part ii, 51.

The preceding grub may occasionally be found in shallow ditches, and about the edges of ponds, in summer; but a remarkable larva, with a very different apparatus for breathing, is much more common in similar situations, and also in the open drains from dunghills, &c. The latter is the maggot of a two-winged, bee-like fly (*Helophilus pendulus*, MEIGEN), and from its shape is appropriately termed *rat-tailed* by Réaumur. The tail is the part of the grub which most merits attention, being formed somewhat after the telescopic model of the ovipositor of the breeze flies*,

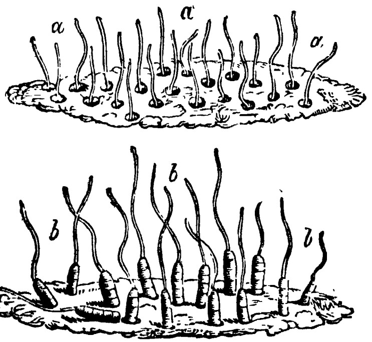


a *b* *c*

Telescopic-tailed water larvæ. *a*, a glass vessel of water containing the larvæ, natural size. *b*, magnified view of the tail, with the breathing-tube partially contracted. *c*, a still more enlarged view of the tail.

* See Insect Architecture, p. 403.

but consisting only of two tubes, the outer one serving as a sheath, within which the inner one can be retracted at pleasure. Both of these are composed of fibrous rings; and are so very extensile, that Réaumur has seen them pushed out to twelve times the length of the body of the maggot. The contrivance by which the inner tube is pushed out is no less simple than ingenious. It is furnished at the base with two flexible pipes, coiled up, when it is sheathed, into several folds, and communicating with the double wind-pipe (*Trachea*) in the body. When it wishes to extend this breathing-tube, therefore, it inflates, by means of air from the wind-pipe, the flexible pipes, and in this way pushes them outward, and with them the breathing-tube, to the extent required. The breathing-tube itself is very slender, but terminates similarly to those of the grub of the chameleon fly, in five bristles. This breathing apparatus is admirably adapted to the economy of these maggots; as from their seeking their food amongst ooze and mud, they would often be exposed to suffocation, which their extensile tube effectually prevents.



Water worms (*Nais*). *a a a*, half-concealed in the sand. *b b b*, their sand-tubes exposed.

It may not be improper to guard our younger readers against mistaking for these telescopic-tailed larvæ, an animal, found in the same situations, which has a considerable general resemblance to them, though it is not even an insect, but a water-worm (*Nais*), upon which Bonnet made numerous curious experiments. The *nais* may be easily known by its being reddish, while the maggot is of a dirty white colour.

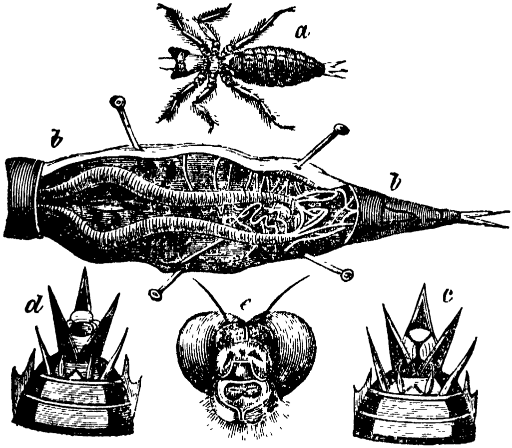
It appears to be the *nais*, or some similar fresh-water worm, which medical men, unacquainted with natural history, have supposed to get into the human stomach through the medium of water, as we shall presently notice.

A no less singular structure for respiration than that just described, occurs in the aquatic larvæ of the dragon-flies (*Libellulidæ*, LEACH), which differ so remarkably from the perfect insects in the beauty of colour and elegance of form that has procured for them the gallant appellation of damsels (*demoiselles*) in France. This title agrees as badly with their habits as the popular English name of *horse-stingers*, since they have no apparatus for stinging; "and so far," says Réaumur, "from seeking an innocent nutriment in the pulp of fruits, or the nectar of flowers, they are more like amazons than damsels, hovering in the air only to pounce upon other insects, which they crush with their powerful mandibles. Should they quit the margin of a pond or the banks of a rivulet, where they may be seen hawking about in multitudes, it is only to pursue and seize the moth or the butterfly, that has fled for shelter to the bushes."

Though these larvæ are furnished with six feet, they not only move very little, but do not use them for walking so much as for capturing their prey. Their motion is effected by a very peculiar method. When one of these larvæ is procured from the bottom of a pond or the pool of a brook, let it be put into a large saucer with water, with some of the dead leaves or sticks it previously employed as a covering; these will soon be seen floating towards the tail, and afterwards repelled, as a floating feather will be by a stick of sealing-wax, or a bit of amber, when electrically excited. When the insect has been kept out of the water for a short time, the desire, or necessity, of respiration is increased, and when again put into the water, the pumping is repeated with unusual force and frequency. If it be held in the hand, head downwards, and some drops of water be let fall on its tail, it instantly sucks it in, and the dimensions of its body become visibly augmented; but it collapses again when the water is expelled, which is effected by the same apparatus.

While in the water, if a solution of cochineal, saffron, indigo, or any other coloured fluid, be let down, with great care, by means of a glass tube, just over the tail of the insect, it will soon be seen to eject a stream of the coloured solution to the distance of several inches. Or the same may be seen by removing it suddenly out of a coloured fluid into limpid water; when the coloured jet stream will be still more conspicuous. The most extraordinary circumstance respecting this jet is, that it propels the creature through the water in consequence of its being resisted by the stationary mass of the fluid behind it, and a contrary current being thence produced by this singular pumping. As the insect, between every stroke of the internal piston, is obliged to draw in a fresh supply of water, an interval consequently occurs between the strokes, during which it will sometimes elevate its tail above water and squirt out a small stream like that from a little syringe.

This wonderful apparatus serves several purposes; for, besides aiding the insect to move, the reverberatory current brings small water insects within its reach: it is also it would appear, partly appropriated to respiration, like the gills of fish, though there are several other spiracles in other parts of the body communicating with the large convoluted windpipes. The anal apparatus is surrounded with five hard, moveable, triangular pieces, all fringed with hairs, which it can open or shut at pleasure. The largest of these pieces is placed above, while the two smallest stand at the sides, and two of the middle size below. When they are shut close they form a blunt cone *.

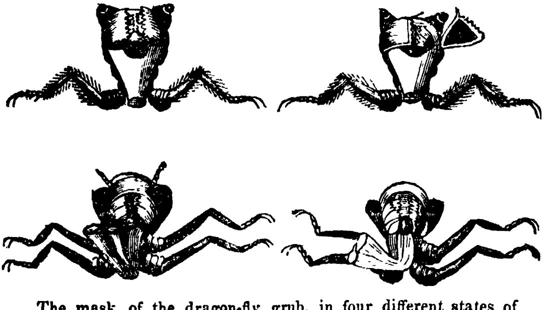


a, grub of a dragon fly; *b b*, the body laid open and magnified, to show the windpipes; *c*, the pumping apparatus shut; *d*, the same open; *e*, head of the insect.

It may not be out of place to take notice here of another singular structure in the same species of larvæ, which is probably unmatched in the insect world. In the larvæ of most insects the under-lip is small and inconspicuous, but in those of the dragon-flies,

* De Geer, ii. 666, and Réaumur, vi. 393, &c.

"it is," to follow the excellent description of Kirby and Spence, "by far the largest organ of the mouth, which, when closed, it entirely conceals, and it not only retains but actually seizes the animal's prey, by means of a very singular pair of jaws with which it is furnished. Conceive your under-lip (to have recourse, like Réaumur on another occasion, to such a comparison) to be horny instead of fleshy, and to be elongated perpendicularly downwards, so as to wrap over your chin, and extend to its bottom,—that this elongation is there expanded into a triangular convex plate, attached to it by a joint, so as to bend upwards again and fold over the face as high as the nose, concealing not only the chin and the first-mentioned elongation, but the mouth and part of the cheeks: conceive, moreover, that to the end of this last-men tioned plate are fixed two other convex ones, so broad as to cover the whole nose and temples,—that these can open at pleasure transversely like a pair of jaws, so as to expose the nose and mouth, and that their inner edges where they meet are cut into numerous sharp teeth, or spines, or armed with one or more long sharp claws;—you will then have as accurate an idea as my powers of description can give of the strange conformation of the under-lip in the larvæ of *Libellulina*, which conceals the mouth and face precisely as I have supposed a similar construction of your lip would do yours. You will, probably, admit that your own visage would present an appearance not very engaging while concealed by such a mask; but it would strike still more awe into the spectators, were they to see you first open the two upper jaw plates, which would project from each temple like the blinders of a horse; and next, having, by means of the joint at your chin, let down the whole apparatus and uncovered your face, employ them in seizing any food that presented itself, and conveying it to your mouth. Yet this procedure is that adopted by the larvæ of the dragon-fly provided with this strange organ. While it is at rest, it applies close to and covers the face. When the insects would make use of it, they unfold it like an arm, catch the prey at which they aim by means of the mandibuliform plates, and then partly refold it so as to hold the prey to the mouth in a convenient position for the operation of the two pairs of jaws with which they are provided. Réaumur once found one of them thus holding and devouring a large tadpole ; a sufficient proof that Swammerdam was greatly deceived in imagining earth to be the food of animals so tremendously armed and fitted for carnivorous purposes. In the larvæ of *Libellula*, FABR., it is so exactly resembling a mask, that if entomologists ever went to masquerades, they could not more effectually relieve the insipidity of such amuse-



The mask of the dragon-fly grub, in four different states of opening and shutting.

ments and attract the attention of the *demoiselles* than by appearing at the supper table with a *mask* of this construction, and serving themselves by its assistance. It would be difficult, to be sure, by mechanism, to supply the place of the muscles with which in the insect it is amply provided; but Merlin, or his successor, has surmounted greater obstacles*."

The larvæ of the dragon-fly do not, however, trust to this mask alone for surprising their prey, but steal upon it, as De Geer observes, as a cat does upon a bird, very slowly, and as if they counted their steps; and then, by suddenly unmasking, seize it by surprise: so artful are they that insects, and even small fishes, find it difficult to elude their attacks†.

The larva of a very singular insect (*Reduvius personatus*, FABR.), which preys upon the bed bug (*Cimex lectularius*), not being furnished with a mask, is at the pains to construct one, composed of dust, particles of sand, fragments of wool or silk, and similar matter, which makes it assume so very grotesque a figure, that the animal would at first be taken for one of the ugliest spiders. Its awkward motions add not a little to the effect of its odd appearance. It can, indeed, if it so chooses, move with considerable speed; but for the purposes of successful hunting, it endeavours to assume the aspect of an inanimate substance, and hitches along in the most leisurely manner possible. It only moves one leg at a time, and having set one foot forward, it pauses a little before it brings up the contiguous one, proceeding in the same way with its other legs. It is no less carefully cautious in moving its antennæ, striking, as it were, first with one, and then, after a short pause, with the other. By means of a camel's hair pencil, or a feather, it is easy to unmask the insect, for, when touched, it usually abandons its covering.

* Introd. to Ent. iii. 126. † De Geer, ii. 674.

CHAPTER VII.

Growth, Moulting, Strength, Defence, and Hybernation of Larvæ.

FROM the facts being commonly known, we are not surprised, that an ostrich, nine feet high and 150 lbs. weight, should be produced from an egg about the size of a cocoa-nut, or that "a grain of mustard-seed —the least of all seeds—when it is grown," should become "a tree (*Phytolacca dioica?*), so that the birds of the air come and lodge in the branches thereof*." But when similar facts are recorded by naturalists respecting insects, general readers are apt to wonder, because they are less familiar with these details, than with the economy of trees springing from seeds and birds being produced from eggs. When we repeat, after Lyonnet, that the caterpillar of the goat-moth (*Cossus ligniperda*, FABR.) becomes 72,000 times heavier than when newly hatched†, we do not state anything more striking and admirable than that an embryo of small dimensions should become an elephant, or that an acorn should produce a lofty and magnificent oak. The facts respecting the growth of insects have an adventitious interest, because, in consequence of the minuteness of the objects to which they relate, they are less familiar to popular observation. In the instance of the silk-worm, the progress of growth has been accurately ascertained by scientific cultivators. It appears that a single caterpillar, weighing when first hatched only the hundredth part of a grain, consumes in thirty days above an ounce of leaves,—that is to say, it devours in vegetable sub-

* See Irby and Mangle's Travels, letter v.

† Traité Anat. de la Chenille, p. 11.

stance about 60,000 times its primitive weight. In warmer climates, silk-worms consume a rather less quantity of leaves, because these are perhaps more nutritive; but, in that case, the silk produced is not so delicate and fine. The following statements are the result of experiments made by Count Dandolo:—

Progressive increase of silk-worms in weight.

	GRAINS.
A hundred worms just hatched weigh about	1
After the first moulting	15
After the second moulting	94
After the third moulting	400
After the fourth moulting	1628
On attaining their greatest size and weight	9500

They have, therefore, in thirty days increased 9500 times their primitive weight.

Progressive increase of silk-worms in length.

	LINES.
A silk-worm just hatched measures about	1
After the first moulting	4
After the second moulting	6
After the third moulting	12
After the fourth moulting	20
After the fifth moulting it may reach	40

The length of the silk-worm, therefore, increases about forty times in twenty-eight days*.

By recalling to memory the comparisons of the eggs of insects with the seeds of plants, and of caterpillars with buds, which ought to be taken (if we may trust Swammerdam) literally rather than poetically, we shall arrive at more distinct notions of the manner in which the growth and changes of larvæ are accomplished. The buds of plants are composed of successive leaves closely embosomed within each other's foldings, the outer one being generally hard and corneous, from the exposure of its vessels to the colds of winter, while the inner

* Count Dandolo on Silk-worms, p. 326, Eng. Trans.

leaves, being thence protected, remain soft and pulpy. But as soon as the inner leaves receive an accession of sap, which rises from the roots on the return of spring, their vessels swell and their nervures expand; while the outer leaf, from its vessels being shrunk and partly obliterated, undergoes little change besides being pushed out and sometimes entirely thrown off by the growth of the inner leaves, which it had previously enclosed. It may be remarked, also, that this outer envelope of a bud is not united with the inner leaves by any interlacing of their substance or of their vessels, though in some cases there is an adhesive gluten which partly binds them together; but this is never so strong as to prevent the expansion of the leaves. On comparing one of the bud envelopes thus thrown off, we can scarcely persuade ourselves that so small a covering could ever have contained the large spreading leaves which have burst from them.

A caterpillar corresponds in several circumstances with the leaf bud. The outer skin encloses a succession of several other skins, each becoming more delicate, soft, and indistinct than the one exterior to it, but gradually, like the expanding leaves, growing more substantial and firm as it receives a supply of nutriment. The chief mechanical difference between the leaves folded up in the bud and the successive caterpillars enveloped within the skin of one newly hatched, is that the leaves in the bud receive all their nourishment through their foot-stalks from the root of the tree, whereas the caterpillar is nourished from within by the food digested in its stomach. The superfluous nourishment, usually in considerable quantity, and called the *fat* of the caterpillar, appears to lie between the successive skins, in a similar way to the adhesive gluten in the leaf bud. But as the first inner skin expands and increases in consistence, the fat which lies between it and the outer skin seems to be absorbed into the body of the caterpillar, and of course swelling it out; while its abstraction from the interior of the outer skin renders this much more dry, separates it from the inner skin, and disposes it to harden and shrivel.

The absorption of the fat also produces the remarkable consequence of gorging all the channels of nutrition, so that there is no longer any demand upon the stomach for fresh supplies of food; and hunger (which we imagine is caused either by the want of the accustomed pressure of food on the terminal nerves in the stomach, or of the irritation of the absorbents when they are left empty) is no longer felt. The caterpillar accordingly ceases to eat, and having no incentive to action remains motionless. The outer skin, in the meanwhile, being deprived of its internal moisture by the absorption of the fat, goes on to harden and shrink, while all the internal organs become enlarged by the nutritive fat. The expansion, therefore, of the body of the caterpillar on the one hand, and the shrinking of the old skin on the other, produce a mutual struggle, which, from the continued operation of the causes, must, it is obvious, be soon brought to a termination.

The skin, from losing its internal moisture, loses also a portion of its colour, and becomes obscure and dull; and the caterpillar, from being girt and squeezed by its pressure, begins to turn and twist itself in various directions, to rid itself if possible of the inconvenience. By continuing these movements, the creature succeeds at length in rending the old skin at its weakest part, which is usually on the back, just behind the head; and in a few minutes, using its body as a wedge, it may be seen issuing through the breach*. The old skin is thus abandoned

* Réaumur, Mem. i. 185.

like a worn shirt; and the caterpillar appears in an entire new dress, the tints of which are fresher and brighter, and the colours and markings often considerably different from the former. The insect, also, in consequence of the quantity of fat which has gone to augment its several parts, becomes all at once so much enlarged in size, that we can with difficulty conceive how it could have been contained in the old skin, out of which it has just crept. The cast skin is frequently so very perfect that it might almost be supposed to be the caterpillar itself, particularly in those which are hairy, as this contributes to conceal the shrivelling.

That the above account of the process of casting the skin is correct, appears both from the careful dissections which have been made by Swammerdam, Lyonnet, and Ramdohr, and also from the diseases incident to caterpillars from deficiency of food or of pure air. It is a circumstance of common occurrence to those who are in the habit of breeding insects, that when they are not supplied with a sufficient quantity of food, their bodies do not increase enough in thickness to rupture the old skin; yet this becomes in due time hard and shrivelled from the absorption of the fat, though the insect, from its inability to break through, remains imprisoned. It might be supposed, that if plenty of food were at this moment supplied, it would subsequently acquire sufficient bulk and strength to rupture and escape from the old skin; but this is impossible, as we have repeatedly found to our great disappointment. In the instance of the caterpillar of the moth, called by collectors the glory of Kent (*Endromis versicolora*, STEPHENS), which we found on a lime-tree at Lee, and were anxious to rear, fresh food was neglected to be given to it a short time before its third moult; and from that time it refused to eat, and soon died. By minute examination we found that it was impossible for it to eat, as all its organs were in a state of forward preparation for throwing off their exterior coat,—the old skin, in fact, covering them as a glove does the hand, and the new head lying distinctly farther back than the old. Neither the old mandibles therefore, which were become dry and stiff, nor the new ones, which were encased in these, could bite the leaves; and even if this had been accomplished, the entrance to the gullet was obstructed by the shrivelling of the old skin there, and deglutition could not have taken place. The poor caterpillar was in consequence starved to death in the midst of abundance of food, which it could neither chew nor swallow. Had it been skilfully assisted (as it was not) to get rid of the encumbrance of its old skin, we doubt not that it might ultimately have recovered *. Réaumur mentions the very singular circumstance of a caterpillar of the six-spot burnet moth (*Anthrocera Filipendulæ*, STEPHENS) having actually, before its last moult, bit off portions of its old skin, which it first raised up and afterwards detached and tossed away. He did not, however, ascertain whether this was an accidental manœuvre, or the usual process of this species of caterpillar †; though the first, we think, is the more probable.

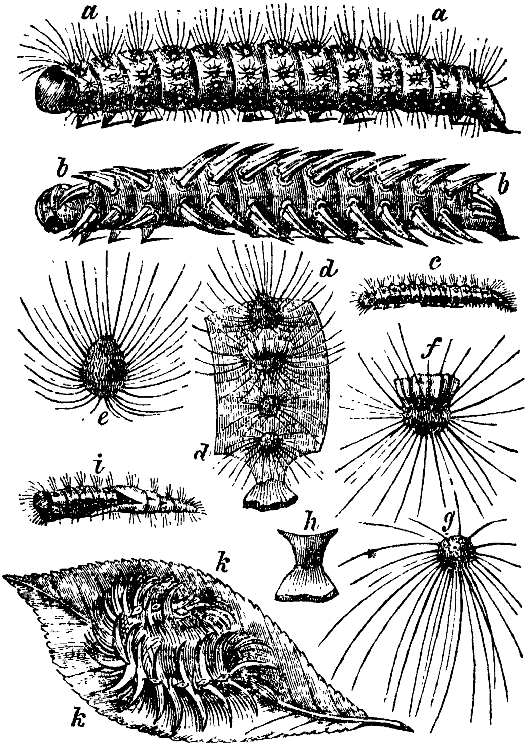
The disorder called the *Reds* by the breeders of silk-worms, shows itself in red-coloured stains and blotches upon the skin; while the caterpillars seem cramped, stupified, and suffocated, their rings dry up, and they look exactly like mummies. Count Dandolo refers this and most other diseases of silk-worms to chemical agency. The great quantity of vegetable food devoured by caterpillars must be liable during hot weather to fermentation, if it be not digested

* J.R. † Réaumur, Mem. ii. 75.

soon after it is swallowed,—a process which often terminates in the production of an acid; and as acids have a tendency to redden vegetable colours, the red blotches are plausibly ascribed to that cause. This conjecture, which originated with Count Dandolo, has been proved to be the fact by Professor Brugnatelli; who made the very unexpected discovery that the red matter contains uric acid combined with ammonia, and consequently that the disorder is similar in its proximate cause to what is called the red gravel (*Lithia renalis β*, Good) in man. This acid, then, from its excess in diseased caterpillars, impedes the process of nutrition, and prevents the animal from acquiring sufficient strength to throw off the old skin when the time for this arrives.

It appears, also, from the experiments of Count Dandolo, that though caterpillars can live longer in air deprived of oxygen, or otherwise contaminated, than warm-blooded animals, yet they do not thrive, and are very liable to diseases, when they have not access to fresh air. In other words, the food which has been digested cannot without oxygen be converted into the fluid analogous to blood; and in such cases, as we have repeatedly witnessed, instead of being appropriated to nourishment, it is thrown into the intestines, producing diarrhœa, or *scour*, as it is termed by the cultivators of the silk-worm. In this case the inner skin never acquires sufficient consistence, nor can the old one ever become dry enough to be cast.

One of the most singular circumstances respecting the moult of caterpillars, is the manner in which the hairs are disposed in the new skin before moulting. These are not, like the feet and other organs, sheathed in the hairs of the old skin, but smoothly folded down in separate tufts; and if the old skin be removed a short time before it would be naturally cast, these tufts may be seen in a moist state, very similar to small wetted camel's-hair pencils lying



Moulting of caterpillars. *a a*, caterpillar magnified; *b b*, the same when it has just cast its skin, the hairs still moist; *c*, the same, natural size; *d e f g*, tufts of its hairs magnified; *h*, leg and foot magnified; *i*, the caterpillar wedging through the old skin; *k k*, hairy caterpillar of the sycamore.

close to the inner skin,—those on the fore part of the body laid towards the head, and from the fourth ring backwards in a contrary direction.

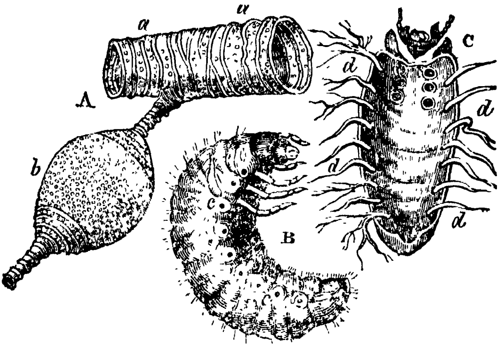
Swammerdam, Réaumur, and other naturalists, repeatedly tried the experiment of cutting off the hair from caterpillars about to moult, without in the least affecting the hairs on the new skin ; but when a foot or any other member is accidentally mutilated, it is also wanting in the moulted caterpillar, facts which strongly corroborate the details we have given above.

It is a still more singular circumstance, ascertained by Swammerdam, De Geer, Lyonnet, and Bonnet, that caterpillars and grubs not only cast their external skins, but also that which lines their breathing-tubes and intestines. " Some days," says Bonnet, "before the change, the caterpillar voids along with its excrements the membrane which invests the interior of its stomach and intestines. I have also remarked, that during the moult, packets of the tracheal vessels may be seen attached to the cast skin, and thrown off along with it." De Geer has distinctly seen white fibres proceeding from the interior spiracles of a butterfly remain attached to the pupa-case. He conjectures that these fibres consist of the delicate membrane which lines the wind-pipes; and that they are moulted like the lining of the stomach of a lobster, or of a caterpillar. Lyonnet, in some measure, confirms this conjecture*.

In his admirable description of the rhinoceros-beetle (*Oryctes nasicornis*), Swammerdam says of the grub : "Nothing in all nature is, in my opinion, a more wonderful sight, than the change of skin in these and other the like grubs. This matter, therefore, deserves the greatest consideration, and is worthy to be called a specimen of Nature's miracles. For

* Bonnet, Œuvres, vol. viii. pp. 303-311.

it is not the external skin only that these grubs cast, like serpents; but the throat and a part of the stomach, and even the inward surface of the great gut, change their skin at the same time. Yet this is not the whole of these wonders; for at the same time some hundreds of breathing-pipes within the body of the grub cast also each its delicate and tender skin. These several skins are afterwards collected into eighteen thicker, and, as it were, compounded ropes, nine on each side of the body, which, when the skin is cast, slip gently and by degrees from within the body through the eighteen apertures or orifices of the tubes before described, having their tops or ends directed upwards towards the head. Two other branches, also, of the breathing-pipes, that are smaller and have no point of respiration, cast a skin likewise. If any one separates the cast little ropes or congeries of breathing-pipes with a fine needle, he



Exuvia and pulmonary vessels of the rhinoceros beetle (*Oryctes nasicornis*). A, magnified view of a pulmonary branch and vesicle; *a a*, pulmonary branch, composed of a membranous sheath and cartilaginous rings; *b*, vesicle. B, larva; *c c*, nine reddish breathing-holes. C, exuvia, or cast skin of the larva; *d d d d*, skins of the pulmonary tubes.

will very distinctly see their several branches and ramifications, and also their ringed structure*."

The caterpillars of moths and butterflies generally cast their skins five times; but some cast them seven and even ten times, as in the case, according to Cuvier, of the great tiger-moth (*Arctia Caja*, STEPHENS). By the breeders of silk-worms this natural process is ranked among their maladies; and not altogether without reason, as it frequently proves fatal, from causes to which we have already alluded. For several hours, often for a whole day, after casting the skin, the caterpillar continues sluggish and moves little; and as the vessels are still replete with the fat previously absorbed, there is no stimulus for it to eat. But as soon as this supply is exhausted, it commences again to eat voraciously, in order to supply another store of fat for its succeeding moult.

The moulting of caterpillars, it may be remarked, bears but a slight resemblance to the casting of the feathers in birds, and the hair in quadrupeds. Birds generally cast their feathers once, and many twice, a-year, namely, in autumn and in spring†; and quadrupeds in a similar way cast their hair. But in both these cases the process is gradual, and resembles that of shedding the milk-teeth when the jaw enlarges. All of these changes, however, produce considerable derangements in the animals; and they are seldom accomplished without disordering health, and sometimes endangering life. The great difference between the changes in insects and the other classes of animals evidently arises from the difference of their internal structure. It must be obvious to all, for example, that the human body wears. As old age advances the bones waste away and become smaller, the muscles and skin shrink and

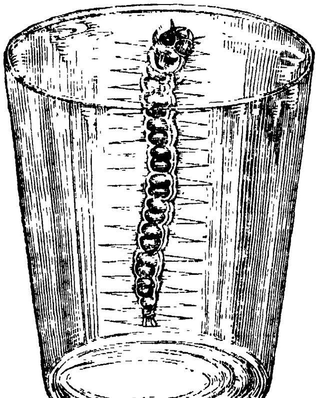
* Swammerdam, Bib. Nat. vol. i. p. 135.
† Temminck, Manuel d'Ornithol. Intr.

grow dry and shrivelled, and the stature grows shorter and more diminutive. Even in youth similar changes are in progress, a system of absorbent vessels being provided for removing worn materials from all parts of the body, and carrying at least one portion of these along with the blood into the lungs, whence it goes off in minute particles with the breath. No similar process of removing worn materials has, so far as we know, been discovered in caterpillars; and it is, indeed, improbable, as the successive changes of the skin accomplish all that is wanted in this respect. That the worn materials, however, of the cast skins are not altogether useless, appears from the singular circumstance of the new-clothed caterpillar often devouring them, as that of the hawthorn-butterfly (*Pieris Cratægi*, STEPHENS) does the shell of the egg it has just been hatched from*. It may be remarked, that it is chiefly the larger caterpillars of the puss and some of the hawk-moths which have been observed to eat their skins; none of the spinous or hairy ones seem to relish this strange sort of food. In the case of the warty-eft (*Triton palustris*, FLEM.), which frequently casts its outer skin, we have observed that it is frequently eaten by the animal itself†.

The grubs of some two-winged flies (*Muscidæ*), and of wasps, bees, ants, and ichneumon flies, do not change their skins like the larvæ we have just been considering; but spiders and other allied tribes (*Arachnidæ*), though they exhibit no other appearance of larvæ, moult frequently during their growth. Goldsmith, amongst other curious mis-statements respecting a house-spider which he himself observed, asserts that it "lived three years, every year it changed its skin, and got a new set of legs: I have sometimes plucked off a limb, which grew

* Bonnet, Œuvres, vol. ii. p. 18. † J. R.

again in two or three days." The fact is, that few spiders live one year, much less three; and all their changes of skin are gone through in a few months, and their acquiring new legs for mutilated ones takes some weeks. It is probable, indeed, that Goldsmith never thought of ascertaining the identity of this spider; if the whole story be not a mere fancy, like his assertion that spiders, "when they walk upon such bodies as are perfectly smooth, as looking-glass or polished marble, squeeze a little sponge which grows near the extremity of their claws, and thus diffusing a glutinous substance, adhere to the surface till they make a second step *." Neither spiders nor any insects with which we are acquainted can thus produce gum from their feet to aid them in walking upon glass,



Goat moth caterpillar (*Cossus ligniperda*) escaping from a drinking glass, by spinning a ladder of silken ropes.

* Animated Nature, pt. vi. ch. iii. See also Insect Architecture, pp. 367-8.

though the house-fly can walk thus by causing a vacuum between its feet and the glass, as we shall subsequently describe at length. But the spider and all caterpillars can only climb in such cases by constructing a ladder of ropes, as is represented by Rösel in the instance of the goat moth caterpillar.

One of these caterpillars, which we possessed*, made its escape in a manner much more unexpected, if not so ingenious, by means of its great muscular power, in which, it is not a little singular, that insects, as Baron Haller remarks, appear to excel in proportion to their diminutiveness. Of this we have a remarkable example in the common flea, which can draw seventy or eighty times its own weight†. The muscular strength of this agile creature enables it not only to resist the ordinary pressure of the fingers in our endeavours to crush it, but to take leaps to the distance of two hundred times its own length; which will appear more surprising when we consider that a man, to equal the agility of a flea, should be able to leap between three and four hundred yards. The flea, however, is excelled in leaping by the cuckoo-spit frog-hopper (*Tettigonia spumaria*, Olivier), which will sometimes leap two or three yards, that is, more than 250 times its own length‡; as if (to continue the comparison) a man of ordinary stature should vault through the air to the distance of a quarter of a mile. The minute observation by which such unexpected facts are discovered has in all ages been a fertile source of ridicule for the wits, from the time when Aristophanes in his Clouds introduced Socrates measuring the leap of a flea§, up to Peter Pindar's lampoon on

* See Insect Architecture, p. 189.
† Haller, Physiol., vol. ix. p. 2.
‡ De Geer, Mem., vol. iii. p. 178.
§ Aristophanes, Νεφέλαι, ά, β.

Sir Joseph Banks and the emperor-butterfly. To all such flippant wit we have merely to retort the question of the Abbé de la Pluche, " if the Deity thought insects worthy of his divine skill in forming them, ought we to consider them beneath our notice * ?"

Mouffet, in his Theatre of Insects†, mentions that an English mechanic, named Mark, to shew his skill, constructed a chain of gold as long as his finger, which, together with a lock and key, were dragged along by a flea; and he had heard of another flea which could draw a golden chariot, to which it was harnessed. Bingley tells us that Mr. Boverich, a watchmaker in the Strand, exhibited some years ago a little ivory chaise with four wheels, and all its proper apparatus, and the figure of a man sitting on the box, all of which were drawn by a single flea. The same mechanic afterwards constructed a minute landau, which opened and shut by springs, with the figures of six horses harnessed to it, and of a coachman on the box, a dog between his legs, four persons inside, two footmen behind it, and a postilion riding on one of the fore horses, which were all easily dragged along by a single flea ‡. Goldsmith remarks upon these displays of pulician strength, that the feats of Samson would not, to a community of fleas, appear to be at all miraculous §. Latreille tells us a no less marvellous story of another flea, which dragged a silver cannon twenty-four times its own weight, mounted on wheels, and did not manifest any alarm when this was charged with gunpowder and fired off ||. Professor Bradley, of Cambridge, also mentions a remarkable instance of insect strength in a stag-beetle (*Lucanus Cervus*)

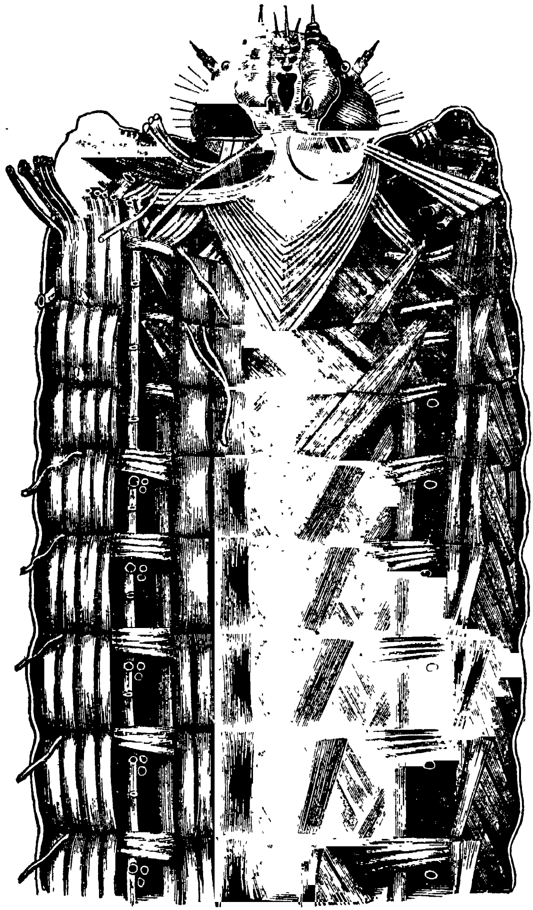
* Spectacle de la Nature, i. 3. † Page 275.
‡ Animal Biography, iii. 468. § Animated Nature, iv. 178.
|| Nouv. Dict. d'Hist. Nat. xxviii. 249.

which he saw carrying a wand a foot and a half long, and half an inch thick, and even flying with it to the distance of several yards*.

It has been remarked, with reference to these facts of comparative size and strength, that a cock-chafer is six times stronger than a horse; and Linnæus observes, that if an elephant were as strong in proportion as a stag-beetle, it would be able to tear up rocks and level mountains. The muscular power of fish, however, seems to bear a near comparison with that of insects. "I have seen," says Sir Gilbert Blane, "the sword of a sword-fish sticking in a plank which it had penetrated from side to side; and when it is considered that the animal was then moving through a medium even a thousand times more dense than that through which a bird cleaves its course at different heights of the atmosphere, and that this was performed in the same direction with the ship, what a conception do we form of this display of muscular strength †." It should, however, be observed, that the muscular power of the sword-fish is principally shewn in the rate of swimming, by which the animal overtakes the ships, and thus acquires the momentum which determines the force of the blow. We may understand the proximate cause of the strength of insects, when we look at the prodigious number of their muscles—the fleshy belts or ribbons by whose means all animal motions are performed. The number of these instruments of motion in the human body is reckoned about 529; but in the caterpillar of the goat-moth, Lyonnet counted more than seven times as many: in the head, 228; in the body, 1647; and around the intestines, 2186; which, after deducting 20,

* Bradley, Phil. Account, p. 184.

† Sir Gilbert Blane, Select Diss. p. 281.



Magnified view of the principal dorsal muscles of the upper half of the Cossus, from Lyonnet.

common to the head and gullet, gives a total of 4061 *.

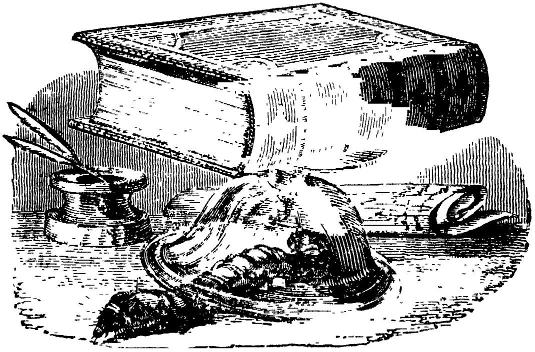
"Any lady," says Kirby and Spence, "fond of going to be tempted with an exhibition of fine lace, would experience an unexpected gratification could she be brought to examine the muscles of a caterpillar under the microscope: with wonder and delight she would survey the innumerable muscular threads that in various directions envelope the gullet, stomach, and lower intestines of one of those little animals;—some running longitudinally, others transversely, others crossing each other obliquely, so as to form a pattern of rhomboids or squares; others, again, surrounding the intestine like so many rings, and almost all exhibiting the appearance of being woven, and resembling fine lace,—one pattern ornamenting one organ; another, a second; and another, a third †."

We put the caterpillar of the goat-moth, to which we have before alluded, under a bellglass, which weighed nearly half a pound, and of course more than ten times the weight of the insect; yet it raised it up with the utmost ease. We then placed over the glass the largest book which we had at hand—"Loudon's Encyclopædia of Gardening," consisting of about 1500 pages of strong paper, and weighing four pounds; but this did not succeed in preventing the escape of the animal, which raised the glass, though loaded with the book, nearly a hundred times its own weight, and made good its exit ‡. The multiplicity of its muscles above enumerated, two hundred and thirty-six of which are situated in the legs alone, will enable us to understand how this extraordinary feat was performed. Even this power of muscle, however, would doubtless have been un-

* Lyonnet, Traité Anat. de la Chenille, pp. 188, 584.

† Intr. iv. 186. ‡ J. R.

availing in raising the loaded glass, except in connexion with two favourable circumstances under which the experiment was performed, and which are necessary to be borne in mind to render the operation perfectly credible:—1st, that the wedge-like form of the caterpillar's head, in connexion with the peculiar shape of the glass, enabled it to lift it;—and 2d, that, one side of the glass resting on the table, the insect only bore half the weight of the glass and book.



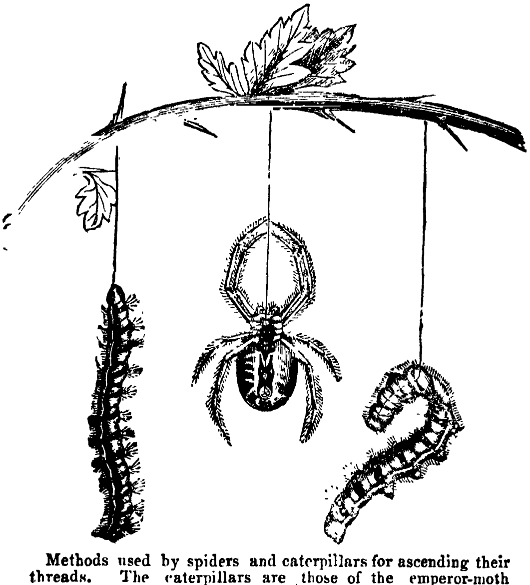
Caterpillar of Cossus escaping from under a loaded glass.

A peculiar toughness of external covering sometimes supplies the place of this muscular power in caterpillars. A singular instance occurs in the history of a common downy two-winged fly, with grey shoulders and a brown abdomen, (*Eristalis tenax*, FABR.). The grub, which is rat-tailed, lives in muddy pools, with the water of which it has sometimes been taken up by paper-makers, and, though subjected to the immense pressure of their machinery, it has survived in a miraculous manner. Such is the account originally given by Linnæus *. A recent compiler, mistaking Kirby and Spence's very apt comparison of this grub to a London porter nicknamed Leather-coat-Jack, from his being able to suffer carriages to drive over him without receiving any injury, forthwith fancies the porter to be "another insect, called leather-coat-jack," which "will bear heavy carriage wheels to pass over it with impunity." Since the grub in question is rather soft, it must be the tough texture of the skin which preserves it, as in the similar instance of the caterpillar (figured at page 125) of the privet hawk-moth (*Sphinx Ligustri*), which Bonnet squeezed under water till it was as flat and empty as the finger of a glove, yet within an hour it became plump and lively as if nothing had happened †.

The instances, however, which we have just recorded are peculiar rather than general, for caterpillars are for the most part very easily bruised and otherwise injured. Those which are large and heavy, therefore, such as the caterpillars of the hawk-moths (*Sphingidæ*), have the power of attaching themselves very firmly to the spots where they feed and rest by means of the numerous hooks of their pro-legs ‡, so that it is almost impossible to detach them from the branch to which they are clinging; and hence collectors always cut the branch itself. All of them have the means of breaking their fall by spinning a cable of silk, which they uniformly do when accidentally forced to quit their situation. Their method of climbing up this cable again is worthy of observation, for it differs considerably from the manœuvre of spiders, under the same circumstances; as must be

* Fauna Suecica, 1799.
† Bonnet, Œuvres, vol. ii. p. 124.
‡ See Insect Architecture, p. 307, right-hand figure.

obvious when we consider that the spinneret of the spider is placed near its tail, while that of the caterpillar is in its mouth. The spider accordingly drops head downwards*, but when it wishes to remount the line, it turns round, and raising its head, it stretches its long triple-clawed legs † up the line, which it bundles up while it ascends. The caterpillar, on the other hand, having very short legs, with only one smooth claw ‡, would make but slow progress in this manner, which it does not attempt; but bending its head downwards till it can grasp the

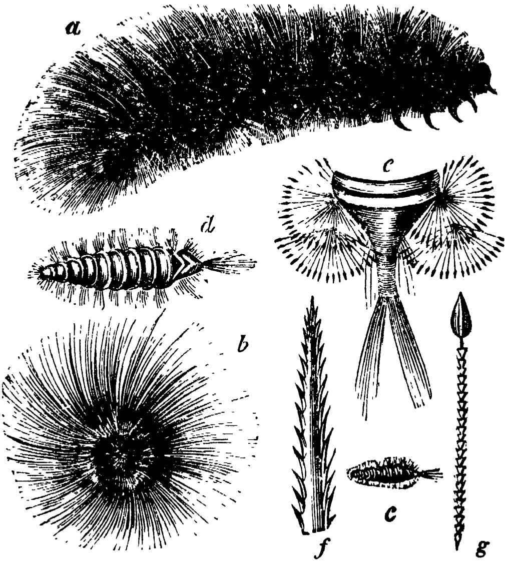


Methods used by spiders and caterpillars for ascending their threads. The caterpillars are those of the emperor-moth (*Saturnia Pavonia*).

* Insect Archit., page 336. † Ibid., p. 367.
‡ Ibid., p. 307, left-hand figure.

cord with its hinder pair of feet, and then raising its head to the perpendicular position again, it thus effects one step, and proceeds in the same manner till it reaches the top.

Other caterpillars, when they are disturbed, employ a different method of breaking their fall without spinning a thread, taking advantage, for this purpose, of the long hairs which cover their body. Those who have seen a hedge-hog (*Erinaceus Europæus*), when attacked by a dog, roll itself up into a prickly ball, will readily conceive the manœuvre of the caterpillars to which we allude, it being precisely similar.



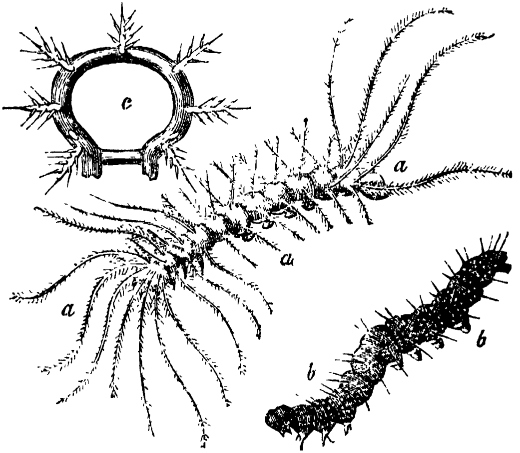
a, Caterpillar of the tiger-moth (*Arctia Caja*). *b*, the same rolled up for defence. *c*, grub of the museum-beetle. *d*, the same magnified. *e*, tail of the same, magnified. *f*, *g*, its hairs magnified.

Should one of those hairy caterpillars, when feeding near the top of a plant, be disturbed or alarmed, it instantly coils itself up into a ball and drops among the grass. Here it is not only difficult to discover, but equally so to lay hold of it; for the pliancy and smoothness of the hair causes it to slip through the fingers as readily almost as quicksilver. The grub of the museum beetle (*Anthrenus Museorum*, FABR.), the pest of our cabinets, affords another example of the same circumstance, being covered with tufts of diverging hairs which cause it to glide through the fingers as if they had been oiled. The six long tufts at the tail, which it can erect at pleasure, are composed of hairs, which rise from a bulb of the form of a halberd, and are curiously jointed with cones through their whole extent. The bead wood-louse (*Armadillo vulgaris*, CUVIER), though not furnished with hairs, rolls itself up into a round ball, trusting to the fine polish of its back for escape, and to its hardness for defence. "One of our maid-servants," says Swammerdam, "once found a number of these wood-lice in the garden contracted into round balls, and thinking she had found a kind of coral beads, she began to put them one after another on a thread; it soon happened that the little creatures, being obliged to throw off the mask, resumed their motions: on seeing which, she was so greatly astonished, that she flung down both them and the thread in great haste, crying out, and running away *."

The hairs with which the caterpillars of some of our finest native butterflies are furnished, are somewhat of the nature of bristles or thorns, being hard, inflexible, and sharply pointed. This is the case with the caterpillars of all the fan-winged butterflies (*Vanessæ*). We have alluded to that of the pea-

* Swammerdam, pt. i. p. 174.

cock's eye, which must be conspicuous to birds from its dark black colour, prettily dotted with white, aided besides by the gregarious habit of feeding in a colony of several dozens together; but if a thrush or a sparrow pounces upon one of them, the formidable spines must present an obstacle somewhat unexpected, perhaps, to the making of a comfortable meal. The ass, indeed, seems to relish the piquant stimulus of the thorns or thistles, and sheep, goats, and deer will browse on the still sharper leaves of holly*; but we think none of our soft-billed birds would venture on a thorny caterpillar. Madame Merian says "that the spines of the caterpillar of *Urania Leilus* are as hard as iron wire†." Abbot tells us that many American caterpillars sting like a



Thorny hairs of caterpillars. *a a a*, spiny caterpillar, from Madame Merian. *b b*, Vanessa Io. *c*, spines magnified.

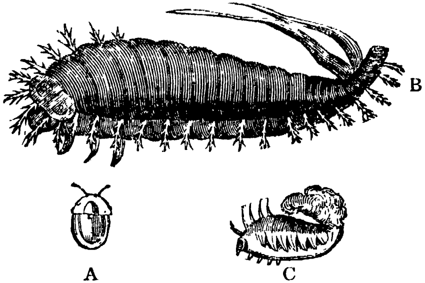
* Withering, Bot. Arrangement. Note on Ilex aquifolium.
† Merian, Insect. Surinam, xxix.

nettle, and blister the skin when touched; which is also partly exemplified in that of our own gipsey moth (*Hypogymna dispar*), the slender hairs of which irritate and inflame the skin. The spines, in some of the caterpillars alluded to, are like smooth thorns or prickles; but on others, they are beset, or feathered with shorter spines.

It is probably for some purpose of defence or concealment that the larvæ of several insects form a singular covering for themselves of their own excrements, which they pile up for that purpose upon their backs. This material, as Kirby has observed, is not always so offensive as might be supposed, being in some instances (*Cassida maculata et Imatidium Leayanum*) formed into fine branching filaments, like lichens or dried fucus*. Others, however, which Réaumur aptly terms Hottentots, do not appear quite so cleanly. One of these, rather uncommon, was observed, many years ago, by Vallisnieri, which he calls the cantharidis of the lily (*Crioceris merdigera*, Leach), and may be found in May on Solomon's-seal, and other liliaceous plants, which it devours and renders unsightly. Under its singular canopy, it has no resemblance to an insect, but looks like an oblong ball of chewed grass stuck on the lily. The beetle which is produced from the grub is of a fine brownish scarlet, and elegantly sculptured with minute dots. Another species, more abundant, similar in manners, and less than half the size of the preceding (*C. cyanella*, Panzer), is of a fine blue colour, with similar dottings. The grub of the green tortoise-beetle (*Cassida equestris*, Fabr.), usually found on burdocks, is furnished with a more ingenious mechanism for this purpose, consisting of a fork in its tail, which it can depress or elevate, so as to carry its strange canopy higher or lower, at pleasure. Like

* Linn. Trans. iii. 10.

the two preceding insects, this grub is also most unexpectedly transformed into a very pretty green beetle, of the form of a tortoise, the wing-cases of which project all round as a covering for the legs.



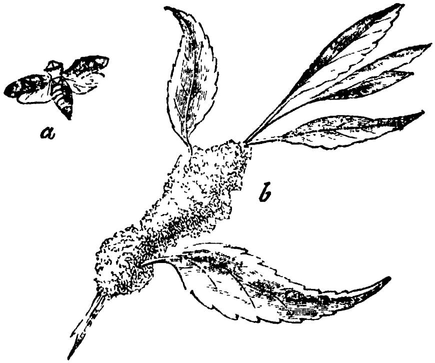
A, Cassida equestris. B, its grub magnified to shew its anal forks. C, the same with its canopy of excrements.

The larva of the golden-eyed fly (*Chrysopa perla*, LEACH), whose very singular eggs we formerly mentioned, covers itself with the fragments of the aphides which it has devoured,—a moving sepulchre of dry bones*.

A very familiar instance of this mode of defence occurs in the larva of the cuckoo-spit frog-hopper (*Tettigonia spumaria*, OLIVIER), so frequently seen in summer on willows, rose-trees, lychnis, grass, and other plants. This creature is of an exceedingly soft structure; and it is probably, therefore, as a protection from the sun, that it throws up all around it the little tuft of white froth, called, from a popular mistake, cuckoo-spit. The perfect insect is covered with hard wing-cases, of a brown colour, with a white spot and pale double band.

It would appear that the hair, which we have described above as covering the bodies of some caterpillars, is partly intended by nature to defend them from cold during the winter. The truth of this

* Réaumur, iii, 380 &c.



a, The spit frog-hopper (*Tettigonia spumaria*) flying. *b*, froth covering the grub of the same.

amounts almost to demonstration, from a circumstance discovered respecting ants by the younger Huber. " The larvæ of some ants," says he, " pass the winter heaped up in the lowermost floor of their dwelling. I have found, at this period, very small larvæ in the nests inhabited by the yellow ant (*Formica flava*), the field ant (*F. cæspitum ?*), and some other species. Those that are to pass the winter in this state are covered with hair, which is not the case in summer; affording another proof of that Providence at which naturalists are struck at every step*." The same growth of a warmer clothing for the winter is well known to occur among quadrupeds, particularly those which inhabit the higher northern atitudes†.

Upon the same principle, a number of the caterpillars which are hatched late in autumn, and are destined to live over winter, are provided with a warm clothing of hair or down. This is the case even with most of those which construct for them-

* M. P. Huber on Ants, p. 82.
† See Menageries, vol. i., p. 50.

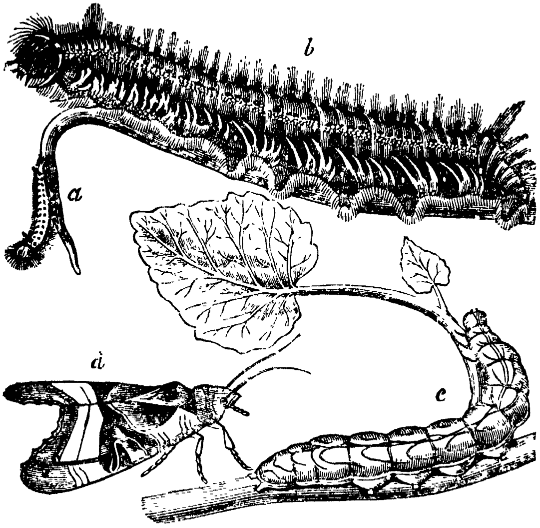
selves a snug nest of silk, such as the caterpillars of the brown-tail moth (*Porthesia auriflua*), and those of the mallow butterfly (*Hesperia malvæ*). But there are others which are provided with no extraneous covering, farther than the occasional shelter they may obtain by crawling under withered leaves, the copings of walls, or the bend of a branch. Among these some are thickly covered with hair, of which we have an instance in the caterpillar of the great tiger moth (*Arctia caja*, STEPHENS), whose mode of rolling itself up into a ball we have already described; but a more remarkable example occurs in the caterpillar of the drinker moth (*Odonestis potatoria*, GERMAR.), whose very feet are covered with fine shaggy down. It is this, no doubt, which preserves it from becoming torpid during winter; and as it feeds on grass, it can always procure food during the severest weather. When a fine sunny day chances to break in upon the gloom of winter, this pretty insect may be often seen stretched at its full length on a low twig, or the withered stem of a nettle, basking in the sunshine with apparent delight. We kept one of them in our study during the winter of 1827-8; and it continued to feed sparingly till February, when, owing to neglect, it unfortunately died *.

There are several other caterpillars, however, which live during the winter, in a no less exposed manner, without being provided with any covering of hair; though some of these, we may remark, do not continue to feed, but become wholly or partially torpid, such as the caterpillar of the magpie moth (*Abraxas grossulariata*). Of this species we have observed numbers, about as thick as a crow-quill, remaining in the same position for weeks together, and never moving, except when some very considerable change of temperature, either colder or hotter, took place. They do not seem to select the warmest places

* J. R.

within their choice, being usually found on an exposed currant branch, or under the upper cross-bar of a paling. We observed one, during several months of the winter of 1828-9, stationary under the lintel of a door, where a continual current of air must have rendered it exceedingly cold. We have endeavoured to rouse some of these from their semi-torpidity by keeping them in a warm room; but though they would make a few lethargic and unwilling movements, none of them would eat, and the change always proved fatal*.

We might be led from this instance to conclude that caterpillars, not covered with hair, become torpid during winter; but such general conclusions



a, Young caterpillar of the drinker. *b*, the same full grown. *c*, smooth caterpillar of the angle shades. *d*, the moth of the same.

* J. R.

from particular facts seldom accord with actual nature, and ought never to be indulged in by naturalists who study accuracy. Another caterpillar, not uncommon in gardens, on the hollyhock and other plants, would at once disprove such an inference: we allude to that of the angle shades (*Phlogophora meticulosa*, OCHSENHEIMER). This caterpillar, which is exceedingly smooth, and is remarkable for changing in its last moult from a clear green to a yellowish brown, we have found during the whole winter in the folds of the fresh leaves of hollyhocks, cabbage-lettuce, savoys, &c., quite lively, and feeding in open weather by no means sparingly. Its defence from cold may perhaps consist in a superabundant supply of fat, which we may infer that it possesses from the soft flabby aspect. It is this circumstance which seems to protect whales from the polar cold; as well as bears during their torpidity.

Some caterpillars seem to have no less power of resisting severe cold than eggs; as authentic instances are recorded of their revival after being frozen stiff,—a circumstance also reported of some serpents in North America *. Dr. Lister in this way revived caterpillars frozen so hard as to chink like stones when thrown into a glass †; and Mr. Stickney exposed some grubs of a common crane-fly (*Tipula oleracea*, LINN.) to a severe frost, till they were congealed into masses of ice, yet several of them survived ‡. Réaumur, however, was unsuccessful in similar experiments on the gregarious moth of the fir (*Cnethocampa Pityocampa*, STEPHENS), so celebrated among the ancients as a poison §; for none of them survived a cold of 2° below zero, Fahr., by which they were frozen to ice ||.

* John Hunter, Obs. on Anim. Econ. p. 99.
† Goedart, Insect. p. 79. ‡ Kirby and Spence, Intr. ii. p. 453.
§ Plin. Hist. Nat. 38, 9. || Mem. ii.

Chapter VIII.

Voracity of Caterpillars, Grubs, and Maggots.

Insects, in the early stage of their existence, may be compared to an Indian hunter, who issues from his hut, as they do from the egg, with a keen appetite. As soon as he is successful in finding game, he gorges himself till he can eat no more, and then laying him down to sleep, only bestirs himself again to go through a similar process of gorging and sleeping; just so the larvæ of insects doze away a day or more when casting their skins, and then make up for their long fast by eating with scarcely a pause. Professor Bradley calculates (though upon data somewhat questionable) that a pair of sparrows carry to their young about three thousand caterpillars in a week*; but this is nothing when compared with the voracity of caterpillars. Of the latter we have more accurate calculations than that of Bradley, who multiplied the number of caterpillars which he observed taken in one hour by the hours of sunlight in a week. Redi ascertained by experiment that the maggot of the common blow-fly (*Musca carnaria*) becomes from 140 to 200 times heavier within twenty-four hours†; and the cultivators of silk-worms know the exact quantities of leaves which their broods devour. "The result," says Count Dandolo, "of the most exact calculations is, that the quantity of leaves drawn from the tree employed for each ounce of eggs amounts to 1609 lbs. 8 oz., divided in the following manner:"—

* Account of the Works of Nature.

† Esperienze de Insetti, p. 23.

	Sorted leaves. lbs.	oz.	Refuse. lbs.	oz.
First age	6	0	1	8
Second age	18	0	3	0
Third age	60	0	9	0
Fourth age	180	0	27	0
Fifth age	1098	0	102	0
Per ounce of eggs of sorted leaves....lbs.	1362	0	142	8
Refuse	142	8		
Lost from the leaves by evaporation, &c...	105	0		
	1609	8		

He adds to this curious table, that from the 1362 lbs. of sorted leaves given to the caterpillars, it is necessary to deduct 155 lbs. 7 oz. 4 drs. of litter, consisting of fragments of uneaten leaves, stalks, fruit, &c., and consequently that they actually devour only 1206 lbs. 4 oz. 4 drs. It is necessary also to mention that of this quantity 745 lbs. 8 oz. of dung are carried from the hurdles; and consequently there is only digested 771 lbs. 7 oz. 4 drs. of pure leaves, which produce 120 lbs. of silk cocoons,—giving a loss by evaporation from the worms in gas and vapour of 496 lbs. 4 oz., nearly three parts of this loss occurring in the six last days of the fifth age *. These deductions, however, do not affect the amount eaten by the caterpillars produced from 1 oz. of eggs, which is upwards of 1200 lbs. A single silk-worm, as we before mentioned, consumes within thirty days about 60,000 times its primitive weight.

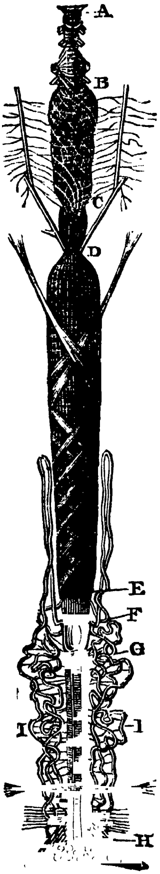
When we take these facts into consideration, we need not be surprised at the extensive ravages committed by other caterpillars, many of which are much larger than the silk-worm, and all of them produced in broods of considerable numbers. Mr. Stephens, in his valuable catalogue of British insects, a work of

* Count Dandolo's Art of rearing Silk-Worms, p. 322-24, Eng. Transl.

very extraordinary accuracy, enumerates nearly 2000 species of native moths and butterflies; and as the females of these are for the most part very prolific, we have little reason to be surprised at the occasional extent of their depredations. The 2000 species just mentioned are, besides, not more than a fifth of our native insects, most of the grubs and maggots of which are exceedingly voracious and destructive.

It appears to be indispensable for most insects to feed copiously during their larva state, in order to supply a store of nutriment for their subsequent changes; for many of them eat nothing, and most of them little, after they have been transformed into pupæ and perfect insects. What is no less wonderful, a corresponding change takes place in the internal formation of their organs of digestion. A caterpillar will, as we have seen, devour in a month 60,000 times its own weight of leaves, while the moth or the butterfly into which it is afterwards transformed may not sip a thousandth part of its weight of honey during its whole existence. Now, in the caterpillar, nature has provided a most capacious stomach, which, indeed, fills a very large portion of its body; but in the butterfly the stomach is diminished to a thread. By a series of minute dissections, conducted with great skill, Heroldt traced these changes, as they successively occur, from the caterpillar to the butterfly. In the caterpillar he found the gullet, the honey stomach, the true stomach, and the intestines capacious. Two days after its first change all these are visibly diminished, as well as the silk reservoirs, which, in a chrysalis eight days old, have wholly disappeared; while the base of the gullet is dilated into a crop, and the stomach still more contracted into a spindle form. When near its change into the perfect insect the gullet is still more drawn out, while the crop, still small, is now on one side of

View of the upper side.



View of the under side.

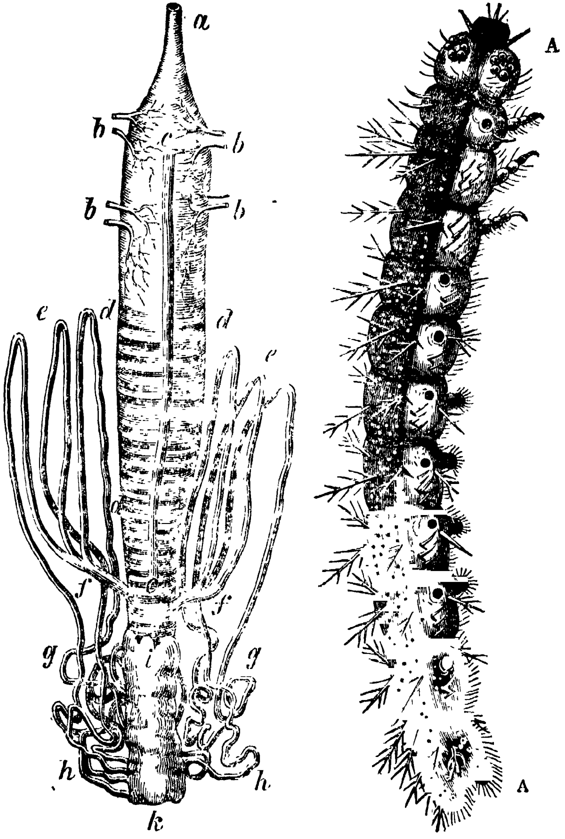
A, B, C, The æsophagus and its appendages.

D, E, The stomach;—a pair of muscles wind spirally round it, and by their contraction squeeze the digested food into the intestines.

E, F, The first large intestine. F, G, the second. G, H, the third.

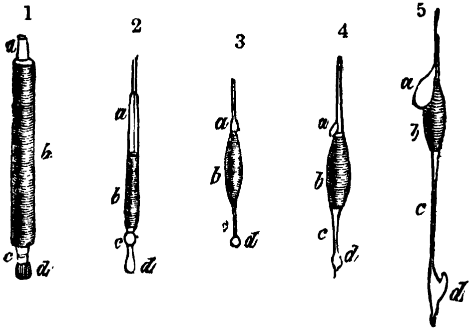
I, I, The six small intestines.

Viscera of the Cossus.



A, A, Caterpillar of Vanessa urticæ magnified. *a*—*k*, the intestines of the same. *a*, the gullet. *b b b b*, pulmonary tubes. *c c*, ligament of the stomach. *d d d d*, transparent rings of the same. *e e*, small intestines. *f f*, their origin. *g g h h*, their windings. *i k*, the rectum.

the gullet; and in the butterfly is enlarged into a honey stomach.



Intestinal canals of the caterpillar, pupa, and butterfly.[1]
1. Caterpillar. *a*, the œsophagus. *b*, the stomach. *c d*, the two large intestines.
2. Pupa *two* days old. *a*, the œsophagus. *b*, the stomach. *c d*, the two large intestines.
3. Pupa *eight* days old. *a*, dilation of the œsophagus, forming the *crop* or *honey-stomach*.
4. Pupa immediately before its transformation. *a*, the honey-stomach become a lateral appendage of the œsophagus. *b*, the stomach. *c d*, the large intestines.
5. Butterfly. *a*, honey-stomach. *b*, the digesting stomach. *c d*, the large intestines, become very long.

It is remarkable that in men of such extraordinary appetite as amounts to a disease (*Bulimia*, Cullen), the natural capacity of the stomach, which, according to Blumenbach, contains about three pints*, is very much enlarged. This was peculiarly the case with Tarare, an Italian juggler, who, from swallowing flints, whole baskets of fruit, &c., seems to have enlarged the capacity of his stomach so as to render his appetite insatiable. M. Tessier, of the Infirmary at Versailles, where Tarare died of consumption, found on examination that his stomach

* Blumenbach, Physiol., s. xxiii.

was prodigiously distended *. The same must have been the case with the French prisoner at Liverpool, who, on the testimony of Dr. Cochrane, consumed, in one day, sixteen pounds of raw meat and tallow candles, besides five bottles of porter †.

The mandibles of caterpillars, which do not act perpendicularly like the jaws of quadrupeds, but horizontally, are for the most part very sharp and strong, being of a hard, horny substance, and moved by powerful muscles. They are, for the most part, slightly bent in the form of a reaping-hook; having the concavity indented with tooth-shaped projections, formed out of the substance of the jaw, and not socketed as the teeth of quadrupeds. These are made to meet like the blades of a pair of pincers; and in some cases they both chop and grind the food ‡. Besides these there is a pair of jaws (*maxillæ*) placed on each side of the middle portion of the under lip; and from their being of a softer substance they seem to be more for the purpose of retaining the food, than for mastication. This formidable apparatus for masticating (*Trophi*) is well adapted to supply the large demands of the capacious stomachs of larvæ; and when we consider that all of them are employed in eating at least for ten or twelve hours in the day, and a great number during the night, we need not wonder at their extensive ravages upon the substances on which they feed. It may be interesting, however, to give a few examples of their destructiveness; and with this view it will be convenient to consider them under the three popular names of caterpillars, grubs, and maggots.

Caterpillars.

The ravages of caterpillars are amongst the most

* M. Percy in Rapport d'Institute Nationelle.
† Med. and Phys. Journ., iii., 209. ‡ Cuvier, Anat. Com., iii., 322.

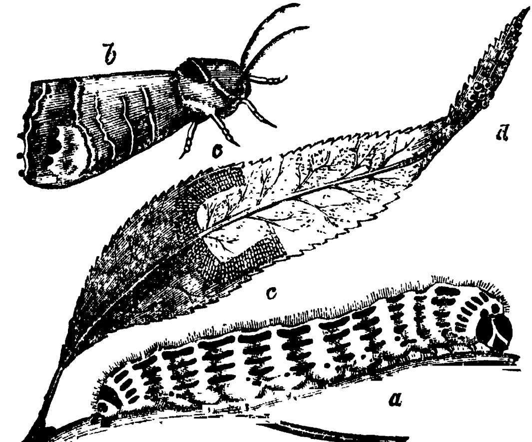
conspicuous of insect depredations, in consequence of their being committed upon the leaves of trees, bushes, and plants, which are often stripped as bare as in winter. Even the smaller sorts of caterpillars become, from their multiplicity, sometimes as destructive as those which are of considerable magnitude. During the summer of 1827 we were told that an extraordinary *blight* had suddenly destroyed the leaves of all the trees in Oak of Honour Wood, Kent. On going thither, we found the report had been little exaggerated; for though it was "in the leafy month of June," there was scarcely a leaf to be seen on the oak-trees, which constitute the greater portion of the wood. But we were rather surprised when we discovered, on examination, that this extensive destruction had been effected by one of the small solitary leaf-rollers (*Tortrix viridana*, HAWORTH) * ; for one of this sort seldom consumes more than four or five leaves, if so much, during its existence. The number, therefore, of these caterpillars must have been almost beyond conception; and that of the moths, the previous year, must also have been very great: for the mother moth only lays from fifty to a hundred eggs, which are glued to an oak branch, and remain during the winter. It is remarkable that in this wood during the two following summers these caterpillars did not abound †.

Instances like this, however, from solitary species, are, we believe, less common than those of the ravages of gregarious caterpillars. In 1826, colonies of the buff-tip (*Pygæra bucephala*, OCHSENHEIM.) were in some parts of the country very abundant. We remarked them particularly at Harrow-on-the-Hill, and at Compton-Basset in Wiltshire. From their feeding in company, they strip a tree, branch after branch,

* See figures of this caterpillar and its moth in "Insect Architecture," pp. 162-3.

† J. R.

scarcely leaving the fragment of a leaf, till a great portion of it is completely bare. Some of the magnificent beeches in Compton Park, from this cause, appeared with the one-half of their branches leafless and naked, while the other half was untouched. Besides the beech, these caterpillars feed on the oak, the lime, the hazel, the elm, and the willow. When newly hatched they may be readily discovered, from their singular manner of marshalling themselves, like a file of soldiers, on a single leaf, only eating it half through; and in their more advanced stage, their gaudy stripes of yellow and black render them very conspicuous on the branches which they have nearly stripped bare. The cuckoo feeds as greedily upon them as they do on leaves, and may be seen early in



Ravages of the buff-tip caterpillar (*Pygæra bucephala*). *a*, the full-grown caterpillar. *b*, the moth. *c c*, a line of young caterpillars, advancing along a leaf and devouring it half through as they march. *d*, the eggs.

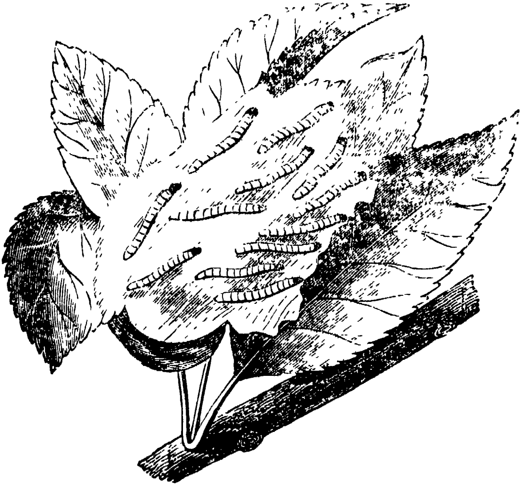
the morning perched in the midst of their colonies, and devouring them by dozens *.

Those caterpillars which feed upon fruit-trees and hedge shrubs are still more likely to attract attention; since, when any of these are abundant, it is scarcely possible to stir out of doors without observing them. Thus, in the suburbs of London, in the summer of 1829, not only the orchards and gardens, but every hedge, swarmed with the lackey caterpillars (*Clisiocampa neustria*), which are what naturalists term *polyphagous* feeders, that is, they do not confine themselves to a particular sort of tree, but relish a great number. The hawthorn, the black thorn, and the oak, however, seem to be most to their taste; while they are rare on the willow, and we have never observed them on the poplar, or the elder.

Another of what may be appropriately termed the encamping caterpillars, of a much smaller size, and of a different genus, is the small ermine (*Yponomeuta padella*), which does not, besides, feed quite so indiscriminately; but when the bird-cherry (*Prunus padus*), its peculiar food, is not to be had, it will put up with black thorn, plum-tree, hawthorn, and almost any sort of orchard fruit-tree. With respect to such caterpillars as feed on different plants, Réaumur and De Geer make the singular remark, that in most cases they would only eat the sort of plant upon which they were originally hatched †. We verified this, in the case of the caterpillar in question, upon two different nests which we took, in 1806, from the bird-cherry at Crawfordland, in Ayrshire. Upon bringing these to Kilmarnock, we could not readily supply them with the leaves of this tree; and having then only a slight acquaintance with the habits of insects, and imagining they would eat any sort of leaf, we tried them with almost every thing

* J. R. † De Geer, Mem. i. 319.

green in the vicinity of the town; but they refused to touch any which we offered them. After they had fasted several days, we at length procured some fresh branches of the bird-cherry, with which they gorged themselves so that most of them died. Last summer (1829) we again tried a colony of these caterpillars, found on a seedling plum-tree at Lee, in Kent, with black thorn, hawthorn, and many other leaves, and even with those of the bird-cherry; but they would touch nothing except the seedling plum, refusing the grafted varieties*.



Encampment of the caterpillar of the small ermine (*Yponomeuta padella*) on the Siberian crab.

A circumstance not a little remarkable in so very nice a feeder is, that in some cases the mother moth will deposit her eggs upon trees not of indigenous growth, and not even of the same genus with her usual favourites. Thus, in 1825, the cherry-apple, or Siberian crab (*Pyrus prunifolia*, WILLDENOW), so commonly grown in the suburbs of London, swarmed with them. On a single tree at Islington, we counted above twenty nests, each of which would contain from fifty to a hundred caterpillars; and though these do not grow thicker than a crow-quill, so many of them scarcely left a leaf undevoured, and, of course, the fruit, which shewed abundantly in spring, never came to maturity. The summer following they were still more abundant on the hawthorn hedges, particularly near the Thames, by Battersea and Richmond. Since then we have only seen them sparingly; and last summer we could only find the single nest upon which we tried the preceding experiment*. This present spring (1830) they have again appeared in millions on the hedges.

Réaumur says that in some years they were exceedingly destructive to his apple-trees, though they did not touch his pears, plums, or apricots†, which agrees precisely with our own remarks. We are well aware that there are several species of the small ermines, all similar in manners, such as the one which feeds on the spindle-tree, (*Euonymus*), and produces the prettiest moth of the genus (*Yponomeuta Euonymella*); but our preceding remarks all apply to one species.

In 1829 we remarked a very extraordinary number of webs of some similar caterpillar, of which we did not ascertain the species, on the willows in Holland and the Netherlands, from Amsterdam to Ostend. In some districts, particularly near Bruges and Rotterdam, the leaves were literally stripped from whole rows of trees; while other rows, at no considerable distance, were entirely free from their ravages. A foreign naturalist, quoted by Harris in

* J. R. † Réaumur, Mem. ii. 198.

his Aurelian, says, that the caterpillar of the Camberwell beauty (*Vanessa Antiopa*), which feeds gregariously on the willow, sometimes defoliates the trees of a whole district in the Low Countries; but the ravages observed by us were evidently made by the caterpillars of some small moth*.

None of the preceding details, however, appear so striking as what is recorded of the brown-tail moth (*Porthesia auriflua*), by Mr. W. Curtis†, whose multitudinous colonies spread great alarm over the country in the summer of 1782. This alarm was much increased by the exaggeration and ignorant details which found their way into the newspapers. The actual numbers of these caterpillars must have been immense, since Curtis says, " in many of the parishes near London subscriptions have been opened, and the poor people employed to cut off the webs‡ at one shilling per bushel, which have been burnt under the inspection of the churchwardens, overseers, or beadle of the parish: at the first onset of this business fourscore bushels, as I was most credibly informed, were collected in one day in the parish of Clapham."

It is not, therefore, very much to be wondered at, that the ignorant, who are so prone to become the victim of groundless fears, should have taken serious alarm on having so unusual a phenomenon forced upon their attention. Some alarmists accordingly asserted that the caterpillars " were the usual presage of the plague;" and others that they not only presaged it, but would actually cause it, for " their numbers were great enough to render the air pestilential," while, to add to the mischief, " they would destroy every kind of vegetation, and starve the cattle in the fields." " Almost every one," adds Curtis,

* J. R.

† Curtis, Hist. of Brown-tail Moth, 4to. London, 1782.

‡ See Insect Architecture, page 330, for a figure of the nest.

"ignorant of their history, was under the greatest apprehensions concerning them; so that even prayers were offered up in some churches to deliver the country from the apprehended approaching calamity."

It seems to have been either the same caterpillar, or one very nearly allied to it, probably that of the golden-tail (*Porthesia Chrysorrhœa*), which in 1731-2, produced a similar alarm in France. Réaumur, on going from Paris to Tours, in September 1730, found every oak, great and small, literally swarming with them, and their leaves parched and brown as if some burning wind had passed over them; for when newly hatched, like the young buff-tips, they only eat one of the membranes of the leaf, and of course the other withers away. These infant legions, under the shelter of their warm nests*, survived the winter in such numbers, that they threatened the destruction not only of the fruit-trees, but of the forests,—every tree, as Réaumur says, being over-run with them. The Parliament of Paris thought that ravages so widely extended loudly called for their interference, and they accordingly issued an edict, to compel the people to uncaterpillar (*décheniller*) the trees; which Réaumur ridiculed as impracticable, at least in the forests. About the middle of May, however, a succession of cold rains produced so much mortality among the caterpillars, that the people were happily released from the edict; for it soon became difficult to find a single individual of the species†. In the same way the cold rains, during the summer of 1829, seem to have nearly annihilated the lackeys, which in the early part of the summer, swarmed on every hedge around London‡. The ignorance displayed in France at the time in question, was not inferior to that recorded by

* See Insect Architecture, p. 331, for a figure.

† Réaumur, ii. p. 137. ‡ Insect Architecture, p. 329.

Curtis; for the French journalists gravely asserted that part of the caterpillars were produced by spiders; and that these spiders, and not the caterpillars, constructed the webs of the slime of snails, which they were said to have been seen collecting for the purpose! "Verily," exclaims Réaumur, "there is more ignorance in our age than one might believe."

It is justly remarked by Curtis, that the caterpillar of the brown-tail moth is not so limited a feeder as some, nor so indiscriminate as others; but that it always confines itself to trees or shrubs, and is never found on herbaceous plants, whose low growth would seldom supply a suitable foundation for its web. Hence the absurdity of supposing it would attack the herbage of the field, and produce a famine among cattle. Curtis says, it is found on the "hawthorn most plentifully, oak the same, elm very plentifully, most fruit-trees the same, black thorn plentifully, rose-trees the same, bramble the same, on the willow and poplar scarce. None have been noticed on the elder, walnut, ash, fir, or herbaceous plants. With respect to fruit-trees the injuries they sustain are most serious, as, in destroying the blossoms as yet in the bud, they also destroy the fruit in embryo; the owners of orchards, therefore, have great reason to be alarmed."

The sudden appearance of great numbers of these caterpillars in particular years, and their scarcity in others, is in some degree explained by a fact stated by Mr. Salisbury. "A gentleman of Chelsea," he says, "has informed me that he once took a nest of moths and bred them; that some of the eggs came the first year, some the second, and others of the same nest did not hatch till the third season*." We reared, during 1829, several nests both of the brown-tails and of the golden-tails, and a number of the females deposited their eggs in our nurse-

* Salisbury, Hints on Orchards, p. 53.

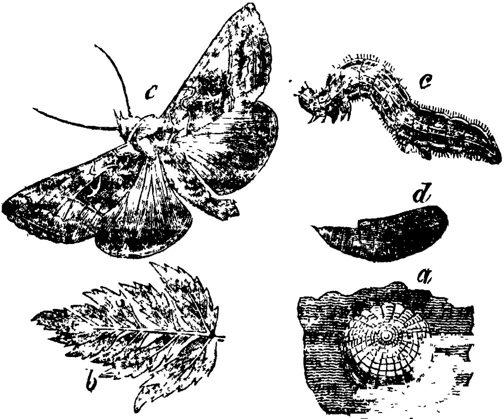
cages; but, contrary to the experiment just quoted, all of these were hatched during the same autumn*. The difference of temperature and moisture in particular seasons may produce this diversity.

An alarm, similar to those we have recorded, was produced in France in 1735 by the green striped caterpillars of a moth very common in Britain, called by collectors, from a mark on its upper wings, the Y, or more properly the γ moth (*Plusia Gamma*, Ochs.). Though ranked in some classifications amongst the nocturnal moths, it flies chiefly by day, and may be seen in Battersea-fields, or other moist meadows, flitting from herb to herb and flower to flower, in short and low flights; for it seldom soars higher than the tallest grass-stem, or the crimson flower-heads of the knapweed, upon whose honey it sometimes regales, remaining on the wing all the while it is sipping it. During the cold rainy summer of 1829 it was almost the only moth which appeared plentiful†. At least two broods seem to be produced during the season; which may account for its being found from May till the setting-in of the winter frosts.

Notwithstanding it being so plentiful, however, we have not heard of its having ever been so destructive here as in France, where, as usual, the most improbable causes were assigned for its increase. "In some places," says Réaumur, "they assured me they had seen an old soldier throw the spell; and in other places an ugly and mischievous old woman had wrought all the evil ‡." These supposed supernatural agents, however, must have been either very numerous or very active to fill, not only the gardens, but every field, with legions of those caterpillars, which devoured almost every green thing, and left only the stalks as monuments of their devastation. The alarm proceeded farther, for it began to be whispered

* J. R. † J. R. ‡ Réaumur, ii. 336.

that they were poisonous; and many were in consequence afraid to touch soups or salads. Réaumur thought it incumbent on him to refute this notion at some length; but we cannot accept his doctrine as very palatable, when he tells us that few dishes of soup or salad are *ever* prepared without containing caterpillars, and yet all the world are not poisoned thereby, any more than by eating oysters or viper broth. He endeavoured also to account by calculation for their excess, from the data of the female moth laying about four hundred eggs. Now, if there were only twenty caterpillars distributed in a garden, and all lived through the winter, and became moths in the succeeding May, the eggs laid by these, if all fertile, would produce 800,000, a number much more than sufficient to effect great destruction*. Did not Providence, therefore, put causes in operation to



Transformations of the γ moth (*Plusia Gamma*). *a*, the egg, greatly magnified, on a morsel of leaf. *b*, the egg on a leaf, natural size. *c*, the larva. *d*, the pupa. *e*, the moth.

* Réaumur, ii. 337.

keep them in due bounds, the caterpillars of this moth alone, leaving out of consideration the 2000 other British species, would soon destroy more than half of our vegetation.

The caterpillar just mentioned, amongst other pot-herbs attacks coleworts and cabbage; and may sometimes be found there along with another, not uncommon, but seldom very destructive, called by collectors the burnished brass (*Plusia chrysitis*), which differs little from the caterpillar of the γ moth, except in being of a brighter green. Another, called the old gentlewoman (*Mamestra brassicæ*, Treitsche), is so destructive to cabbages in Germany, that the gardeners gather whole baskets full and bury them; but as Rösel remarks, they might as well endeavour to kill a crab by covering it with sea-water, for it is natural to them to burrow under ground when they change into chrysalides*. We have seen this caterpillar, as well as that of the brown-eye (*Mamestra oleracea*), do considerable damage in Wiltshire, but nothing to what is reported of it in Germany.

The leaves of cabbages, cauliflower, brocoli, coleworts, and turnips, are frequently devoured to a more considerable extent by the sub-gregarious caterpillars of the white butterflies (*Pontia brassicæ, P. napi*, &c.) From the great multiplicity of the butterflies, indeed, and from there being two broods in the year, we have reason to wonder that their ravages are not more extensive. But we have remarked, that they seem more partial to wild than cultivated plants; for we have seen, near Islington, the oleraceous weeds, such as rape (*Brassica napus*), over-run with them in the very same fields with cultivated cabbages, which were not touched†; so that the caterpillars are not always so injurious as we might at first suppose, since in this case they tend to

* Rösel, Inseckten, i. iv. 170. † J. R.

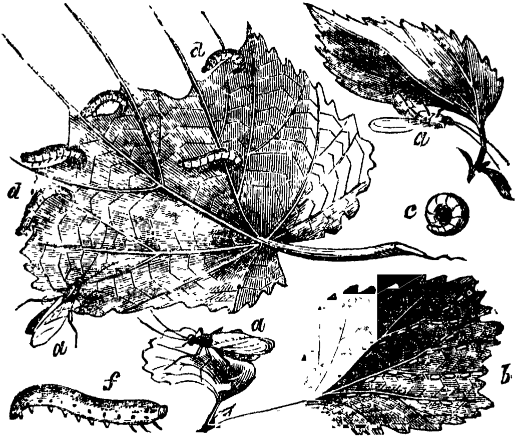
keep down the weeds, while the birds and the ichneumon flies keep them in check by making prey of them.

The gregarious caterpillars of an allied species, called the black-veined white butterfly (*Pieris Cratægi*, STEPHENS), is in some seasons and districts no less destructive to orchards and hawthorn hedges than the preceding ones are to the kitchen-garden. Salisbury, who wrote at Chelsea in 1815, says it "commits great destruction every spring, and not only to the apple-trees, but other kinds of fruits*." Mr. Stephens, writing in 1827, says, "in June 1810, I saw it in plenty at Coombe Wood, and in the following year I captured several at Muswell-hill, since which time I have not seen any at large†." Mr. Haworth also says, "it has not of late years been seen at Chelsea, where it formerly abounded." We have never met with it at all. According to Salisbury the female butterfly lays her eggs near the extremity of an old rather than a young branch, and covers them with a coating of gluten, which is both impervious to moisture and impenetrable (this we doubt) to the bills of birds. "In this state," he adds, "we have instances of their remaining without losing their vitality for several years, until a favourable opportunity of their being brought into existence arrives‡." The caterpillars, which are at first black and hairy, live in common in a silken tent. They become subsequently striped with reddish brown, and disperse over the trees. This caterpillar and its butterfly are figured in a subsequent page.

Our gooseberry and red-currant bushes are very frequently despoiled of their leaves, both by the speckled caterpillar of the magpie moth (*Abraxas grossulariata*), and by what Réaumur terms the

* Hints on Orchards, p. 56. † Illustrations, i. Haustellata, 27.
‡ Hints on Orchards, p. 57.

pseudo-caterpillars of one of the saw-flies (*Nematus Ribesii*, STEPHENS). The latter insect has a flat yellow body and four pellucid wings, the two outer ones marked with brown on the edge. In April it issues from the pupa, which has lain under ground from the preceding September. The female of the gooseberry saw-fly does not, like some of the family, cut a groove in the branch to deposit her eggs;—"of what use, then," asks Réaumur, "is her ovipositor saw*?" In order to satisfy himself on this point, he introduced a pair of the flies under a bell-glass along with a branch bent from a red-currant bush, that he might watch the process. The female immediately perambulated the leaves in search of a place suited to her purpose, and passing under a leaf began to lay,



a a a, Saw-fly of the gooseberry (*Nematus Ribesii*, STEPHENS). *b*, its eggs on the nervures of a leaf. *d d*, the caterpillars eating. *c*, one rolled up. *f*, one extended.

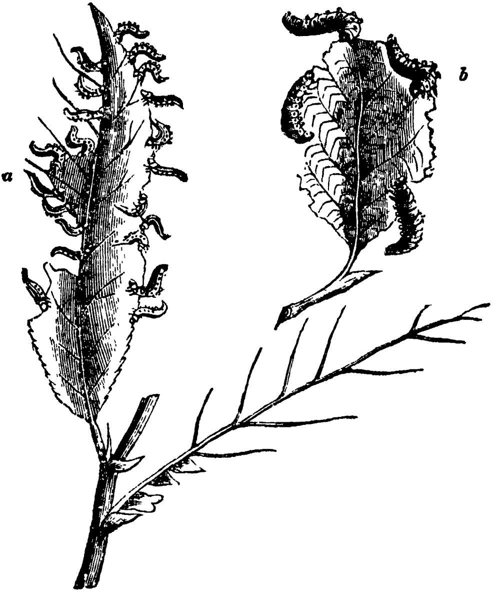
* See Insect Architecture, chap. vii. for a description of this curious instrument.

depositing six eggs within a quarter of an hour. Each time she placed herself as if she wished to cut into the leaf with her saw; but, upon taking out the leaf, the eggs appeared rather projecting than lodged in its substance. They adhered so firmly, however, that they could not be detached without crushing them. He could not discover any groove *; but we think it likely that a minute cut is made in the exterior membrane of the leaf, the edges of which grasp and hold firm the part of the egg which is thrust into it by the insect. Be this as it may, the caterpillars are hatched in two or three weeks; and they feed in company till after midsummer, frequently stripping both the leaves and fruit of an extensive plantation. The caterpillar has six legs and sixteen prolegs, and is of a green colour mixed with yellow, and covered with minute black dots raised like shagreen. In its last skin it loses the black dots and becomes smooth and yellowish white. The Caledonian Horticultural Society have published a number of plans for destroying these caterpillars.

An allied species of saw-fly (*Nematus Capreæ*, STEPHENS) frequently becomes extensively destructive to several species of willow, sallow, and osier. It is so like that of the gooseberry and that of the willow (*Nematus salicis*), which is not British, that it has been confounded with these by Fabricius, Stewart, Gmelin, and other authors. In the summer of 1828, we observed a considerable group of young standards of the golden osier (*Salix vitellina*), in a nursery at Lewisham, rendered quite leafless by these caterpillars ; which, when feeding, throw themselves into singular postures by holding only with their fore feet. The fly appears in spring, and places its eggs in a round patch on the back of the leaf, and not along the nervures, like the gooseberry saw fly.

* Réaumur, v. 125.

During the three last summers, we also remarked that the alders (*Alnus glutinosa*) along the banks of the Ravensbourne, in Kent, were extensively stripped of their leaves by a saw-fly caterpillar, very like the preceding, but of a larger size*. It appears to be the same as one figured by Réaumur† (*Selandria Alni?* STEPHENS).



a, *Nematus capreæ*, on the osier; *b*, *Selandria alni*? on the alder.

Another slimy caterpillar of a saw-fly, allied to that of the cherry (*Tenthredo Cerasi*), is called the slug worm in North America, where it has increased

* J. R. † Réaumur, vol. v., pl. 11, fig. 1, 2.

so numerously as to threaten the entire destruction of fruit trees, including the cherry, plum, pear, and quince. Where they are numerous, the air becomes loaded with a disagreeable and sickly effluvium. The history of this orchard pest has been admirably written by Professor Peck*.

When a turnip crop has been fortunate enough to escape the ravages committed on it in the seed leaf by a small jumping beetle (*Haltica nemorum*, ILLIGER), and by a root weevil (*Nedyus contractus*, STEPHENS), a no less formidable depredator sometimes appears in a caterpillar belonging to the saw-fly family (*Tenthredinidæ*), and apparently of the genus *Athalia*. An instance is recorded by Marshall, in the Philosophical Transactions, of many thousand acres having had to be ploughed up on account of the devastations caused by these insects. It is, he informs us, the general opinion in Norfolk, that they come from over-sea; and a farmer averred that he saw them arrive in clouds so as to darken the air, while the fishermen reported that they had repeatedly witnessed flights of them pass over their heads when they were at a distance from land. On the beech and the cliffs, indeed, they lay in heaps, so that they might have been taken up with shovels; while three miles inland they crowded together like a swarm of bees†.

We have little doubt, however, that these details are put in an inverse order; as frequently occurs in histories of the proceedings of insects by those but little acquainted with their habits. Insects of this family, indeed, seldom fly far, and could not at all events cross the sea, unless it might be a narrow bay or inlet; and if they had, we ought to have heard of their departure as well as their arrival, since their

* Nat. Hist. of the Slug Worm, Boston, 1799.

† Phil. Trans. vol. lxxiii. p. 317.

extraordinary number could not have failed to attract public notice on other shores. The nature of these insects is to lie in the pupa state during the winter under ground; and when, at its appointed time, the fly comes forth, it only lives to lay its eggs, usually dying within a few days or weeks. It must have been, therefore, after the laying their eggs on the turnips, and not before, that clouds of the flies were seen at sea and on the shore, though not arriving, but going away. They were, doubtless, impelled by that restless desire of change felt by all animals when death is approaching, and which in tropical countries is yearly exemplified in the destruction of locusts, for these always make for the sea, and perish there. But though they were thus got rid of in August, 1782, they left a progeny behind them in the black caterpillars which were hatched from their eggs. In the summer of 1783, accordingly, we are told by Mr. Marshall, that whole districts were ravaged by them,—the descendants, of course, in the second generation, of the saw-flies which perished on the beach and at sea the preceding autumn.

Some caterpillars, which either conceal themselves under ground, or feed on roots and the wood of trees, do considerable injury, without apparent cause; and often give occasion to the popular notions respecting mysterious blights. In this manner will the caterpillars of the ghost moth (*Hepialus Humuli*) gnaw the roots of the burdock, and, what is of more consequence, of the hop plant, till the shoots are weakened and the leaves droop in bright sunshine. We have repeatedly seen, in the gardens about Lee, a large branch of the red-currant bush, though previously healthy and loaded with fruit, all of a sudden droop and wither, giving good cause to surmise, except in the leaves not being brown or parched, that it had been struck with lightning. On cutting into such branches, however, the cause was uniformly found to be the ravages of the caterpillar of the currant hawk-moth (*Ægeria tipuliformis*, Stephens), which abounds in the vicinity. But we have also remarked that it only occasionally produces this effect upon the trees; for several bushes upon which we have found old pupa-cases projecting from the bark, remained healthy and uninjured*. Sir Joseph Banks showed Mr. Kirby a currant branch perforated by this caterpillar to the pith, and said the size of the fruit was in consequence diminished†. In Germany it is reported to destroy even large bushes of the red currant. There can be no doubt that the caterpillars of the goat moth frequently destroy willow, poplar, and oak trees, of considerable magnitude; but the mother moth seems to prefer laying her eggs upon those which have already begun to decay. A black poplar tree, not thicker than a man's leg, and stripped on one side of more than a foot of the bark, was bored by above a dozen caterpillars of the clear underwing (*Ægeria asiliformis*, Stephens), without seeming to have its growth at all retarded‡.

It does not appear that a minute moth, called by Leeuwenhoeck, who writes its history, the wolf, and by Haworth the mottled-woollen (*Ph. Tinea granella*, Linnæus), is so abundant in Britain as to do much damage to the grain stored in granaries, upon which it feeds. But it seems to have created considerable alarm on the Continent. It has been found near London, and *may* increase with us. The caterpillar, which is smooth and white, ties together with silk several grains of wheat, barley, rye, or oats, weav-

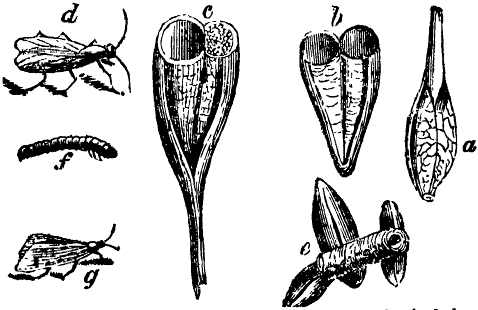
* J. R.

† Kirby and Spence, vol. i. p. 197.

‡ See Ins. Archit., p. 192.

ing a gallery between them, from which it projects its head while feeding; the grains, as Réaumur remarks, being prevented from rolling or slipping by the silk which unites them. He justly ridicules the absurd notion of its filing off the outer skin of the wheat by rubbing upon it with its body, the latter being the softer of the two; and he disproved, by experiment, Leeuwenhoeck's assertion that it will also feed on woollen cloth. It is from the end of May till the beginning of July that the moths, which are of a silvery grey, spotted with brown, appear and lay their eggs in granaries.

The caterpillar of another still more singular grain moth (*Tinea Hordei*, KIRBY) proves sometimes very destructive to granaries. The mother moth, in May or June, lays about twenty or more eggs on a grain of barley or wheat; and when the caterpillars are hatched they disperse, each selecting a single grain. M. Réaumur imagines that sanguinary wars must sometimes arise, in cases of preoccupancy, a single grain of barley being a rich



Transformations of the grain moths. *a*, grain of barley including a caterpillar; *b*, *c*, the grain cut across, seen to be hollowed out, and divided by a partition of silk; *d*, the moth (*Tinea Hordei*); *e*, grains of wheat tied together by the caterpillar, *f*; *g*, the moth (*Euplocamus granella*).

heritage for one of these tiny insects; but he confesses he never saw such contests*. When the caterpillar has eaten its way into the interior of the grain, it feeds on the farina, taking care not to gnaw the skin nor even to throw out its excrements, so that except the little hole, scarcely discernible, the grain appears quite sound. When it has eaten all the farina, it spins itself a case of silk within the now hollow grain, and changes to a pupa in November†.

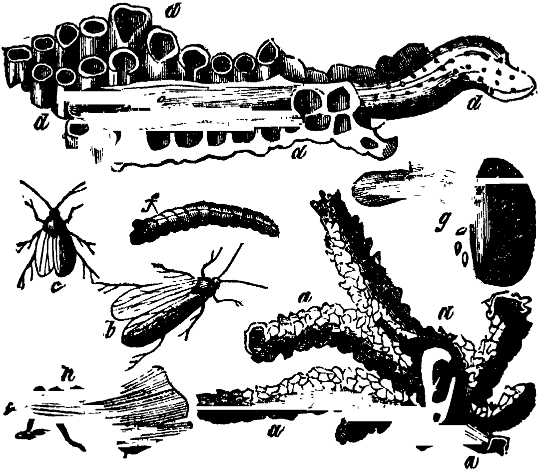
Two other caterpillars of a different family, the honeycomb moth (*Galleria cereana*, FABR.), and the honey moth (*G. alvearia*, FABR.), the first having square, and the second rounded wings‡, do very considerable damage to the hives of bees. The moths of both, according to Réaumur, appear about the end of June or beginning of July; and when in danger they run rather than fly, gliding with such celerity that they can easily elude the vigilance of the bees, which, indeed, if we may trust Swammerdam, never attack them, nor prevent their entrance into the hives, unless they chance to brush against them in their passage. But Réaumur actually saw the bees pursue one, though without success. It becomes easy for a moth, at all events, to lay eggs among the combs; or as Keys says, at the entrance of the hive: this writer adds, "she spins a close and strong web to defend the young§;" which is impossible, as no insect, subsequent to its larva state, can spin.

The caterpillar of the first species, "wherever it passes," says Swammerdam, "gnaws round holes through the waxen cells, one caterpillar sometimes breaking open and destroying fifty or sixty cells.

* See Insect Architecture, p. 231.
† Réaumur, Mem., vol. ii. p. 486, &c.
‡ Stephens's Catalogue, vol. ii. p. 213.
§ Keys, Treatise on Bees, p. 178, edit. 1814.

Wherever it penetrates it always fabricates a hollow tubulated web, in which, as a rabbit in its burrow, it can very swiftly pass from one part to another, and speedily run back again. It fills the whole comb with such webs, and turns itself in them every way into various bendings and windings; so that the bees are not only perplexed and disturbed in their work, but they frequently entangle themselves by the claws and hairs of their legs in those webs, and the whole hive is destroyed."

The other species he accuses of being not only destructive to the wax, but to the bees themselves. "I saw one of these little caterpillars," he says, "whilst it was still small, and was breaking the cells in which the pupa of the bees lie, and eating the wax



Transformations of the honeycomb moths. *a*, *a*, *a*, Galleries of the cell-boring caterpillar; *b*, the female; *c*, the male moth (*Galleria alvearia*); *d*, *d*, *d*, *d*, galleries of the wax-eating caterpillar, *e*, seen at the entrance; *f*, the same exposed; *g*, its cocoon; *h*, the moth (*Galleria cereana*).

there, cover up these pupæ with its excrements, so that they could scarcely be known." He adds with great naïveté, "I have learned these matters much against my inclination, and have been full of wrath against the insect for thus defiling and killing some bee pupæ which I had designed to observe in their changes*."

M. Bazin, a friend of Réaumur's, discovered the caterpillar of a moth of this order feeding on chocolate, of which it seemed very choice, always preferring that which had the finest flavour. The moth is sometimes produced in September, and sometimes in the beginning of the following summer. It is probable that, like the cheese-fly, it might, in default of chocolate, select some other aliment†.

* Swammerdam, vol. i. p. 225. † Réaumur, vol. iii. p. 277

Chapter IX.

Voracity of Caterpillars, Grubs, and Maggots;—continued.

Grubs.

We frequently hear farmers and gardeners complaining that their produce is destroyed by "*the* grub;" they might with equal propriety accuse "*the* bird" when their ripe seeds are devoured by sparrows, chaffinches, linnets, and other seed-eaters. Instead of one sort of grub, as the expression seems to indicate, we are far under the mark in reckoning a thousand species indigenous to Britain, each peculiar in its food and its manners. We shall, however, adhere as nearly as possible to the terms in common use; but as the larvæ of the crane-flies (*Tipulidæ*, Leach), being without legs, cannot be accurately ranked with the legged grubs of beetles, we shall consider them as maggots, though they are usually termed grubs by the farmers.

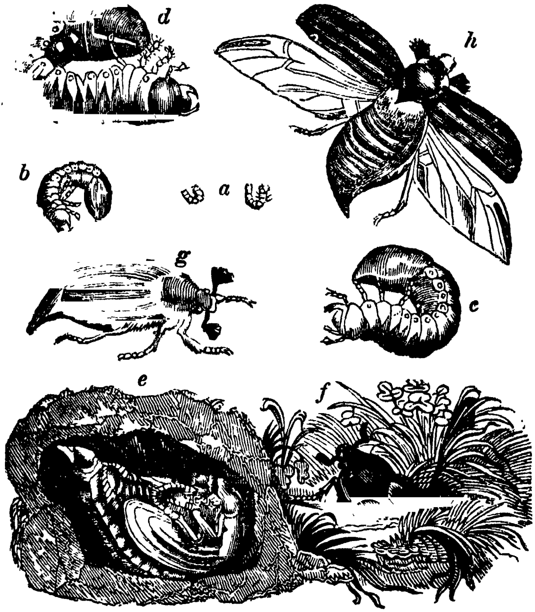
The most destructive, perhaps, of the creatures usually called grubs, are the larvæ of the may-bug or cockchafer (*Melolontha vulgaris*), but too well known, particularly in the southern and midland districts of England, as well as in Ireland, where the grub is called the Connaught worm*; but fortunately not abundant in the north. We only once met with the cockchafer in Scotland, at Sorn, in Ayrshire†. Even in the perfect state, this insect is not a little destructive to the leaves of both forest and fruit trees. In 1823, we remember to have observed almost all the trees about Dulwich and Camberwell

* Bingley, Anim. Biog. vol. iii. p. 230. † J. R.

defoliated by them; and Salisbury says, the leaves of the oaks in Richmond Park were so eaten by them, that scarcely an entire leaf was left. But it is in their previous larva state that they are most destructive, as we shall see by tracing their history.

The mother cockchafer, when about to lay her eggs, digs into the earth of a meadow or corn-field to the depth of a span, and deposits them in a cluster at the bottom of the excavation. Rösel, in order to watch their proceedings, put some females into glasses half-filled with earth, covered with a tuft of grass, and a piece of thin muslin. In a fortnight, he found some hundreds of eggs deposited, of an oval shape and a pale yellow colour. Placing the glass in a cellar, the eggs were hatched towards autumn, and the grubs increased remarkably in size. In the following May they fed so voraciously that they required a fresh turf every second day; and even this proving too scanty provender, he sowed in several garden pots a crop of peas, lentils, and salad, and when the plants came up, he put a pair of grubs in each pot; and in this manner he fed them through the second and third years. During this period, they cast their skins three or four times, going for this purpose deeper into the earth, and burrowing out a hole where they might effect their change undisturbed; and they do the same in winter, during which they become torpid and do not eat.

When the grub changes into a pupa, in the third autumn after it is hatched, it digs a similar burrow about a yard deep; and when kept in a pot, and prevented from going deep enough, it shows great uneasiness and often dies. The perfect beetle comes forth from the pupa in January or February; but it is then as soft as it was whilst still a grub, and does not acquire its hardness and colour for ten or twelve days, nor does it venture above ground before May, on the fourth year from the time of its hatching. At this time, the beetles may be observed issuing from their holes in the evening, and dashing themselves about in the air as if blind.



Transformations of the cockchafer (*Melolontha vulgaris*). *a*, newly hatched larvæ. *b*, larva, one year old. *c*, the same larva at the second year of its growth. *d*, the same three years old. *e*, section of a bank of earth, containing the chrysalis of the fourth year. *f*, the chafer first emerging from the earth. *g*, the perfect chafer in a sitting posture. *h*, the same flying.

During the three summers then of their existence in the grub state, these insects do immense injury, burrowing between the turf and the soil, and devouring the roots of grass and other plants; so that the turf may easily be rolled off, as if cut by a turfing spade, while the soil underneath for an inch or more is turned into soft mould like the bed of a garden. Mr. Anderson, of Norwich, mentions having seen a whole field of fine flourishing grass so undermined by these grubs, that in a few weeks it became as dry, brittle, and withered as hay *. Bingley also tells us that "about sixty years ago, a farm near Norwich was so infested with cockchafers, that the farmer and his servants affirmed they gathered eighty bushels of them; and the grubs had done so much injury, that the court of the city, in compassion to the poor fellow's misfortune, allowed him twenty-five pounds†." In the year 1785, a farmer, near Blois, in France, employed a number of children and poor persons to destroy the cockchafers at the rate of two liards a hundred, and in a few days they collected fourteen thousand‡.

"I remember," says Salisbury, "seeing, in a nursery near Bagshot, several acres of young forest trees, particularly larch, the roots of which were completely destroyed by it, so much so, that not a single tree was left alive §." We are doubtful, however, whether this was the grub of the cockchafer, and think it more likely to have been that of the green rose beetle (*Cetonia aurata*), which feeds on the roots of trees.

The grub of an allied genus, the midsummer chafer (*Zantheumia Solstitialis*, LEACH), has for the last two years been abundant on Lewisham Hill, Blackheath, doing considerable injury to herbage and garden plants. This beetle may be known from being smaller and paler than the cockchafer, and from its not appearing before midsummer. The grub is very similar.

* Philosoph. Trans. xliv. 579. † Anim. Biog. iii. 233.
‡ Anderson's Recr. in Agricult. iii. 420. § Hints, 74.

The best way of preventing the ravages of these insects would be to employ children to collect the perfect insects when they first appear, before they lay their eggs; but when a field is once overrun with the larva, nothing can be done with it, except paring and burning the surface, or ploughing it up, and turning in a flock of ducks or other poultry, or a drove of pigs, which are said to eat these grubs, and to fatten on the fare. Drenching the field with stable urine* by means of reservoir carts, like those used for watering roads, would, if sufficiently done, both kill the grubs, and beneficially manure the land.

The grub called the *wire worm*, though not very appropriately, is the larva of one of the spring or click beetles (*Hemirhipus lineatus*, and *H. obscurus*, LATREILLE), known by their long flattish body, and their power of springing with a clicking sound out of the hand when caught. In some works on agriculture, the larva of a common crane fly (*Tipula oleracea* or *T. crocata*) is called the *wire worm*,—we suppose by mistake †. The grubs of the click beetles, just alluded to, are said by Bierscander ‡ and by Mr. Paul of Starston, Norfolk §, who watched their transformations, to continue five years before producing the perfect insect. During this time the grub feeds chiefly on the roots of wheat, rye, oats, barley, and grass; but seems also sometimes to attack the larger roots of potatoes, carrots, and salads. Its ravages are often so extensive as to cut off entire crops of grain. It appears to be most partial to land newly broken up; and has not been found so abundant in meadows and pastures, unless in fields recently laid down with grass. "The wire worm," says Spence, "is particularly destructive for a few years

* See the Harleian Dairy System, p. 222.

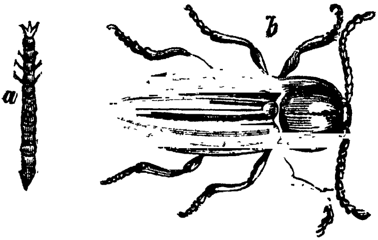
† See Loudon's Encycl. of Agricult. §. 6921.

‡ Act. Holm. 1779, p. 284.

§ Kirby and Spence, i. 182.

in gardens recently converted from pasture ground. In the botanic garden at Hull, thus circumstanced, a great proportion of the annuals sown in 1813 were destroyed by it. A very simple and effectual remedy, in such cases, was mentioned to me by Sir Joseph Banks. He recommended that slices of potatoes stuck upon skewers, should be buried near the seeds sown, examined every day, and the wire-worms, which collect upon them in great numbers, destroyed *."

The wire worm is long, slender, and very tough and hard; but otherwise it has no resemblance to wire, being whitish in colour, of a flattish form, and jointed or ringed. Its breathing spiracles, two in number, are on the back of its last ring.



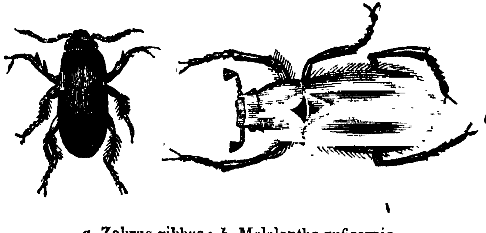
a, Wire worm ; *b*, Click beetle.

An insect of this family (*Elater noctilucus*, Linn.) is exceedingly destructive, in the West Indies, to the sugar-cane; the grub, according to Humboldt and Bonpland, feeding on its roots and killing the plants †.

Instances are by no means rare, however, of insects being accused of depredations of which they are not guilty, from the mere circumstance of their being

* Intr. i. 182-3. † Geog. des Plantes, 136.

found in abundance where ravages have been committed by others that have naturally disappeared. It is not improbable that this was the case with a grub of some beetle (*Staphylinidæ?*), mentioned by Mr. Walford, and mistaken by him for the wire worm. Out of fifty acres of wheat sown in 1802, ten had been destroyed in October, by this grub eating into the centre of the young stem an inch below the surface and killing the plant*. It seems still more probable that the grub of a native beetle (*Zabrus gibbus*, STEPHENS), which has been found in considerable numbers near Worthing, Brighton, Hastings, and Cambridge, has been unjustly blamed as a destroyer of corn; though we have the respectable authority of Germar, who, with other members of the society of Natural History of Halle, imagined he had ascertained the fact. In the spring of 1813, about two hundred and thirty acres of young wheat are said to have been destroyed by it; and it is farther supposed to be the same insect which caused great destruction in Italy in 1776. This grub is said to take probably three years in coming to a beetle, in which state it is alleged to clamber up the stems at night, to get at the corn. It is important to remark, that along with these grubs were found

a  b

a, Zabrus gibbus; *b*, Melolontha ruficornis.

* Linn. Trans. ix. 156-61.

those of a chafer (*Melolontha ruficornis*, Fabr.), in the proportion of about a fourth *.

To this account, Mr. Stephens appends the shrewd questions—"May not these herbivorous larvæ [of the chafer] have been the principal cause of mischief to the wheat, while those of the *Zabrus* rather contributed to lessen their numbers, than to destroy the corn? And is it not probable that the perfect insects ascend the corn for the purpose of devouring the insect parasites thereon? This is a subject," he justly adds, "that requires investigation, as it is highly important, for the interests of the agriculturist in those districts where the insect abounds, that the question should be thoroughly set at rest; because, should the Zabri depart from the habits of the group to which they belong, and become herbivorous instead of carnivorous, their destruction would be desirable; while, on the contrary, if they destroy the devourers of our produce their preservation should be attempted †."

We have little doubt that Mr. Stephens is right, and Germar wrong; but it would be improper to decide the question by analogy unsupported by direct experiment. One thing is certain, that both this family (*Harpalidæ*, MacLeay) and the whole section (*Adephaga*, Clairville) are not herbivorous, but carnivorous ‡. Similar errors will come under our notice, as we proceed, not more defensible than that of the old soldier causing caterpillars in France.

Even when agricultural produce escapes being devoured at the root, or the young shoots eaten up, the seeds are often made the prey of the grubs of

* Germar, Mag. der Entomol., i. 1-10; and Kirby and Spence, i. 169.

† Stephens, Illustrations, i. Mandib. pp. 4 and 140.

‡ See an Illustration in Insect Architect., p. 207-8.

beetles and weevils. Among the first, the gnawing beetles (*Bruchidæ*, LEACH) are very destructive. In North America, the pea beetle (*Bruchus Pisi*, LINN.) commits such extensive depredations on pulse, that in some districts the sowing of peas has been abandoned as useless. Kalm, the Swedish traveller, having witnessed these depredations in America, became quite alarmed when he discovered the insect among some peas he had brought to Sweden, lest he should be the means of introducing so formidable a pest*. His fears seem to us to have been in a great measure groundless; for, probably, the insect may be indigenous to Sweden, as it is to Britain, though from circumstances of climate, and other causes, it is seldom produced in such numbers with us as to occasion extensive damage. It may have been the same or an allied species of grub mentioned by Amoroux as having spread an alarm in France in 1780, when the old fancy of its being poisonous induced the public authorities to prohibit peas from being sold in the markets†. The insect most destructive to our peas is the pulse beetle (*Bruchus granarius*, LINN.), which sometimes lays an egg on every pea in a pod, which the grub, when hatched, destroys. In the same way, clover seed is often attacked by two or more species of small weevil (*Apion*, HERBST), known by the yellow colour of their thighs or their feet; and when the farmer expects to reap considerable profit, he finds nothing but empty husks.

We have mentioned the ravages committed in granaries by the caterpillars of small moths; but these are rivalled in the work of destruction by several species of grubs. One of these grubs is

* Kalm's Travels, vol. i. p. 173.

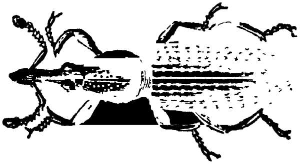
† Amoroux, Insectes Venimeux, 288. Kirby and Spence, i. 177.

called by the French cadelle (*Trogosita mauritanica*, Olivier), and is reported to have done more damage to housed grain than any other insect*. The pest of the granaries, which is but too well known in this country, is the grain weevil (*Calandra granaria*, Clairville), the same, probably, which is mentioned by Virgil,

——— Populatque ingentem farris acervum
Curculio. *Georg*. i. 87.

——— The high stacks of corn
Are wasted by the weevil. *Trapp*.

Kirby and Spence calculate that a single pair of weevils may produce in one season 6000 descendants; and they were told by an extensive brewer that he had collected and destroyed them by bushels†,—meaning, no doubt, insects and damaged grain together.



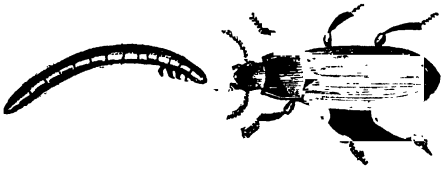
Corn weevil (*Calandra granaria*), magnified.

Another beetle grub, popularly called the meal worm, the larva of *Tenebrio molitor*, Linn., which lives in that state two years, does no little damage to flour, as well as to bread, cakes, biscuit, and similar articles. Accounts are also given of the ravages committed by the grubs of other beetles, of several species apparently not well ascertained, upon different sorts of provisions, such as bacon, ham, dried tongues, ship-biscuit, &c. Sparrman tells us, that he has witessed the ground peas on ship-board so infested

* Olivier, ii. 19. † Intr. i. 173.

with these grubs, that they were seen in every spoonful of the soup. In the case of soup, or of other food which has been exposed to heat, the only inconvenience is the disgust which must ensue; but, unfortunately, there may sometimes occur circumstances of a more serious nature,—from either the eggs or the insects themselves being incautiously swallowed alive. We do not wish, however, to create, so much as to allay, the fears entertained by those who are unacquainted with the habits of insects; and nothing we are persuaded will do this more effectually than a statement of facts well ascertained. "Several people," says the Abbé de la Pluche, "never eat fruit because they believe that spiders and other insects scatter their eggs upon it at random*;" but even if this were so, as it is not, it would be impossible for the young, should they be hatched in the stomach, to live there for an instant. The possible cases in which this may occur we shall now briefly notice; they are fortunately very rare.

The meal worm, and some of the grubs which feed on grain and other provisions, are recorded to have been swallowed, and to have given rise to disorders in the stomach and bowels; but in all such cases it is plain, that if the insects did survive the increased temperature of the stomach, they could only live on the food swallowed from time to time, for, not being carnivorous, they would not attack



Meal worm, and the beetle produced from it.

* Spectacle de la Nature, i. 65.

the stomach itself. The same remark will apply no less forcibly to the herbivorous larvæ, which might chance to be swallowed in salad, &c. The caterpillar of the tabby moth (*Aglossa pinguinalis*, LATREILLE), which feeds on butter, the leather on book-boards, &c., is said, on the authority of Linnæus, to get sometimes into the stomach, and to produce considerable disorder*; but this insect is very common in houses†, and, from the rarity of such accidents, we are led to doubt the evidence usually brought forward. In this case we are the more induced to question the authority of Linnæus, from his having made an evident mistake in a similar case respecting intestinal worms.

Transformations of the tabby moth (*Aglossa pinguinalis*). *a*, the caterpillar feeding on butter; *b*, *c*, *d*, feeding on leather under galleries; *e*, the moth with the down rubbed off; *f*, the same perfect.

Linnæus affirms, that in the presence of seven of his companions he discovered, near Reuterholm, in Dalecarlia, a tape worm in acidulous ochre (*Ochram acidularem*), at which he marvelled the more since

* Linnæus, quoted by Kirby and Spence, i. 136.
† Latreille, Hist. Générale, xiv. 229.

acidulous water of this kind had been drank with the design of expelling these worms*. This account, however, proves too little; for, as Bonnet, Réaumur, Pallas, and other eminent naturalists remark, if such were the fact, we should find intestinal worms (so very numerous in most animals) swarming in such places, and from their size (Boerhaave saw one thirty ells long) they could not escape observation; whereas this was at that time the only instance recorded of one found out of the body. We are of opinion that Linnæus must have been deceived by similarity of form. A subsequent instance is recorded by Dr. Barry, of Cork, who imagined he had found the origin of the common small thread worm (*Oxyuris vermicularis*, BREMSER) in the water of a well—the aquatic only differing from the intestinal worms *in colour*. But were all descriptions as loose as this the grossest mistakes must ensue; for it is quite clear that Dr. Barry's aquatic worms were a very common species (*Naïs*), and though similar in external form, altogether different in internal structure from the *Oxyuridæ* of the intestines. Were the latter, indeed, introduced into the body from water, they would not only be found in this particular well, two miles from Cork, but would swarm in all the waters in the empire; since there are few individuals who are not affected with these worms at some period of their lives. According to our experiments, the *naïs* ceases to exist in a temperature considerably less than that of the human body; besides, as it lives on minute fresh-water molluscæ, it could find no food in the intestines†.

The celebrated Dr. J. P. Frank is no less mistaken in referring us for the origin of intestinal worms to "minute insects flying in the air‡;" for, if so, the

* Linnæus, quoted by Bonnet, Œuvres, iii. 137. † J. R.
‡ Frank. De Curand. Homin. Morb. lib. vi.

worms would naturally produce similar insects to their parents; whereas they are either oviparous, as Goetze affirms, or, as Bremser thinks, ovo-viparous * both agreeing that they are not transformed into flying insects. Réaumur made the more plausible conjecture, that they might be introduced by eating tench and other fish, in which they are known to abound †; but, independently of their being destroyed by heat in cooking, this has been subsequently disproved by experiment; for M. Deslonchamps says, that "when animals are fed for some time on intestinal worms (*Entoözaria*) alone, and then killed, they are not found infested with these worms ‡." Valisnieri and Hartsöcker suppose, without a shadow of proof, that worms are transmitted from parents to children like other hereditary disorders; while the late M. Lamarck refers their production to "the march of nature in the production of all living beings §!" This indefinite doctrine is also held by Geoffroi St. Hilaire, Cuvier, Blumenbach, and other distinguished living naturalists; but we think it more philosophical and more manly, in such obscure cases, at once to confess our ignorance of the ways of nature, and to wait for further observation, than to frame idle theories, supported only by vague analogies and doubtful facts.

It may not be uninteresting to mention, however, that upwards of 1200 species of intestinal worms have been discovered; and probably there may be twice as many more of whose existence nothing is yet known. Sixteen of these species have been found in the human body; the rest are peculiar to other animals ‖. Some of the more singular species

* Bremser, Uber Lebende Würmer in leb. Mensch.

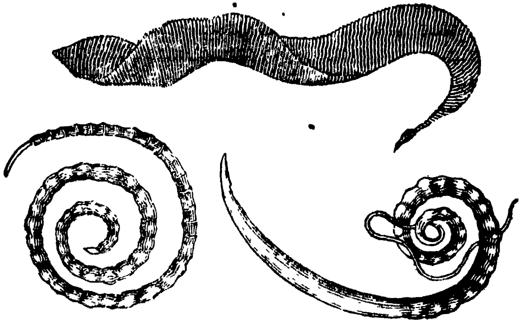
† Letter to Bonnet, Œuvres, vol. iii. p. 344.

‡ Dict. Classique, vol. viii. p. 589.

§ Anim. sans Vertebres, vol. i. p. 15.

‖ Dict. Classique, vol. viii. p. 593.

are here represented, from the splendid work of Bremser.



Intestinal worms.

That insects are, in some rare cases, introduced into the human stomach, has been more than once proved; though the greater number of the accounts of such facts in medical books are too inaccurate to be trusted*. But one extraordinary case has been completely authenticated, both by medical men and competent naturalists; and is published in the Dublin Transactions, by Dr. Pickells of Cork†. Mary Riordan, aged 28, had been much affected by the death of her mother, and at one of her many visits to the grave seems to have partially lost her senses, having been found lying there on the morning of a winter's day, and having been exposed to heavy rain during the night. When she was about fifteen, two popular Catholic priests had died, and she was told by some old women that if she

* See Good's Nosologia, Helminthia Alvi; and Study of Med. vol. i. p. 336.

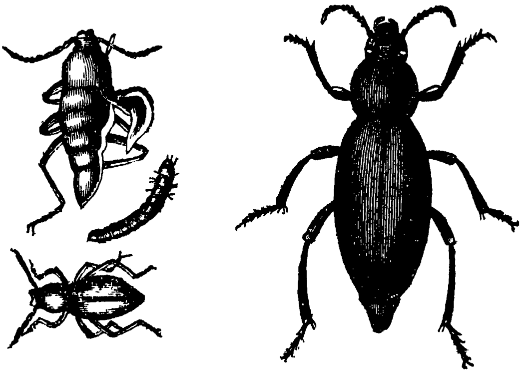
† Trans. of Assoc. Phys. in Ireland, iv. vii. and v., p. 177, 8vo. Dublin, 1824—1828.

would drink daily, for a certain time, a quantity of water, mixed with clay taken from their graves, she would be for ever secure from disease and sin. Following this absurd and disgusting prescription, she took from time to time large quantities of the draught; some time afterwards, being affected with a burning pain in the stomach (*Cardialgia*), she began to eat large pieces of chalk, which she sometimes also mixed with water and drank.

Now, whether in any or in all of these draughts she swallowed the eggs of insects, cannot be affirmed; but for several years she continued to throw up incredible numbers of grubs and maggots, chiefly of the churchyard beetle (*Blaps mortisaga*, FABR.). "Of the larvæ of the beetle," says Dr. Pickells, "I am sure I considerably underrate, when I say that not less than 700 have been thrown up from the stomach at different times since the commencement of my attendance. A great proportion were destroyed by herself to avoid publicity; many, too, escaped immediately by running into holes in the floor. Upwards of ninety were submitted to Dr. Thomson's* examination; nearly all of which, including two of the specimens of the meal worm (*Tenebrio molitor*), I saw myself, thrown up at different times. The average size was about an inch and a half in length, and four lines and a half in girth. The larvæ of the dipterous insect, though voided only about seven or eight times, according to her account, came up almost literally in myriads. They were alive and moving." Altogether, Dr. Pickells saw nearly 2000 grubs of the beetle, and there were many which he did not see. Mr. Clear, an intelligent entomologist of Cork, kept some of them alive for more than twelve months. Mr. S. Cooper cannot understand whence the continued supply of the grubs was provided, seeing that

* The well-known author of "Zoological Researches," &c.

larvæ do not propagate, and that only one pupa and one perfect insect were voided*; but the simple fact that most beetles live several years in the state of larvæ sufficiently accounts for this. Their existing and thriving in the stomach, too, will appear less wonderful from the fact that it is exceedingly difficult to kill this insect; for Mr. Henry Baker repeatedly plunged one into spirits of wine, so fatal to most insects, but it revived, even after being immersed a whole night, and afterwards lived three years †.



'Churchyard beetle (*Blaps mortisaga*), in the grub and perfect state, from the figures of Dr. Pickells.

That there was no deception on the part of the woman, is proved by the fact that she was always anxious to conceal the circumstance; and that it was only by accident that the medical gentlemen, Drs. Pickells, Herrick, and Thomson, discovered it. Moreover, it does not appear that, though poor, she ever took advantage of it to extort money. It is interest-

* Cooper's edition of Good's Study of Medicine, i. 358.

† Philosoph. Trans., No. 457.

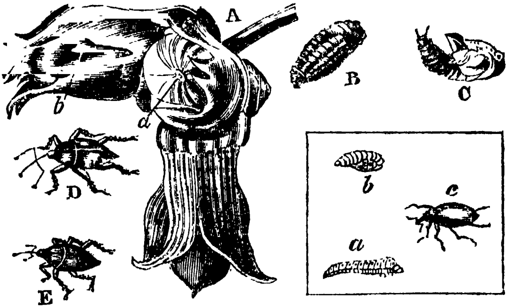
ing to learn that by means of turpentine, in large doses, she was at length cured.

The grub of the nut weevil (*Balaninus Nucum*, Germar) might, perhaps, by rare accident, get into the stomach, either of man or of the quadrupeds which feed on nuts; but as it is by no means so tenacious of life as the grub of the churchyard-beetle (*Blaps mortisaga*) above described, it is unlikely that it would produce any considerable disorder. The weevil in question, like the rest of its congeners, is furnished with an instrument for depositing its eggs considerably different from those of the ichneumons and saw-flies. For this purpose the weevil makes use of its long horny beak (*Rostrum*) to drill a hole in filberts and hazel-nuts, while in their young and soft state, about the beginning of August. The mother weevil may then be seen eagerly running over the bushes, and it would appear that she always rejects the nuts in which one of her neighbours may have previously laid an egg; at least we never find two grubs in the same nut. The egg, which is thus thrust into the young nut, is of a brown colour, and is hatched in about a fortnight, the grub feeding on the interior of the shell as well as the soft pulp, till the one becomes too hard and the other too dry to be nutritive. It is remarkable that, during this period, he takes care not to injure the kernel, but permits it to ripen before he attacks it. Had he done this prematurely, he would have ultimately been starved, as he has not the power of perforating another nut when the first is consumed. It is said also that he is very careful to preserve the original hole made by the mother, by gnawing around its inner edges, in order to facilitate his exit*, which he effects when the

* Bingley, Animal Biography, vol. iii., p. 251.

nut falls to the ground in September or October. The hole found in the nut appears much too small to have admitted of its passage; but from being very soft it no doubt stretches itself out for the purpose, using its short claws as instruments of motion.

Rösel, in order to observe the transformation of these nut grubs, put a number of them, at the commencement of winter, into glasses half filled with earth, covered with green turf. All of them dug directly down into the earth, remained there all the winter, and did not change into pupæ till the following June; the perfect weevils appeared from the 1st till about the 20th of August, but still kept under ground for the first week after their change.



Nut and apple-tree beetles. A, a branch of the filbert-tree. *a*, egg hole in the nut; *b*, exit hole of the grub. B, the larvæ of the nut beetle. C, the same in the pupa state. D, female beetle. E, male beetle. *c*, the beetle that destroys the bloom-bud of the apple-tree; *a*, the same in the larva state; *b*, the chrysalis of the same.

"During the autumn," says Salisbury, "we frequently observe a small red weevil busily employed in traversing the branches of apple-trees, on which it lays its eggs by perforating the bloom buds. In the spring, these hatch, and the grubs feed on the petals of the flowers, drawing up the whole flower into a cluster by means of their web. The bloom thus becomes destroyed, and the grub falls to the ground, where it lays itself up in the chrysalide state; and in the autumn afterwards we find the weevil renewed, which again perforates the buds, and causes a similar destruction in the following spring. Mr. Knight, in his treatise on the apple, mentions a beetle which commits great destruction on the apple-trees in Herefordshire; but I do not think it the same as the one I have described above, and which is very common in the gardens near London*." Salisbury's weevil is probably the *Anthonomus Pomorum* of Germar; and Knight's, his *Polydrusus Mali.* Another weevil (*Rhynchites Bacchus*, Herbst), one of our most splendid but not very common native insects, bores into the stone of the cherry, &c. while it is young and soft, and deposits an egg there, as the nut weevil does in the nut.

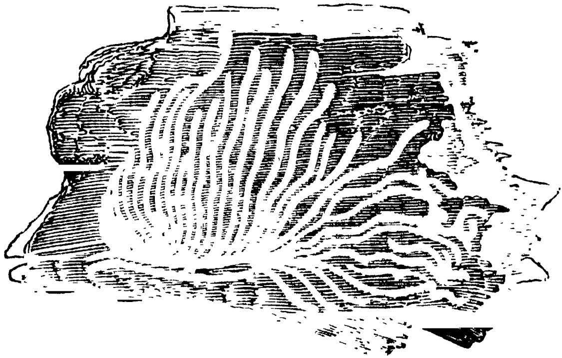
Perhaps the most voracious grub on record is that of a large and beautiful beetle (*Calosoma sycophanta*, Weber), which is rare in Britain. It is sometimes found in the nests of the processionary and other gregarious caterpillars, so gorged with those it has devoured that it can scarcely move without bursting. Not contented with this prey alone, however, the younger grubs are said "often to take advantage of the helpless inactivity into which the gluttony of their maturer comrades has thrown them, and from mere wantonness, it should seem, when in no need of other food, pierce and devour them†." It is a familiar occurrence to those who breed insects to find caterpillars, whose natural food is leaves, devouring others in the same nurse-box; and without any

* Salisbury's Hints on Orchards, p. 92.

† Kirby and Spence, vol. i. p. 277.

apparent discrimination whether these are the progeny of their own mother, or of a different species *.

We have frequently observed a very remarkable instinct in the grubs of a species of beetle (*Scolytus Destructor*, GEOFFROY), which lives under the dead bark of trees. The mother insect, as is usual with beetles, deposits her eggs in a patch or cluster in a chink or hole in the bark; and when the brood is hatched, they begin feeding on the bark which had formed their cradle. There is, of course, nothing won derful in their eating the food selected by their mother; but it appears that, like the caterpillars of the clothes moth, and the tent insects, they cannot feed except under cover. They dig, therefore, long tubular galleries between the bark and the wood; and, in order not to interfere with the *runs* of their brethren, they branch off from the place of hatching like rays from the centre of a circle: though these are not always in a right line, yet, however near they may approach to the contiguous ones, none of them ever



Bark mined in rays by beetle grubs.

* J. R. See also De Geer, i. 533, &c., and Réaumur, ii. 413.

break into each other's premises. We cannot but admire the remarkable instinct implanted in those grubs by their Creator; which guides them thus in lines diverging farther and farther as they increase in size, so that they are prevented from interfering with the comforts of one another.

The various instances of voracity which we have thus described sink into insignificance, when compared with the terrible devastation produced by the larvæ of the locust (*Locusta migratoria*, Leach), —the scourge of oriental countries. "A fire devoureth before them," says the Prophet Joel, "and behind them a flame burneth: the land is as the garden of Eden before them, and behind them a desolate wilderness; yea, and nothing shall escape them. The sound of their wings is as the sound of chariots, of many horses running to battle; on the tops of mountains shall they leap, like the noise of a flame of fire that devoureth the stubble, as a strong people set in battle-array. Before their faces, the people shall be much pained, all faces shall gather blackness. They shall run like mighty men; they shall climb the wall like men of war; and they shall march every one in his ways, and they shall not break their ranks; neither shall one thrust another*."

The intelligent traveller, Dr. Shaw, was an eyewitness of their devastations in Barbary in 1724, where they first appeared about the end of March, their numbers increasing so much in the beginning of April as literally to darken the sun; but by the middle of May they began to disappear, retiring into the Mettijiah and other adjacent plains to deposit their eggs. "These were no sooner hatched in June," he continues, "than each of the broods collected itself into a compact body, of a furlong or more in square; and marching afterwards directly

* Joel ii. 2, &c.

forwards toward the sea, they let nothing escape them,—they kept their ranks like men of war; climbing over, as they advanced, every tree or wall that was in their way; nay, they entered into our very houses and bed-chambers, like so many thieves. The inhabitants, to stop their progress, formed trenches all over their fields and gardens, which they filled with water. Some placed large quantities of heath, stubble, and other combustible matter, in rows, and set them on fire on the approach of the locusts; but this was all to no purpose, for the trenches were quickly filled up, and the fires put out, by immense swarms that succeeded each other.

"A day or two after one of these hordes was in motion, others were already hatched to march and glean after them. Having lived near a month in this manner, they arrived at their full growth, and threw off their nympha-state by casting their outward skin. To prepare themselves for this change, they clung by their hinder feet to some bush, twig, or corner of a stone; and immediately, by using an undulating motion, their heads would first break out, and then the rest of their bodies. The whole transformation was performed in seven or eight minutes; after which they lay for a small time in a torpid, and, seemingly, in a languishing condition; but as soon as the sun and the air had hardened their wings by drying up the moisture that remained upon them after casting their sloughs, they resumed their former voracity, with an addition of strength and agility. Yet they continued not long in this state before they were entirely dispersed *."

It is difficult to form an adequate conception of the swarms of locusts which, in 1797, invaded the interior of southern Africa, as recorded by Mr. Barrow. In the part of the country where he was,

* Shaw's Travels, p. 287.

the whole surface of the ground, for an area of nearly two thousand square miles, might literally be said to be covered with them. The water of a very wide river was scarcely visible, on account of the dead carcases of locusts that floated on the surface, drowned in the attempt to come at the reeds that grew in it. They had devoured every blade of grass, and every green herb, except the reeds. But they are not precisely without a choice in their food. When they attack a field of corn just come into ear, they first, according to Mr. Barrow, mount to the summit and pick out every grain before they touch the leaves and stem, keeping the while constantly in motion, with the same intent of destruction always in view. When the larvæ, which are much more voracious than the perfect insects, are on a march during the day, it is utterly impossible to turn the direction of the troop, and this seems usually to correspond with that of the wind. Towards the setting of the sun the march is discontinued, when the troop divides into companies that surround the small shrubs, or tufts of grass, or ant-hills, in such thick patches, that they appear like so many swarms of bees; and in this manner they rest till day-light. At these times it is that the farmers have any chance of destroying them; this they sometimes effect by driving among them a flock of two or three thousand sheep, by whose restlessness great numbers of them are trampled to death. The year 1797 was the third of their continuance in Sneuwberg; and their increase had been more than a million-fold from year to year.

This district, however, had been entirely free from them for ten years preceding their visit in 1794. Their former exit was singular: all the full-grown insects were driven into the sea by a tempestuous north-west wind, and were afterwards cast up on the beach, where they formed a bank of three or four feet high, and extending to a distance of nearly fifty miles. When this mass became putrid, and the wind was at south-east, the stench was sensibly felt in several parts of Sneuwberg, although distant at least a hundred and fifty miles*.

Pallas gives a more detailed account of the daily proceedings of the larvæ of the Italian locust (*Locusta Italica*, Leach). " In serene weather," he tells us, " the locusts are in full motion in the morning, immediately after the evaporation of the dew; and if no dew has fallen, they appear as soon as the sun imparts his genial warmth. At first, some are seen running about like messengers among the reposing swarms, which are lying partly compressed upon the ground at the side of small eminences, and partly attached to tall plants and shrubs. Shortly after the whole body begins to move forward in one direction, and with little deviation. They resemble a swarm of ants, all taking the same course, at small distances, but without touching each other: they uniformly travel towards a certain region as fast as a fly can run, and without leaping, unless pursued; in which case, indeed, they disperse, but soon collect again and follow their former route. In this manner they advance from morning to evening without halting, frequently at the rate of a hundred fathoms, and upwards, in the course of a day. Although they prefer marching along high roads, foot-paths, or open tracts, yet, when their progress is opposed by bushes, hedges, and ditches, they penetrate through them: their way can only be impeded by the waters of brooks or canals, as they are apparently terrified at every kind of moisture. Often, however, they endeavour to gain the opposite bank, with the aid of overhanging boughs; and, if the stalks of plants or shrubs be laid across the water, they pass in close

* Barrow's Travels in South Africa, p. 257.

columns over these temporary bridges, on which they even seem to rest, and enjoy the refreshing coolness. Towards sun-set, the whole swarm gradually collect in parties, and creep up the plants, or encamp on slight eminences. On cold, cloudy, or rainy days, they do not travel. As soon as they acquire wings, they progressively disperse, but still fly about in large swarms*."

When Captains Irby and Mangles were travelling round the southern extremity of the Dead Sea, in the end of May, they had an opportunity of observing these insect depredators. "In the morning," say they, "we quitted Shobek. On our way we passed a swarm of locusts that were resting themselves in a gully; they were in sufficient numbers to alter apparently the colour of the rock on which they had alighted, and to make a sort of crackling noise while eating, which we heard before we reached them. Volney compares it to the foraging of an army. Our conductors told us they were on their way to Gaza, and that they pass almost annually†."

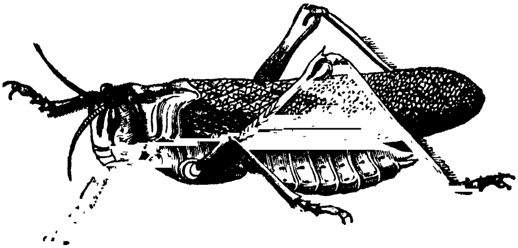
Even our own island has been alarmed by the appearance of locusts, a considerable number having visited us in 1748; but they happily perished without propagating. Other parts of Europe have not been so fortunate. In 1650 a cloud of locusts were seen to enter Russia in three different places; and they afterwards spread themselves over Poland and Lithuania in such astonishing multitudes, that the air was darkened, and the earth covered with their numbers. In some places they were seen lying dead, heaped upon each other to the depth of four feet; in others they covered the surface of the ground like a black cloth: the trees bent with their weight, and the

* Travels in Russia, ii. 422-6.

† Irby and Mangles' Travels in Egypt and Syria, p. 443.

damage the country sustained exceeded computation *. They have frequently come also from Africa into Italy and Spain. In the year 591 an infinite army of locusts, of a size unusually large, ravaged a considerable part of Italy, and being at last cast into the sea, (as seems for the most part to be their fate,) a pestilence, it is alleged, arose from their stench, which carried off nearly a million of men and beasts. In the Venetian territory, likewise, in 1478, more than 30,000 persons are said to have perished in a famine chiefly occasioned by the depredations of locusts †.

* Bingley, Anim. Biog., iii., 280.
† Mouffet, Theatr. Insect., 123.



Locust.

CHAPTER X.

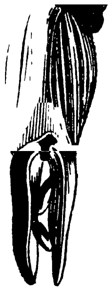
Voracity of Caterpillars, Grubs, and Maggots;—concluded.

MAGGOTS.

ADHERING to the distinction of terming those larvæ which are destitute of feet, *maggots*, we shall notice here a very destructive one, which is sometimes popularly called *the* grub, and sometimes confounded with the wire worm*. We allude to the larvæ of one or two common species of crane flies (*Tipulidæ*), well known by the provincial names of father-long-legs, Jenny-spinners, and tailors. These insects are so common in some meadows, that, being very shy and fearful of danger, they rise in swarms at every step—some of them flying high, others only skipping over the grass, and others running and using their long legs as the inhabitants of marshy countries use stilts, and employing their wings like the ostrich to aid their limbs.

These flies deposit their eggs in the earth; sometimes in grass fields or moist meadows, and sometimes in the tilled ground of gardens and farms. For this purpose the female is provided with an ovipositor well adapted to the operation, consisting of a sort of pincers or forceps of a horny consistence, and sharp at the point. By pressure, as Réaumur says, the eggs may be extruded from this in the same way as the stone can be easily squeezed out of a ripe cherry, as in the following figure.

* See Stickney's Observ. on the Grub, 8vo. Hull, 1800.



Ovipositor and eggs of the crane fly (*Tipula*).

The eggs are exceedingly small and black, like grains of gunpowder, and each female lays a good many hundreds. The position which she assumes appears somewhat awkward, for she raises herself perpendicularly on her two hind legs, using her ovipositor as a point of support, and resting with her fore-legs upon the contiguous herbage. She then thrusts her ovipositor into the ground as far as the first ring of her body, and leaves one or more eggs in the hole; and next moves onwards to another place, but without bringing herself into a horizontal position. The maggot, when hatched from the egg, immediately attacks the roots of the grass and other herbage which it finds nearest to it; and of course the portion of the plant above ground withers for lack of nourishment.

The maggots of this family which seem to do most injury are those of *Tipula oleracea* and *T. cornicina.* In the summer of 1828, we observed more than an acre of ground, adjoining the Bishop of Oxford's garden, at Blackheath, as entirely stripped, both of grass and every thing green, as if the turf had been

Crane fly ovipositing, and the larva beneath, in the earth, feeding upon grass roots.

pared off from the surface, the only plant untouched being the tiny bird tare (*Ornithopus perpusillus*). On digging here to learn the cause, we found these larvæ already full-fed, and about to pass into pupæ, after having left nothing upon which they could subsist. It was not a little remarkable that they seemed to be altogether confined to this spot; for we did not meet with a single foot of turf destroyed by them in any other part of the heath, or in the adjacent fields. So very complete, however, was their destruction of the roots on the spot in question, that even now, at the distance of two years, it is still visibly thinner of herbage than the parts around it *.

Réaumur gives a similar account of their ravages in Poitou, where, in certain seasons, the grass of the low moist meadows has been so parched up in consequence, as not to afford sufficient provender for the cattle. He describes the soil in Poitou as a black peat mould; and it was the same in which we found them at Blackheath, with this difference, that the spot was elevated and dry. According to M. Réaumur, also, their only food is this sort of black mould, and not the roots of grass and herbage, which he thinks are only loosened by their burrowing †. This view of the matter appears strongly corroborated by the fact that several species of the family feed upon the mould in the holes of decaying trees, particularly the larva of a very beautiful one (*Ctenophora flaveolata*, MEIGEN), which is very rare in Britain. It is proper to mention, however, that Mr. Stickney's experiments ‡, contrary to the conclusions of Réaumur, indicate that these larvæ devour the roots of grass; and Stewart says they "feed on the roots of plants, corn, and grasses, and are thence destructive to gardens, fields, and meadows. They prevailed in the neighbourhood of Edinburgh, and other places in Scotland, in the spring of 1800, when they laid waste whole fields of oats and other grain §."

In many districts of England these insects cut off a large proportion of the wheat crop, particularly, it would appear, when it had been sown on clover leys. "In the rich district," say Kirby and Spence, "of Sunk Island, in Holderness, in the spring of 1813, hundreds of acres of pasture have been entirely de-

* J. R. † Réaumur, v. 12, &c.
‡ Obs. on the Grub. § Elements, ii., 267.

stroyed by them, being rendered as completely brown as if they had suffered a three months' drought, and destitute of all vegetation except a few thistles. A square foot of the dead turf being dug up, 210 grubs were counted on it; and, what furnishes a striking proof of the prolific powers of those insects, last year it was difficult to find a single one *."

It is worthy of remark that the mandibles of these destructive creatures, which are claw-shaped and transverse, do not act against each other as is usual among insects, but against two other pieces which are immoveable, convex, and toothed,—as if the under-jaw in quadrupeds were divided into two, and should act vertically on the two portions of the immoveable upper-jaw thrown in between them.

The maggot of a minute fly of the same family, known by the name of the wheat fly (*Cecidomyia Tritici*, KIRBY), is frequently productive of great damage in the crops of wheat. Its history was first investigated by Marsham, and subsequently by Kirby, and several other intelligent naturalists The parent fly is very small, not unlike a midge (*Culicoides punctata*, LATR.), of an orange colour, and wings rounded at the tip, and fringed with hairs †. The female is furnished with a retractile ovipositor, four times as long as the body, and as fine as a hair, for depositing her eggs, which she does in the glumes of the florets of the grain. The following account of its proceedings is given by Mr. Shireff, an intelligent farmer of East Lothian.

"Wheat-flies," he says, "were first observed here this season on the evening of the 21st of June, and, from the vast number seen, it is probable a few of them may have been in existence some days previous.

* Intr. i. 318, note.

† Linn. Trans., iii., 243—iv., 234–240; v., 96.

The eggs were visible on the 23d, the larvæ on the 30th of that month, and the pupæ on the 29th of July. The flies were observed depositing eggs on the 28th, and finally disappeared on the 30th July; thus having existed throughout a period of thirty-nine days.

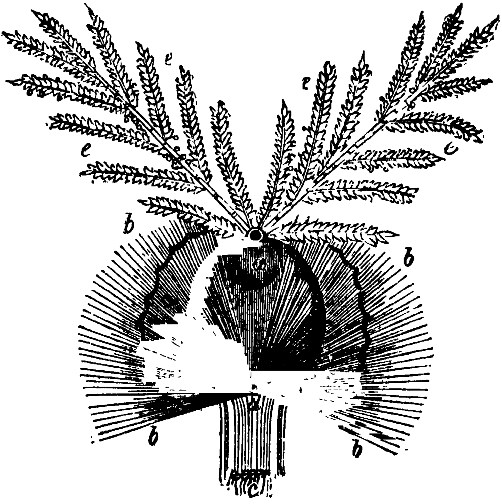
"The flies were observed to frequent the wheat-plant, including the thick-rooted couch-grass (*Triticum repens*). They generally reposed on the lower parts of the stems during the day, and became active about sunset, except when the wind was high. I have, however, seen them flying about on cloudy mornings, till seven o'clock; and, upon one occasion, witnessed them depositing their eggs, in a shaded situation, at two in the afternoon. Their movements appear to be influenced by the rays of light, of which they seem impatient, being active when the sun is below or near the horizon: they frequent the most umbrageous part of the crop, and shun that which is deficient in foliage.

"The flies almost invariably preferred the ears emerging from the vagina to those farther advanced, for depositing their eggs on; and as one side only of the ear is exposed when the plant is in this stage of growth, the other side generally remained uninjured. The fly deserted the fields as the crop advanced towards maturity, and were found longest on the spring-sown portion of the crop. It seemed to feed on the gum adhering to the newly emerged ears; and as there is a great diversity in the time of sowing wheat in this neighbourhood, and consequently of the ears escaping from the vagina, I attribute the unusual length of time it has existed this season, to the supply of food thus gradually furnished.

"The fly deposits its eggs with much intensity, and may easily be taken when so employed. Upon one occasion, I numbered thirty-five flies on a single ear; and, after carrying it a distance of a quarter of a mile, six of them still continued to deposit eggs. At another time, I placed a fly, then laying, between the face and glass of my watch, where it deposited several eggs, although invariably interrupted by the revolution of the moment hand.

"The eggs of the fly are generally found in clusters, varying in number from two to ten, upon the inner chaff, in which the furrowed side of the grain is embedded, and are also occasionally to be seen in the interior parts of the flower and chaff. The eggs are deposited by means of a long slender tube, and fixed with a glutinous substance possessed by the fly. A thread of glutinous matter frequently connects a cluster of eggs with the style, where the larvæ seem to subsist on the pollen; in one instance, fifteen eggs were numbered on such a thread, several of which were suspended on the portion extending between the chaff and the style. The fly not only seems thus to provide a conveyance from the larvæ to the style, but also food for their support. The anthers are prevented from leaving the style in consequence of being gummed down by the glutinous matter of the fly, and the pollen thereby detained for the use of the larvæ, which otherwise would, in part, be carried out of the glumes by the expansion of the filaments,—known to farmers by the term *bloom*. In the exertion of gumming down the anthers, many of the flies are entangled in the vascules of the corolla, and thus become a sacrifice to their maternal affection.

"The larvæ are produced from the eggs in the course of eight or ten days: they are at first perfectly transparent, and assume a yellow colour a few days afterwards. They travel not from one floret to another, and forty-seven have been numbered in one. Occasionally there are found in the same floret larvæ and a grain, which is generally shrivelled, as if deprived of nourishment; and although the pollen may furnish the larvæ with food in the first instance, they soon crowd around the lower part of the germen, and there, in all probability, subsist on the matter destined to have formed the grain*."



Germination of a grain of wheat. *a*, the heart of the grain, the part devoured by the insect. *b*, bag of the seed. *c*, the root. *d*, vessels to convey the nutriment for the root. *e*, feathers conveying the pollen to fructify the seed.

Another intelligent observer, Mr. Gorrie, of Annat Gardens, Perthshire, found that by the first of August all the maggots leave the ears, and go into the ground about the depth of half an inch, where it is probable they pass the winter in the pupa state†."

It is interesting to learn that this destructive in-

* Loudon's Mag. of Nat. Hist., Nov. 1829, p. 450.
† Ibid. September, 1829, p. 324.

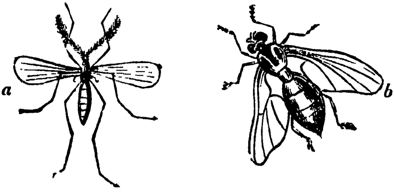
Transformations of the wheat fly. *a*, the female fly magnified; *b*, larvæ, natural size, feeding; *c*, one magnified.

sect is providentially prevented from multiplying so numerously as it might otherwise do, by at least two species of ichneumons, which deposit their eggs in the larvæ. One of these (*Encyrtus inserens*, LATR.) is very small, black, and shining. The other (*Platygaster Tipulæ*, LATR.) is also black, with red feet, and a blunt tail. These have been frequently mistaken for the wheat-fly; but as it has only *two* wings, while they have *four*, the distinction is obvious. In order to observe the proceedings of the ichneumons, Kirby placed a number of the larvæ of the wheat-fly on a sheet of white paper, and set a female ichneumon in the midst of them. She soon pounced upon her victim, and intensely vibrating her antennæ, and bending herself obliquely, plunged her ovipositor into the body of the larva, depositing in it a single egg. She then passed to a second, and proceeded in the same manner, depositing a single egg in each. Nay, when she examined one which she found had already been pricked, she always rejected it and passed to another *. Mr. Shireff repeated these experiments successfully, except that he saw an ichneumon twice prick the same maggot, which " writhed in seeming agony," and " it was again stung three times by the same fly." He adds, " the earwig also destroys the larvæ, three of which I successively presented to an earwig, which devoured them immediately †." Mr. Gorrie describes these ichneumons as appearing in myriads

* Linn. Trans. *ut supra*. † Loudon's Mag. *ut supra*.

on the outside of the ear; but as impatient of bright light, sheltering themselves from the sun's rays among the husks.

Our English naturalists were for many years of opinion, that the insect called the Hessian-fly, so destructive to wheat crops in America, belonged to the same family (*Muscidæ*) with the common house-fly; and Mr. Markwick, an intelligent naturalist, by a series of observations on a British fly (*Chlorops pumilionis*, MEIGEN) which attacks the stems of wheat, created no little alarm among agriculturists. Markwick's fly is less than a fourth of an inch in length, with dark shoulders striped with two yellow lines, and the maggot is white. He planted roots of wheat containing larvæ in a small flower-pot, and covered them with gauze. Each stem produced one of the above flies. The crop of wheat attacked by this maggot, though at first it appeared to fail, turned out well in consequence of numerous side shoots. It is only the early wheat sown in October that is affected by it *.



a, The Hessian fly (*Cecidomyia destructor*); *b*, Markwick fly *Chlorops pumilionis*) magnified.

It now appears that Markwick was altogether mistaken in identifying his insect with the Hessian fly (*Cecidomyia destructor*, SAY), which has been accurately described by Mr. Say in the "Journal of the Academy of Natural Sciences of Philadelphia"

* Mag. Nat. Hist. July 1829, p. 292.

for 1817. It is a little larger than our wheat-fly, more slender in the body, has longer legs, and is not orange, but black and fulvous. The female deposits from one to eight or more eggs on a single plant of wheat, between the sheath of the inner leaf and the stem nearest the roots; in which situation, with its head towards the root or first joint, the young larva passes the winter, eating into the stem, and causing it to break *.

The devastation committed by the Hessian fly seems to have been first observed in 1776, and it was erroneously supposed that the insect was conveyed among straw by the Hessian troops from Germany. It was first noticed in the wheat fields of Long Island, from which it spread gradually at the rate of fifteen or twenty miles round; and in 1789 it had advanced two hundred miles from its original station in Long Island. Other accounts state that it did not travel more than seven miles annually, and did little serious damage before 1788. Their numbers seem almost incredible. The houses in the infested districts swarmed with them to so great a degree, that every vessel was filled with them; five hundred were actually counted on a glass tumbler which had been set down for a few minutes with a little beer in it. They were observed crossing the Delaware river like a cloud; and even mountains do not seem to interrupt their progress †. We can well understand, therefore, that so formidable a ravager should have caused a very great alarm; and even our own government was in fear lest the insect should be imported. The privy council, indeed, sat day after day in deep consultation what measures should be adopted to ward off the danger of a calamity more to be dreaded, as they well knew, than the plague or the pestilence. Expresses were sent off in all direc-

* Mag. Nat. Hist., vol. i. p. 228.

† Kirby and Spence, vol. i. p. 172.

tions to the officers of the customs at the different outports respecting the examination of cargoes,—despatches were written to the ambassadors in France, Austria, Prussia, and America, to gain information,—and so important altogether was the business deemed, that the minutes of council, and the documents collected from all quarters, fill upwards of two hundred pages *.

As in the case of the English wheat-fly, the American Hessian fly has a formidable enemy in a minute four-winged fly (*Ceraphron destructor*, SAY), which deposits its eggs in the larvæ. Were it not for the Ceraphron, indeed, Mr. Say is of opinion that the crops of wheat would be totally annihilated in the districts where the Hessian fly prevails †.

Those who have, from popular associations, been accustomed to look with disgust at the little white larvæ common in cheese, well known under the name of *hoppers*, will be somewhat surprised to hear the illustrious Swammerdam say, "I can take upon me to affirm, that the limbs and other parts of this maggot are so uncommon and elegant, and contrived with so much art and design, that it is impossible not to acknowledge them to be the work of infinite power and wisdom, from which nothing is hid, and to which nothing is impossible ‡." But whoever will examine it with care, will find that Swammerdam has not exaggerated the facts.

The cheese-fly (*Piophila Casei*, FALLEN) is very small and black, with whitish wings, margined with black. It was one of those experimented upon by Redi to prove that insects, in the fabric of which so much art, order, contrivance, and wisdom appear,

* Young, Annals of Agric., vol. xi.

† Journ. of Acad. Philadelph. *ut supra.*

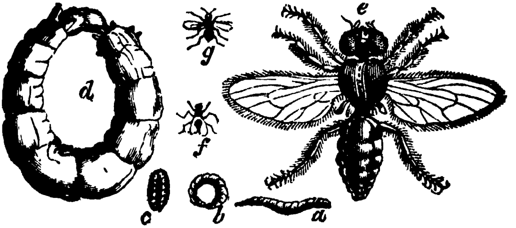
‡ Bibl. Naturæ, vol. ii. p. 63.

could not be the production of chance or rottenness, but the work of the same Omnipotent hand which created the heavens and the earth. This tiny little fly is accordingly furnished with an admirable instrument for depositing its eggs, in an ovipositor, which it can thrust out and extend to a great length, so that it can penetrate to a considerable depth into the cracks of cheese, where it lays its eggs, 256 in number. "I have seen them myself," says Swammerdam, "thrust out their tails for this purpose to an amazing length, and by that method bury the eggs in the deepest cavities. I found in a few days afterwards a number of maggots which had sprung from those eggs, perfectly resembling those of the first brood that had produced the mother fly. I cannot but also take notice that the rottenness of cheese is really caused by these maggots; for they both crumble the substance of it into small particles and also moisten it with some sort of liquid, so that the decayed part rapidly spreads. I once observed a cheese which I had purposely exposed to this kind of fly grow moist in a short time in those parts of it where eggs had been deposited, and had afterwards been hatched into maggots; though, before, the cheese was perfectly sound and entire*."

The cheese-hopper is furnished with two horny claw-shaped mandibles, which it uses both for digging into the cheese and for moving itself, being destitute of feet. Its powers of leaping have been observed by every one; and Swammerdam says, "I have seen one, whose length did not exceed the fourth of an inch, leap out of a box six inches deep, that is, twenty-four times the length of its own body: others leap a great deal higher†." For this purpose it first erects itself on its tail, which is furnished with two wart-like projections, to enable it to

* Swammerdam, vol. ii. p. 69. † Bibl. Nat., vol. ii. p. 65.

maintain its balance. It then bends itself into a circle, catches the skin near its tail with its hooked mandibles, and after strongly contracting itself from a circular into an oblong form, it throws itself with a jerk into a straight line, and thus makes the leap.



Cheese hoppers (*Piophila casei*, FALLEN). *a*, the maggot extended; *b*, in a leaping position; *d*, the same magnified; *e*, the fly magnified; *f*, *g*, the fly, natural size.

One very surprising provision is remarkable in the breathing-tubes of the cheese maggot, which are not placed, as in caterpillars, along the sides, but a pair near the head and another pair near the tail. Now, when burrowing in the moist cheese, these would be apt to be obstructed; but to prevent this, it has the power of bringing over the front pair a fold of the skin, breathing in the meanwhile through the under pair. Well may Swammerdam denominate these contrivances "surprising miracles of God's power and wisdom in this abject creature."

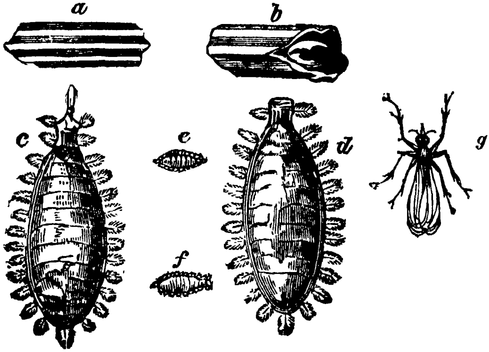
Like the other destructive insects above mentioned, the multiplication of the cheese fly is checked by some insect, whose history, so far as we are aware, is not yet known. Swammerdam found many of the maggots with other larvæ in their bodies; but he did not trace their transformations. If they were the larvæ of an ichneumon, it must be exceedingly minute.

It must have attracted the attention of the most incurious, to see, during the summer, swarms of flies crowding about the droppings of cattle, so as almost to conceal the nuisance, and presenting instead a display of their shining corslets and twinkling wings. The object of all this busy bustle is to deposit their eggs where their progeny may find abundant food; and the final cause is obviously both to remove the nuisance and to provide abundant food for birds and other animals, which prey upon flies or their larvæ. The same remarks apply with no less force to the blow flies which deposit their eggs, and in some cases their young, upon carcasses. The common house fly (*Musca domestica*) belongs to the first division, the natural food of its larvæ being horse-dung; consequently it is always most abundant in houses in the vicinity of stables, cucumber beds, &c., to which, when its numbers become annoying, attention should be primarily directed, rather than having recourse to fly-waters.

Another common insect (*Bibio hortulanus*, MEIGEN) lives in the larva state in cesspools, along with rat-tailed larvæ, &c. The maggot of the bibio is very peculiar in form. They are hatched from eggs with shells as hard as Paris plaster, deposited on the adjacent walls, and frequently upon the pupa case which the mother has previously quitted. Like the larvæ of the crane flies above described, this one moves itself chiefly by means of its mandibles, and therefore it can make no progress on a piece of smooth glass. Its skin, it may be remarked, is so exceedingly hard and tough, that it is no easy matter to kill it *. We have introduced this insect here, however, chiefly for the purpose of refuting an erroneous popular accusation against it, which is supported by the high authorities of Ray and Réaumur. Our great English naturalist calls it the deadliest enemy of the flowers in spring, and accuses it of despoiling the gardens and fields of

* Swammerdam, x. 212.

every blossom*. Réaumur is less decided in his opinion; for though he perceived that, not being furnished with mandibles, they could not, as is supposed, gnaw the buds of fruit-trees; yet, from their being found crowded upon flowers and buds, he thinks they may suck the juices of these, and thus cause them to wither†. We are satisfied, by repeated observation, that the fly only uses its sucker (*haustellum*) for sipping the honey of flowers, or the gum with which the opening bud is usually covered. The damage of which it is accused is more probably done by caterpillars, snails, or other night-feeding insects, which, not being seen by day, the fly is blamed for what it is entirely innocent of‡.



Transformations of *Bibio hortulanus*, MEIGEN. *a*, the egg magnified; *b*, the same when hatched; *c*, *d*, the maggot and pupa magnified; *e*, *f*, the same, natural size; *g*, the fly.

In the case of the blow-flies, Linnæus tells us that the larvæ of three females of *Musca vomitoria* will devour the carcase of a horse as quickly as would a lion; and we are not indisposed to take this

* Raii Hist. Insect. Pref. p. xi.

† Réaumur, v. 56.

‡ J. R.

literally, when we know that one mother of an allied species (*M. carnaria*) produces about 20,000, and that they have been proved by Redi to increase in weight two-hundred-fold within twenty-four hours. The most extraordinary fact, illustrative of the voracity of these maggots which we have met with, is the following, given by Kirby and Spence, from "Bell's Weekly Messenger:"—

"On Thursday, June 25th, died at Asbornby, Lincolnshire, John Page, a pauper belonging to Silk-Willoughby, under circumstances truly singular. He being of a restless disposition, and not choosing to stay in the parish work-house, was in the habit of strolling about the neighbouring villages, subsisting on the pittance obtained from door to door: the support he usually received from the benevolent was bread and meat; and after satisfying the cravings of nature, it was his custom to deposit the surplus provision, particularly the meat, betwixt his shirt and skin. Having a considerable portion of this provision in store, so deposited, he was taken rather unwell, and laid himself down in a field, in the parish of Scredington; when, from the heat of the season at that time, the meat speedily became putrid, and was of course struck by the flies: these not only proceeded to devour the inanimate pieces of flesh, but also literally to prey upon the living substance; and when the wretched man was accidentally found by some of the inhabitants, he was so eaten by the maggots that his death seemed inevitable. After clearing away, as well as they were able, these shocking vermin, those who found Page conveyed him to Asbornby, and a surgeon was immediately procured, who declared that his body was in such a state, that dressing it must be little short of instantaneous death; and, in fact, the man did survive the operation but a few hours. When first found, and again when examined by the surgeon, he presented a sight loathsome in the extreme; white maggots of enormous size were crawling in and upon his body, which they had most shockingly mangled, and the removing of the external ones served only to render the sight more horrid." Kirby adds, "in passing through this parish last spring, I inquired of the mail-coachman whether he had heard this story; and he said the fact was well known*." The year in which this remarkable circumstance occurred is not mentioned.

The importance of the insects just mentioned, in removing with great rapidity what might otherwise prove nuisances of considerable magnitude, naturally leads us to notice another sort of larva, no less useful in diminishing the numbers of the plant-lice (*Aphides*) which do so much damage to cultivated vegetables. We do this also the more readily, that these very insects, which are so beneficial to the husbandman and the gardener, are often erroneously accused of being themselves the cause of the mischief. A correspondent of the Natural History Magazine, for example, says, "the lady-bird is remarkably abundant this season. The shrimp (*larva*) of this insect destroys both turnips and peas in many parts of England†." The truth is, however, that all the species of lady-birds (*Coccinellidæ*, LATR.), both in the larva and the perfect state, feed exclusively on aphides, and never touch vegetable substances. The eggs are usually placed in a group of twenty or more upon a leaf, where aphides abound; and when the young are hatched they find themselves in the midst of their prey. There are a considerable number of species of this family (Mr. Stephens enumerates fifty); but the most common, perhaps, is the seven-spotted lady-bird (*Coccinella septempunctata*), whose larva is of

* Intr. i. 140, and note. † Mag. of Nat. Hist. i. 191.

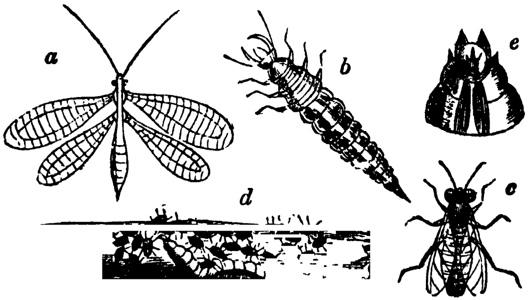
considerable size, and, of course, when abundant, must destroy a vast number of aphides.

Transformations of the lady-bird (*Coccinella 2-punctata*, LINN.) *a*, the eggs. *b*, the larva. *c*, the pupa. *d*, the beetle. *e*, the same flying. *f*, *Coccinella 20-punctata*, LINN., flying.

The maggots of many species of a beautiful family (*Syrphidæ*, LEACH) of two-winged flies are also voracious devourers of the aphides. These larvæ are of a tapering form, and they can contract or lengthen their bodies to a considerable extent; while they have a retractile instrument, armed with three prongs like a trident, with which they transfix their helpless and hapless victims. "When disposed to feed," says Kirby, "he fixes himself by his tail, and being blind, gropes about on every side, as the Cyclops did for Ulysses and his companions, till he touches one, which he immediately transfixes with his trident, elevates into the air, that he may not be disturbed with its struggles, and soon devours. The havoc which these grubs make amongst the aphides is astonishing. It was but last week that I observed the top of every young shoot of the currant-trees in my garden curled up by myriads of these insects. On examining them this day, not an individual remained; but beneath each leaf are three or four full-fed larvæ of aphidivorous flies, surrounded with heaps of the skins of the slain, the trophies of their successful wàrfare*."

The larvæ of the lace-winged flies (*Hemerobidæ*, LEACH) are even more destructive to the aphides than either of the preceding; insomuch that Réaumur was induced to call them the lions of the aphides. The mandibles of the larva of Hemerobius are somewhat crescent-shaped, and, like those of the ant-lion, are hollow, by means of which they suck the juices of their victims. These are rarely so numerous as the two preceding families, but they make up for their fewness in the voracity with which they devour the little destroyers of our vegetables.

* Intr. i. 264.



a, Lace-winged fly; *b*, the grub of the same, magnified; *c*, syrphus; *d*, larva of the same devouring the aphides of the elder; *e*, the head magnified, to shew the mouth.

SECTION III.—PUPÆ.

Chapter XI.

Mechanism of suspending Chrysalides.

A sailor would find it no easy process to cut for himself a suit of clothes out of a set sail, holding, the while, only by the portion that he was cutting. This is an operation which is performed every day by the tent-making caterpillars*. Difficult, however, as this may be considered to be, it appears as nothing when compared with another problem performed by a different family of caterpillars. " Country fellows, for a prize," says Kirby, " sometimes amuse the assembled inhabitants of a village by running races in sacks: take one of the most active and adroit of these, bind him hand and foot, suspend him by the bottom of his sack, head downwards, to the branch of a lofty tree; make an opening in one side of the sack, and set him to extricate himself from it, to detach it from its hold, and suspend himself by his feet in its place. Though endowed with the suppleness of an Indian juggler, and promised his sack full of gold for a reward, you would set him an absolute impossibility; yet this is what our caterpillars, instructed by a beneficent Creator, easily perform †." The manner in which this is effected we shall now describe.

A caterpillar, when about to change into a chry-

* See Insect Architecture, p. 223. † Intr. iii. 209.

salis, usually steals away from the plant on which it has been feeding, to find some secluded corner where it may undergo its transformation unmolested; as if it were previously aware that it would no longer be able to escape from its enemies. Those which we shall first notice climb up the highest objects near them, such as walls, gates, palings, and trees, under the projections of which they think they may begin their operations in safety. Thus we once found a caterpillar of the small tortoiseshell butterfly upon the branch of a fir-tree, in Epping Forest, from ten to twelve feet above its native patch of nettles below; and we have seen the cabbage butterfly under the lintel of a window on the third story*.

Having thus selected a safe spot, the caterpillar begins, in order to attach itself securely, to weave a mooring of silk, the structure of which is well worthy of notice. The threads of which this is composed are so fine, that they are not easily distinguished; and we recollect being not a little astonished at seeing a chrysalis of the admirable butterfly (*Vanessa Atalanta*) hanging within an inverted glass tumbler, where we had confined it, the silk being transparent, and all but invisible. It is necessary, therefore, in order to see it distinctly, to confine the caterpillars within a black box or other vessel. The silk threads are not drawn tight along, so as to be parallel with the surface, but are formed into a sort of projecting button, the caterpillar, for this purpose, alternately raising and depressing its head over the spot so as to draw out the threads, in the same way as a tambouring needle is worked in making a dot upon muslin: the base is accordingly made the broadest part, and the centre the most projecting, for a reason which will immediately appear.

When it has finished this little button of silk

* J. R.

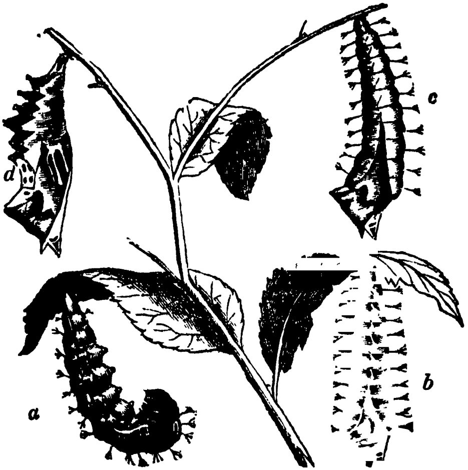
a, Caterpillar of *Vanessa Antiopa* weaving its button of silk. *b*, suspended by its hinder pro-legs from the silk button. *c*, bending in order to split the old skin.

which is thickly interlaced and strong, it turns round to examine it with its hinder pair of pro-legs; and if it judges it to be sufficiently firm, it thrusts these among the meshes, taking secure hold with the numerous hooks with which these are fringed *, and swings itself fearlessly into the air, hanging with its head downwards. All this seems easy enough of performance, but it is only preliminary; for it has still to throw off its skin, together with the hooks by which it is suspended, and this without losing its hold. The old skin is rent by the forcible bending round of the upper part of the body, which pushes through some of the angular projections of the chrysalis—a tedious and probably a painful operation, in

* See Insect Architecture, p. 307, right hand figure.

which it is often engaged the greater part of a day, and sometimes two, according to its strength. When the first rent is made, however, the included chrysalis soon wedges itself through the breach, the lower portion swelling out greatly more than the upper, so as to form an inverted but somewhat irregular cone. The included insect continuing its laborious exertions, by successively contracting and dilating the rings of its body, pushes off the now rent skin by degrees from the head towards the tail, as the sack-racers mentioned by Kirby would disengage themselves from the sacks in which they were inclosed, or as one would roll down a stocking from the leg. There are two circumstances worthy of notice in this process: the position of the insect in hanging with its head downwards, throws a greater portion of the fluids of the body towards the head, by means of their weight, which swell out the part that splits; and also pushes back the old skin, while the sloughing skin is prevented from resiliating by a series of pegs, which act like the toothed rack of a sluice-gate. The old skin, being by these means pushed towards the tail, is of course compressed into several folds, which in some degree prevent the extension of the rent, and serve to keep the chrysalis from falling; for being now detached from the skin, it has no hold upon the meshes of the silk button, and is, in fact, at some distance from it.

This, then, is the part of the process where the nicety of the mechanism is most worthy of admiration; for the hooks by which the insect is in the first instance suspended from the meshes of the silk are sloughed off, together with the skin, the grasp of whose folds becomes then the only support of the chrysalis. But this chrysalis, now deprived of feet, and some distance from the suspensory cordage of silk, has still to reach this, fix itself there, and cast off the sloughed skin altogether. This operation causes, says Bonnet, a spectator to tremble for the consequences, for every movement seems to render its fall almost certain. It is, however, provided with means which answer the same purpose as hands, to enable it to climb; it can elongate and contract at pleasure the rings of its body. It accordingly, with two contiguous rings, lays hold, as with a pair of pincers, of the portion of the sloughed skin nearest the head; and elongating the rings beyond this, seizes upon a more distant portion, while it lets go the first. Repeating this process several times, it at length arrives at the silk button.



a, suspended caterpillar of *Vanessa Antiopa* splitting its skin for the evolution of the chrysalis. *b*, the head of the chrysalis emerging. *c*, the same process farther advanced. *d*, the perfect pupa.

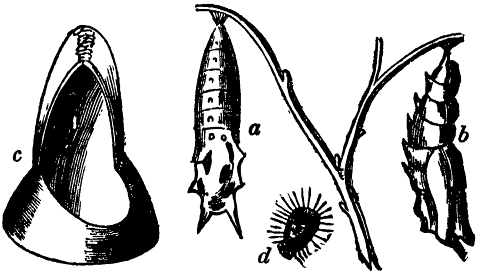
The tail of a chrysalis, to an ordinary observer, would appear smooth, and quite unfitted for being fixed to the silk in such a manner as to sustain its weight; but careful examination discovers that it has been furnished with an efficient apparatus for this purpose, in a number of very minute hooks, similar to those of the pro-legs which have been sloughed off. Feeling about then with its tail for the silk, it insinuates these hooks among the meshes, and being no longer in danger of falling, it can swing secure, as it had previously done in the caterpillar state.

Réaumur has, however, seen some chrysalides fall before they completed the process, in consequence, as he thinks, of having spun too slight a mesh-work of silk. In order to ascertain the correctness of this inference, we tried a series of experiments upon a considerable number of a brood of the peacock butterfly (*Vanessa Io*), the same upon which Réaumur made his observations. We allowed some to spin only half the usual portion, and removed them to another station. Here they eagerly recommenced the task, and, if left unmolested, never fell from the spot; but if previously removed a second time, they seldom succeeded in completing the process in the usual way. They did not, indeed, in such cases, attempt spinning an imperfect silken suspensory; but abandoning in despair what they felt themselves incapable of performing, they crept down to the bottom of the nurse box, and cast their skins without having anything to which they could attach themselves*.

When the hooks of a chrysalis have been properly fixed among the meshes, it remains suspended contiguous to the skin which it has just cast; but not liking the neighbourhood of its now useless spoil, it sets itself to get rid of it. For this purpose it contorts itself in various ways, sometimes assuming a figure similar to an S, so that it may push against

* J. R.

the spines of the old skin; and then giving itself a sudden jerk, it spins itself rapidly round a dozen or twenty times. Réaumur says that this gyration usually throws off the slough, in consequence of its being farther from the centre of motion, and therefore exposed to a greater centrifugal force; but unluckily for this refined philosophy, it is not the silk button, but the chrysalis which spins round, and consequently the old skin does not twirl at all, and only moves like a pendulum;—the best method, evidently, of disengaging the hooks it hangs by. Besides, the threads of the silk are *not* broken by the gyration, as Réaumur, followed by Kirby and Spence, asserts; otherwise the weight of the chrysalis would to a certainty break its threads, more easily than the supposed centrifugal force would break those which suspend the slough. Repeated observation has satisfied us, therefore, that the twirling of the chrysalis is both for the purpose of disengaging the old skin and strengthening its own hold*. Bonnet may be right or wrong in thinking the stimulus of the spines of the old skin is the cause of the twirling: we have observed that the insects which change into chrysalides,



a, *b*, front and side view of chrysalides of *Vanessa urticæ* suspended by their anal hooks. *c*, anal hooks magnified. *d*, old skin fallen off.

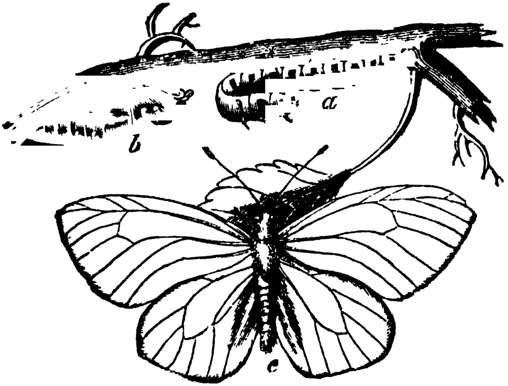
* J. R.

after being removed from their suspensories, also roll about and manifest great uneasiness*.

But this is only one mode by which chrysalides are suspended; for nature, rich in variety, has taught others to employ a different mechanism, and considerably more complicated, not only fixing themselves by the tail, but throwing around their body a girdle of silk, which binds it firmly to the spot selected, and frequently in a horizontal position. Amongst those, the caterpillars of the pretty butterflies called by collectors hairstreaks (*Theclæ*, Fabr.), are remarkable, both for their resemblance in shape to the common woodlouse (*Oniscus*), and for their singular proceedings. In order to construct a silken cincture around the middle of its body, after it has secured itself at the tail, the Thecla draws back its head, and pushing out its spinneret on one side, forms an arched thread by passing it over to the other side. It then insinuates its head under this thread, and pressing the fore part of its body down as closely as possible, it contrives to place the girth over its middle. This circumstance is the more remarkable when it is considered that the silk is so fine as scarcely to be distinguishable to the eye, and that the back of the caterpillar over which it has to pass is thickly bestudded with spines. The caterpillars, indeed, of this whole family (*Lycænæidæ*, Leach), which includes our splendid blue and copper butterflies, seem to follow the same process, repeating it from thirty to fifty times, in order to strengthen the band. As the caterpillars of the family just mentioned are but seldom found, those who are desirous of observing the formation of the cincture of a chrysalis may readily gratify their curiosity by watching a brood of any of the native white butterflies, as those of the cabbage or of the hawthorn (*Pieris Cratægi*, Stephens). A caterpillar of this kind,

* Bonnet, Œuvres, vol. ii., p. 109.

however, though it forms a silken suspensory girth similar to the *Lycænæidæ*, constructs it in a different manner. Instead of retracting its head, it takes advantage of its great pliability, and bending itself nearly double, fixes a thread, carrying it over to the other side simply by turning its head. It repeats this process a great number of times, till it has formed a packet of threads sufficient for its cincture. It then stretches its head out into a right line with the body, and remains in this position till it casts its skin. The usual position of the chrysalides belonging to the family (*Papilionidæ*, LEACH) in question, is horizontal; but they frequently also hang vertically, and at different angles. We possess one of the large garden white butterfly (*Pontia Brassicæ*), which was bound horizontally on the *upper* surface of a leaf of the abele tree (*Populus alba*), being laid, and not hung, as is almost the invariable practice of the species. The leaf, moreover, is drawn together in



a, Caterpillar of the black-veined white butterfly spinning its suspensory band. *b*, chrysalis horizontally bound to a branch. *c*, the butterfly (*Pieris Cratægi*), smaller than in nature.

the manner of the leaf-rollers, another most unusual and remarkable circumstance *.

Another caterpillar of the same family, that of the swallow-tailed butterfly (*Papilio Machaön*, LINN.), one of our finest but local native insects, having a body less pliable than the preceding, has recourse to a still different method of forming a cincture. The proceedings of this beautiful caterpillar, distinguished by two retractile horns, like those of a snail, may be illustrated by the mode in which a skein of silk is wound from the hand. The insect first attaches the end of his thread to the spot selected for hanging up the chrysalis, such as the bend of a branch of fennel or wild carrot, on which he has been feeding; and extends it outwards by the hooks on his claws, by which means he keeps it stretched till he fixes it on the other side, forming a

a, Caterpillar of the swallow-tailed butterfly, weaving its suspensory cincture. *b*, the caterpillar suspended for its change. *c*, the chrysalis suspended in a similar manner.

* J. R.

loop about twice the diameter of his body. He repeats this process successively till he has spun forty, sixty, or as many threads as he deems strong enough for his cincture; and then throwing it over his head towards the middle of his body, he proceeds to disencumber himself of his old skin.

As the numerous threads composing the cincture are not glued together, but remain separate, it sometime happens that they slip, in whole or in part, from the claws of the caterpillar; and Réaumur had one which was foiled in all its efforts to repair such an accident. It did not, indeed, make any attempt to spin a fresh cincture, probably from its materials being exhausted or from want of strength; so that when it could not recover the fallen and entangled threads, it collected a few of them, suspended in which it cast its skin, but they, being too weak to sustain it, gave way, and it fell and perished *.

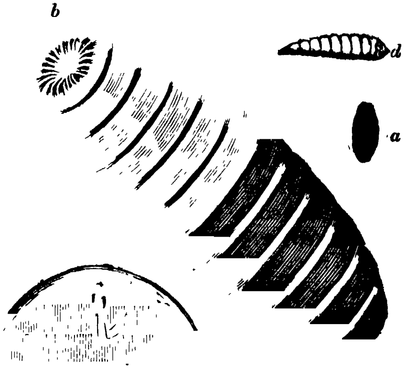
We will not revert in this place to the varied contrivances of those insects which construct coverings either of silk or other materials for inclosing their pupæ, such as the silk worm, the puss-moth caterpillar, the tent-makers, &c.; but there is one family whose proceedings are so singular that they well merit investigation. We refer to the numerous species of what are indefinitely termed common flies, (*Muscidæ*), and some families allied to them. Unlike most other larvæ, these never cast their skins, not even when they change into pupæ. The maggot of the common blow-fly (*Musca vomitoria*), for example, when about to undergo its transformation, quits the carcase where it has been feeding, and burrows for an inch or two into the first soft earth it can meet with. Here it draws in its body into a shorter compass, and the soft skin being thus condensed,

* Mem. sur les Insectes, vols. i. ix.

it acquires in thickness what it loses in extension: its moisture, also, disappearing by evaporation, or more probably by internal absorption, it becomes hard and tough, like thin parchment, and of a dull reddish-brown colour. The form is now that of an oblong ball; and it was from that circumstance termed an egg by Redi and other early naturalists,—a term at which Swammerdam takes great offence in this instance. The various changes undergone by the included insect were traced from hour to hour by Réaumur with his usual patience and accuracy: but few of the minute circumstances detailed by him would probably interest our readers; except that in casting its mandibles, which are henceforth useless, they are not thrown off on the outside of the case, but remain on the inside.

Were such an extraordinary transformation as this to happen to one of the larger animals, it would be held forth as altogether miraculous. Were a lion or an elephant, for example, to coil itself up into a ball, compressing its skin into twice the thickness and half the extent, while it remained uniform in shape and without joinings or openings; and, at the same time, were it entirely to separate its whole body from this skin, and lie within it, as a kernel does in a nut, or a chick in an egg, throwing off its now useless tusks into a corner,—and then, after a space, should it acquire wings, break through the envelope, and take its flight through the air,—there would be no bounds to our admiration. Yet the very same circumstances in miniature take place every day during summer, almost under the eye of every individual, in the case of the blow fly, without attracting the attention of one person in a million.

The maggots of the genus of two-winged flies (*Syrphidæ*) mentioned above as feeding voraciously on aphides, do not, like those of the blow fly, burrow in the earth, but attach themselves to a leaf or a branch. Being furnished with a species of adhesive gluten, a maggot of this sort applies a portion of this with its mouth to the spot which it has selected for its transformation, and, pressing its body upon it, becomes immoveably glued down there. When thus securely fixed, it contracts and shortens its body similarly to the maggot of the blow-fly; but, instead of becoming like that, uniformly oblong, the head swells out and the tail becomes slender, till it terminates in a point, just reversing the previous form of the maggot, which is rounded at the tail and pointed at the head. When the change is completed, indeed, it is a good deal in the form of one of Prince Rupert's glass drops. When we first met with these pupæ, indeed, we concluded they were galls, and were not a little surprised to see large wasp-looking flies issue from them; but as they may be found in considerable abundance, it becomes easy to gratify curiosity and to confirm the facts just stated. It may not be out of place to remark, that several species of ichneumon



a, Pupa of blow fly. *b*, the same magnified. *c*, head of puparium opened to shew the cast mandibles. *d*, pupa of *syrphus*.

flies make reprisals upon them for their destruction of the helpless aphides. Swammerdam observed eight of these parasites issue from one pupa of a *Syrphus**

The lady-birds (*Coccinellidæ*) glue their pupæ to leaves in much the same manner with the flies just mentioned: but their skin, instead of becoming smooth, wrinkles up by the shortening of the body of the grub; because it is not so soft and pliable, and cannot, therefore, be compressed. The interior, however, is smooth †.

Those insects which live during their first stages in the water, exhibit a very different economy when they change from larvæ into nymphs, as may be exemplified in the May-flies (*Ephemeridæ*) and the dragon-flies (*Libellulina*). But as these will require to be described in a future page, we shall content ourselves at present with an account of an interesting but minute species of tipulidan gnat (*Corethra plumicornis*, Meigen), of a straw colour, whose history was first given by Réaumur and De Geer. The latter was induced, from the beautiful transparency of the larva, to name it *Tipula cristallina*,—a quality which renders it, its size being also very minute, rather difficult to discover: it is, however, a good subject for microscopical observations. Taking advantage of the recent improvements in microscopes, Dr. Goring has accordingly given coloured figures both of the larva and pupa, as observed by him, in which he has added a few minute details ‡ that are not in the otherwise very accurate figures of Réaumur.

The larva is rather less than a quarter of an inch long, and somewhat resembles in form those of the same family, particularly in the parts about the head,

* Part ii., p. 99. † J. R.

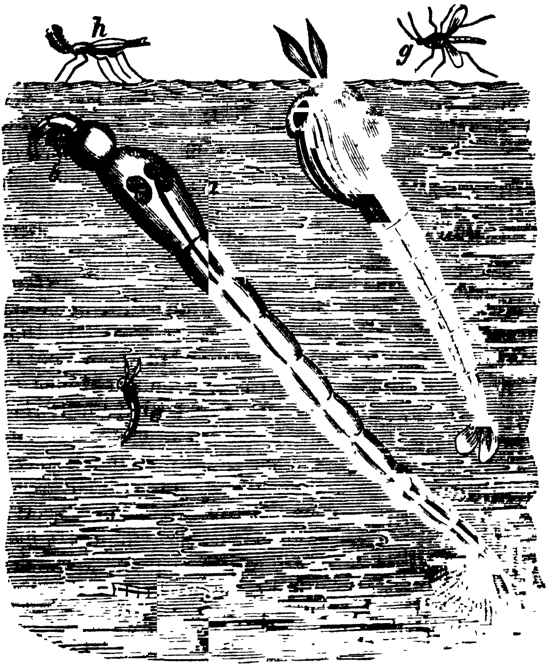
‡ Goring and Pritchard's Nat. Hist., No. 1; and Réaumur, vol. v., mem. 1.

the mandibles being horny, jointed, and capable of uniting into one pointed borer. The tail is furnished with plumed bristles, which appear to serve the purpose of fins. The nearer this crystalline larva is to its transformation, the more distinctly may be seen four kidney-shaped transparent bodies, of a brown colour, a pair on the fourth ring from the tail, and another pair at the shoulders. The former, perhaps, serve to inclose the tail fins of the pupa; the latter the horns of the pupa, which again encase the antennæ of the gnat; but in another species (*Corethra culiciformis*) De Geer supposed these to be respiratory organs. We are not aware that this larva has been actually seen to cast its skin, but there can be no doubt of the fact, for Réaumur found exuviæ at the bottom of the glasses where he kept them*; and we are not, consequently, authorized to assert that its transformation is "not effected, as in other insects, by casting the outer skin, but by an actual conversion of one form of matter into another†." We watched above a hundred of them without being so fortunate as to see their transformation into pupæ, though we more than once observed the emergence of the fly.

Our chief reason, however, for introducing it here, is to shew the mode in which the pupa is suspended, or rather buoyed up, in the water, by means of its foliated tail and the shape of its body, which is bulged out above, and narrowed as it approaches the lower extremity. It is, besides, very lively in the pupa state, and jerks about with great agility, but usually keeps close to the surface of the water, so as to project its horns or antennæ cases above it. In the figures we have endeavoured to combine the details of Réaumur and Dr. Goring.

* Réaumur, vol. v., p. 41-2.

† Goring and Pritchard, Nat. Hist., No. 1, p. 23.



a a, larva of *Corethra plumicornis* magnified. *b*, themandibles and palpi. *c*, the respiratory fins. *d*, the pupa magnified. *e*, pupa, natural size. *f*, larva, natural size. *g*, the female fly. *h*, the male fly.

We possess a small aquatic pupa which is furnished at the tail with four horny hooks resembling the prickles on the stem of a rose-tree, and evidently intended as suspensory appendages. It was found hanging to a deal board, which had been immersed in running water, and seems from its form to be the pupa of a moth (*Hydrocampa ?*)*.

* J. R.

Chapter XII.

Form and Structure of Pupæ.

The figures delineated in the preceding chapter shew how different in form many pupæ are, both from their larvæ and from the insects to be afterwards evolved from them,—as different, indeed, as the form of a bud from the seedling tree, or from the leaf, branch, or blossom, which is destined to shoot from it. Pupæ, as we formerly remarked, have as striking an analogy to the buds of plants, as eggs have to seeds; —and this is the more necessary to be insisted on, that their nature has been grossly misrepresented even by authors of eminence, and, in other matters, of unquestionable accuracy. The term *Metamorphosis*, so long applied to the various stages of insect life, has been one of the chief means of propagating the erroneous views in question, inasmuch as it implies a supernatural change like those described in the poetical fables of Ovid. The term *Transformation*, though not perhaps free from a similar implication, is much less strong and less likely to mislead.

That our objection does not originate in hypercritical nicety, but is of no little importance with regard to the accurate knowledge of the history of insects, could be proved by reference to many well-known works of natural history; but we shall limit our illustrations to one or two of those strange fancies which have obscured and perplexed this branch of our subject.

We shall begin with the illustrious Harvey,—the discoverer of the circulation of the blood,—who, in his exercitations on the generation of animals, says—"There are two ways in which we observe one thing to be made out of another (as out of matter), both in art and nature, especially in the generation of animals: one is, when a thing is made out of another already in being, as a bed out of wood, and a statue out of a stone; when, for example, all the materials of the workmanship exist before the workman begins the work or attempts to give it any form. The other way is, when the stuff receives both being and form at the same time. As, therefore, the works of art are performed two ways; the one by the workman's dividing, cutting, and paring away the matter prepared for those operations, so as to leave behind, like a statuary, the figure of the thing he intends to make: the other, by the workman's adding and moulding, as well as paring away, the materials, and at the same time tempering the matter itself, so as to produce, like a potter, the figure; which, for this reason, may be said to be made, rather than formed;—in the same manner it happens in the generation of animals; some of which are formed and transfigured out of matter already digested and increased for this purpose, all the parts springing out together distinctly by a kind of metamorphosis, and thus forming a perfect animal, while other animals are made piece by piece."

He proceeds to tell us, that the generation of insects is performed after the first manner; the egg, by metamorphosis, producing the worm; or matter in a state of putrefaction, when it becomes too dry or too moist, producing the primary rudiments; and these again, by metamorphosis, a caterpillar, which, when grown to its full size, is metamorphosed into an aurelia (*pupa*), a butterfly, or a common fly. "Bees," he subjoins, "wasps, hornets, or butterflies, and whatever other animals are generated by metamorphosis from a creeping insect, are said to be the offspring of chance, and therefore never to keep up their species. But the lion or cock are never produced spontaneously or by chance. In the generation by metamorphosis, animals are fashioned as it were by the impression of a seal, or framed in a curious mould, all the matter of which they consist being transformed *."

Goedart, a later naturalist of eminence, both falls into the foolish fancy of supposing that the form of the human face can be traced in the chrysalis, of which he has actually given a figure in his plates, as Réaumur has done after him; and also tells us, "that wherever the legs are situated in the caterpillar, there is placed the back of the insect which is to arise by transmutation; and, on the contrary, where the back of the caterpillar was, there are the legs in the insect to be produced from it. This metamorphosis," he adds, "is performed in a short space of time, so that it may be distinctly seen; because, immediately after shedding its skin, this change appears to the eye †."

Had this most absurd and untrue doctrine passed into oblivion, or become obsolete, we should have passed it by in silence; but as, like many of the theories of former ages, it often meets us even in modern books ‡, where we might least expect to find it, we deemed it proper to give it in the language of two of its most eminent advocates, which Swammerdam justly says contains almost as many errors as words. The best method of opposing and overturning error being the simple explanation of the truth, we shall proceed to describe the form and

* Harvey, de Generat. Anim., Exercit. xlv.

† De Insectis, Exp. 77.

‡ See our quotation from Goring and Pritchard, p. 286.

structure of pupæ, rather than stop to refute circumstantially the preceding theory of Harvey and Goedart.

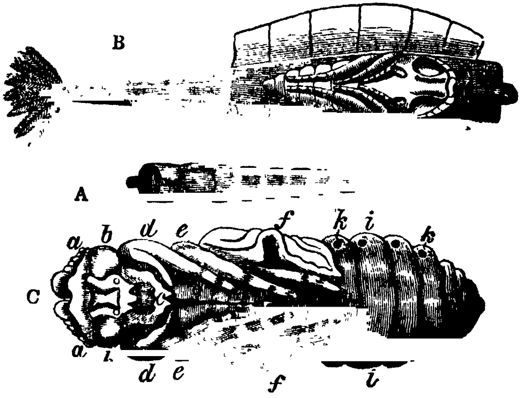
In the pupa state, then, we may remark, that the legs, wings, and other external appendages of the insect, are, in the greater number of instances, closely folded up and enveloped by an external covering, usually of a membranous structure, and differing considerably both from the skin of the larva and from that of the perfect insect. It is as different, indeed, as the winter envelope of the bud of a tree is from the bark or from the cuticle of a leaf. The angular forms exhibited in some chrysalides, are for the purpose of encasing particular limbs, &c. of the insect which Providence has not seen meet to fold down smoothly to the body. The spines, hooks, and hairs, again, which are also of occasional occurrence, and which Goedart strangely enough mistook for feet*, are manifestly for aiding the animal in casting its old skin, as has been explained in a preceding page; while the grooves, ridges, and other markings, are the indications of the various members of the insects folded up, or otherwise disposed under them.

As we have shown all the parts of the perfect insect contained in the caterpillar, so these can be much more easily exhibited in the pupa, particularly when near its final change; for in more early periods the substance is so soft and pulpy—almost fluid indeed—that it would be next to impossible to develop them artificially. In some pupæ the parts can even be seen through the membranous envelope, which in other cases requires, for this purpose, to be removed. In order to exhibit this, we shall select a few instances in which the facts may be readily verified, by those who will take the trouble of breeding the insects.

The first we shall advert to is that of the chame-

* Goedart, de Insectis, 77.

leon fly (*Stratiomys chameleon*), whose singular larva we formerly described *. When this draws near the period of its transformation, it leaves the water, betaking itself to the adjacent bank, or to the plants which float on the water, creeping up so as to leave only a part of its tail submersed. In this position it remains, contracting itself by degrees in a manner scarcely perceivable, and losing all power of locomotion. The internal portion of the tail at the same time separates gradually and insensibly from the exterior skin, becoming greatly contracted; and, gathering into three or four curvatures, the extremity is thereby left empty. Into this space the air penetrates and soon fills the place previously occupied by the body, which is now contracted to one-third of its former size. When the air is prevented by too much



A, Pupa of chameleon fly, with the lid of the puparium raised. B, the same magnified, and the puparium laid open to shew the embryo fly. C, the embryo fly magnified:—*a a*, antennæ; *b b*, the eyes; *c*, sucker; *d d*, first pair of legs; *e e*, second pair; *f f*, the wings folded up; *g h i*, rings of the body; *k k*, breathing-tubes.

* Page 156, 7.

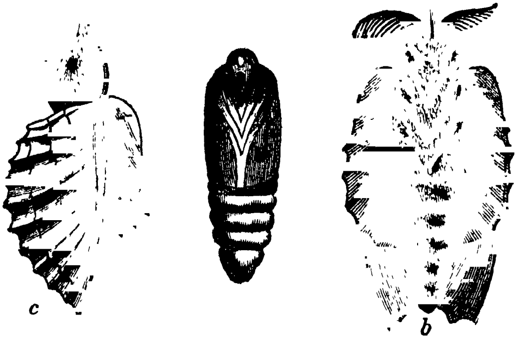
moisture from entering and distending the skin, it shrivels up; but this occurs seldom. If the old skin, now become detached and forming a tubular envelope, be cut open, the pupa will be brought into view, exhibiting the parts of the future fly neatly folded down upon the body, as may be seen in the figure.

This is one of the larvæ which Swammerdam observed to cast, along with its external skin, the lining of the intestines, and breathing-tubes likewise, which, he remarks, "is very singular, and amazingly shows the miracles of God, teaching at the same time how the former body is entirely cast off and renewed *." The pupa, when exposed in the preceding manner, is of a bright green colour, interspersed with white transparent particles, and the spiracles of the windpipe glittering like pearls.

When the pupa of the lappit moth (*Gastropacha quercifolia*) is disengaged from the cocoon, it has much the appearance of an Egyptian mummy, or an infant in the old-fashioned swaddling bands. The feet are crossed over the breast, and folded closely down nearly in the same manner as in the instance of the chameleon fly just mentioned; but the wings are compressed into a very small compass. This appears the more remarkable as the wings of the moth are large and conspicuous, and so like the withered leaf of an oak, both in form and colour, that the insect would readily impose upon a careless observer. It is, we believe, the only British example of what have been popularly termed leaf insects,—which have given origin to the fanciful and untenable theory of intentional deception on the part of Providence. It was by opening one of these pupæ that Réaumur first discovered the various sheaths appropriated to the feet, the antennæ, and the wings; the sheath of the sucker (*haustellum*) being wanting, as it

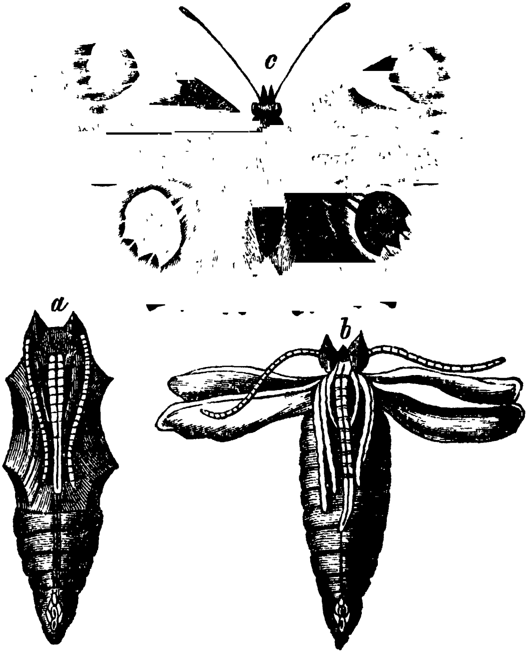
* Bibl. Nat. vol. ii. p. 54.

is obsolescent in the moth. It is furnished, however, with a peculiar horn or projection on the forehead,—the palpi—which the theorists to whom we have alluded might term its leaf stalk.



a, Pupa of lappit moth. *b*, under side of the moth, with its feet folded up. *c*, side view of the same.

We can demonstrate the same position still more obviously in the chrysalis of a butterfly,—for example, in that of the peacock (*Vanessa Io*), whose caterpillars feed on the nettle. This chrysalis is angular like the others of the genus,—the two terminating angles encasing the eyes, and the four lateral ones the marginal folds of the wings, the contour of which is disposed on what may be called the shoulder of the chrysalis (*Ptero-theca*, Kirby). The legs, antennæ, and sucker, are folded down longitudinally upon the breast, very similarly to what occurs in the moth just described. When the membranous covering, which is thinner but more firm and elastic than Indian paper, has been carefully removed,—selecting for this operation an advanced period of the chrysalis,—the several members of the butterfly may be seen folded up in the manner we have here indicated. The wings are still covered with moisture, so that the powdery down which clothes them is scarcely visible, and they have not yet assumed their beautiful colours and elegant markings, but are of a dusky ash-grey. The legs, however, are already so firm that the insect moves them about, and also coils up its sucker, and plays its antennæ. It is worthy of remark, that the



a, under side of the chrysalis of the peacock butterfly. *b*, the wings and antennæ traced out from the same. *c*, the perfect insect (*Vanessa Io*) fully developed.

membrane which covers the more prominently exposed parts, such as the legs, is considerably thicker than the other portions *. Our description will be rendered more intelligible by the preceding figures.

It will obviously appear from these details, in what manner superficial observations led to the fancy of one insect being on a sudden miraculously metamorphosed or transmuted into another. Those, indeed, who persuaded themselves that a morsel of tainted beef, or a bit of rotten wood, could, by some inexplicable chemistry, grow into limbs, wings, eyes, and all the other parts of an insect, with its admirable organization of muscles, nerves, and digestive apparatus, had no difficulty to overcome in believing that the green pulpy mass of a chrysalis could be transmuted into the light airy wings of a butterfly:—nay, they considered the matter as proved, and admired the supposed metamorphosis, without giving themselves the trouble of investigating whether it was real or possible †. Accurate observation, founded on the principles of the Baconian philosophy, gradually put to flight the reveries of those who (to use the words of Harvey) "philosophize by traduction, who are not a whit wiser than the inanimate books through which they come at their ill-digested notions ‡." Yet this distinguished physiologist, though he could so express himself, occasionally struck upon the very sand-bank of which he here warns us to take care; perhaps in consequence of a cause shrewdly and profoundly assigned for philosophical errors by Des Cartes, in his Essay on Method, who says, "I was always of opinion, that more truth is to be found in those reasonings which men make use of in the common affairs of life, whose bad success may prove a kind of punishment for their reasoning ill, than those which

* Swammerdam, vol. ii. p. 17.

† Réaumur, vol. i. p. 350. ‡ Harvey, De Gen. An., Exer. 44.

some idle doctor, cooped up in his study, has invented, that conduce nothing to the ease and happiness of life, and from which he expects no other advantage unless that of reaping so much the greater harvest of empty glory from his arguments; as they contain less of truth and common sense, on account of the extraordinary strength of genius and application requisite to give an imposing air to such absurdities."

It was the decided opinion of Swammerdam that the several transformations of insects, particularly the change from the egg to the caterpillar, and from the pupa to the perfect insect, are chiefly effected by the evaporation of the superabundant fluids. Thus he tells us that the nit, or egg of the louse (*Pediculus humanus*), is nothing more than the insect itself, which only requires the evaporation of the surrounding moisture and the casting of the old skin, to bring it to its perfect form *. It is not a little surprising that so very accurate a naturalist should never have thought of investigating the truth of such an opinion by experiment. That he neglected this precaution, is an instance, among thousands more, of the imperfection of human studies; for his very first trial would have demonstrated the error, which pervades every page of his great work. He was evidently misled into the opinion by perceiving how fluid the contents of an egg or of a pupa are when opened previous to their change, and how dry the insect is upon its evolution.

It is much more surprising to find Kirby and Spence repeating the same, or nearly the same opinion, at the very time, too, when they are in the act of quoting the experiments of Réaumur, by which it is refuted, though the great experimenter himself misinterpreted them. "If you open a pupa," say they,

* Swammerdam, *passim*.

"soon after its assumption of that state, you will find its interior filled with a milky fluid, in the midst of which the rudiments of its future limbs and organs, themselves almost as fluid, swim. Now the end to be accomplished during the pupa's existence is, the gradual evaporation of the watery parts of this fluid, and the developement of the organs of the enclosed animal by the absorption and assimilation of the residuum*." The evaporation, however, is so very inconsiderable, that it is evidently only of secondary consequence.

When the great quantity of fluid in the body of the chrysalis is taken into consideration, we must infer that if it were evaporated to any extent, the insect would be reduced to a mere shadow. We are disposed, therefore, to agree with Réaumur in thinking it more probable that the fluids of pupæ become united to the more solid parts, in the same way as the blood and lymph in our own bodies go to the extension or to the repair of our bones and muscles. To put this to the test of experiment, Réaumur, in the month of July, accurately weighed two chrysalides the instant they were disencumbered of the sloughs of the larvæ. The lightest weighed a trifle less than 18, and the heavier a trifle less than 19 grains. Putting them aside separately, with a note of their respective weights, he re-weighed them every two or three days for sixteen days successively, that is, till they were transformed into perfect insects. On the last day, the lighter weighed more than 17, and the heavier more than 18 grains; consequently the fluid evaporated during this period did not amount to a grain, perhaps not to more than $\frac{3}{4}$ of a grain. On weighing the insects themselves which issued from these pupa, together with the cast slough, the weight was not sensibly different. The fluid, therefore,

* Introd. iii. 262.

which escapes by what is termed insensible perspiration, is not so great as might have been supposed. To ascertain what it was, Réaumur enclosed several chrysalides, whose envelope seemed very dry, in separate glass tubes, terminating at one end in a bulb, and at the other hermetically sealed. He kept these in a temperature of from 14° to 15° of his own thermometer, corresponding to 63°—65° Fahr.; and in a few days minute drops of water appeared on the sides of the tube, which rolled down into the bulb in form of a larger drop—not "eight or ten large drops," as Kirby and Spence, by some oversight, have stated *.

It would certainly be considered a strange and untenable doctrine to maintain that it is the evaporation produced from the egg by the heat of the incubating mother, which causes the development of the chick in the egg; yet this is precisely similar to what is maintained by Swammerdam, Kirby, and Spence,—the chief difference being, as Réaumur observes, that the chick has obvious organs for appropriating the nutriment contained in the egg, while the insect in the pupa is surrounded, and, as it were, bathed by the fluid, whose passage into the interior vessels we cannot trace by the eye †. That they do find their way thither, the experiments above recorded unanswerably demonstrate.

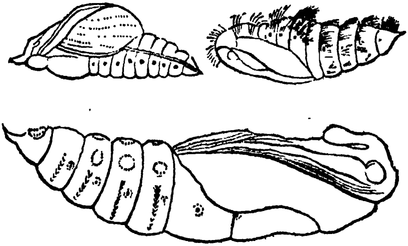
The pupæ of insects, though they, in most instances, cease from locomotion, and appear torpid, are by no means really so; for it would be no less incorrect to look upon them in such a light, than to consider an ox torpid when reclining in a meadow to ruminate and digest the grass he had just been de-

* Réaumur, vol. i. p. 373, "Une goutte beaucoup plus grosse;" and Kirby and Spence, Intro. iii. 262.

† Mem. vol. i. p. 362, &c.

vouring. This is, in fact, the nearest analogy which occurs to us among the other classes of animals; for the pupa, though it does not chew the cud like the ox, assuredly rests for the purpose of digesting or (if the term be preferred) of assimilating the cruder fluids stored up by the caterpillar, and forming or perfecting therefrom the organs and members of the mature insect *.

Some pupæ have a slight motion, particularly of the lower parts of the body, and a few others differ little from the perfect insect, continuing to move and feed; but the greater number remain apparently motionless. That they have internal though imperceptible motions, however, is proved by their possessing similar organs of respiration with caterpillars and perfect insects. We have adverted, in a former page, to the eighteen spiracles which communicate with the double windpipe of caterpillars, and the same apparatus is always found in chrysalides, situated on the sides of the abdominal rings. This we think might have convinced such distinguished observers as Lyonnet and Muschenbrök, that the most quiescent pupæ could not exist without breathing.



b

c

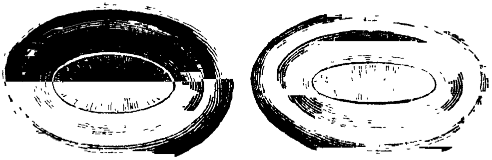
a, Chrysalis of *Gonepteryx Rhamni*. *b*, pupa of *Laria fascelina*. *c*, pupa of *Sphinx Ligustri*.

* J. R.

Réaumur and De Geer proved this position by numerous experiments. When a chrysalis, for instance, is suspended by a thread and immersed in oil up to the tip of the wing-cases, it does not seem to be much injured, and the perfect insect is disclosed in due time. If respiration, therefore, be essential to the life of the chrysalis, it appears as if it could exist with at least the greater number of its spiracles obstructed; but this does not happen with a chrysalis just formed, which always dies. By immersing the whole chrysalis in oil, it is certainly killed; and even by immersing its head downwards as far as the first pair of spiracles situated near the head. This seems to indicate accordingly that this first pair is more essential to the insect than all the rest; and in other experiments it is also found to emit a much greater quantity of air by this first pair. It seems of much importance in such experiments to attend to the age of the pupa; for when near the change the function of respiration is carried on more feebly, and at length nearly ceases.

Besides the decisive experiments of immersion in oil, Réaumur placed pupæ of various species in the exhausted receiver of an air-pump, and at every fresh stroke of the piston their bodies both bulged out and became elongated: because, as he inferred, the envelope is not pervious to the air contained in the body, and the spiracles do not allow of its escape with sufficient rapidity to keep pace with the exhaustion of the receiver;—contrary to what happens when caterpillars are subjected to the same circumstances. Varying his experiments, he placed in the exhausted receiver a vessel containing water deprived of its air, and in this plunged a chrysalis, keeping it immersed by means of a weight attached by a thread. At the two or three first strokes of the piston, bubbles of air appeared at each of the spiracles, issuing by jets, and a few smaller bubbles over the body of the chrysalis, probably from not taking the precaution afterwards suggested by Bonnet, of moistening it before immersion*.

Upon examining the structure of the spiracles, M. Réaumur farther discovered that their mouths are furnished with ciliary valves, which are shut when the pupa is plunged into water, but opened again when it is taken out. This circumstance accounts for the swelling of the body under the exhausted receiver of the air-pump, for it may be supposed the animal would closely shut the valves when it felt the air forcibly extracted from its body. It is remarkable, however, that though the shutting of the valves prevents the entrance of water, it has not the power of excluding oil; because, as Réaumur conjectures, it is not in the ordinary course of its nature exposed to such an accident, and therefore Providence made no provision for it†. It may be recollected that the larvæ of the cheese-fly and of blow-flies are provided with a sort of valve with which they can cover such of their spiracles as become immersed in any greasy matter‡.



a *b*

Spiracles of pupæ. *a*, the valve open; *b*, the same shut.

In the aquatic pupa of the ringed China-mark moth (*Hydrocampa stratiotata*, STEPHENS) De Geer

* Bonnet, Œuvrés, vol. iii., p. 39, &c. † Mem. i. 407, &c.
‡ See page 265.

found three pairs of conspicuous spiracles, occupying the second, third, and fourth rings, and placed on cylindrical tubes. It is worthy of remark, that the caterpillar spins a double cocoon, the outer of a thin, and the inner of a close texture; and when the respiratory gills of the larva are cast off with the old skin, the insect knows how to surround itself with an atmosphere of air in the midst of the water where it resides, the inner cocoon being impervious to moisture. How it contrives to renew this air when vitiated is not yet known, but that it derives it from the water is proved by its always dying if removed into the air *.

We have formerly described the beautiful apparatus for respiration in the larvæ of the gnat family (*Culicidæ*, LATR.) †; but this is rivalled by the organs destined for the same purpose in their pupæ, which organs are situated in the head instead of the tail. The pupa, in the same way, changes its position in the water, swimming with its head upwards instead of downwards as before. To enable it to maintain this position, the pupa is farther provided with a fin-tail, like a fish, by which it can move itself at pleasure in the water. It no longer, indeed, requires to take food, but air is indispensable to it; and water being so unstable, were the pupa incapable of swimming, it would seldom escape being drowned. Its respiratory apparatus consists of two tubes, situated behind the head, on what may be called the shoulders. They are of a funnel shape, and project very sensibly, though we should not be disposed to compare them, as Réaumur does, to asses' ears. The transparency of this pupa renders it easy to see in it the parts of the gnat.

An apparently more simple, though no less remarkable, apparatus for respiration, was observed by Réaumur in the pupa of a small crane-fly (*Tipula*,

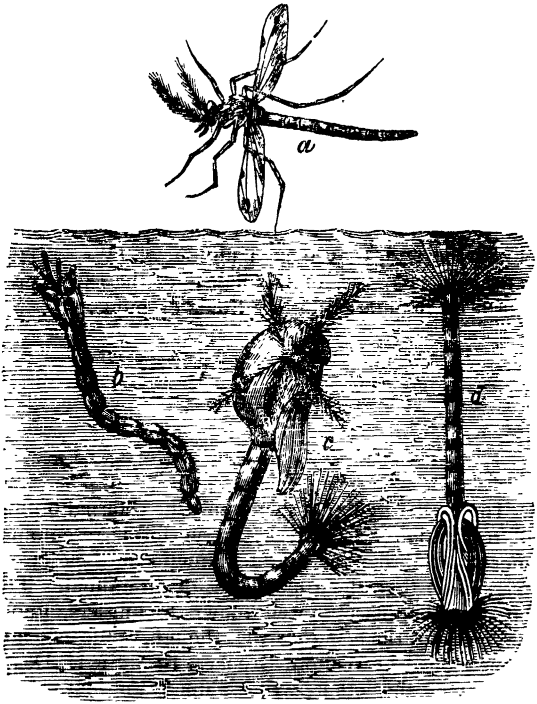
* De Geer, Mem. i. 531. † See page 156.

———). This consisted in a single tube, two or three times longer than the body of the pupa, and as fine as a hair. The point of this hair always remains above or at the surface of the water, for the purpose of carrying on respiration, till the perfect fly is ready to emerge from the water.

a, *Tipula*, ——— ? *b*, telescopic-tailed pupa of the same. *c*, front view of the pupa of the common gnat (*Culex pipiens*). *d*, side view of the same.

In another genus of this family the external organs of respiration are very elegant in form, resembling more the fibrillæ of minute aquatic mosses (*Conferuoideæ*) than the appendages of an animal. The larva of this insect is well known to anglers, under the name of the *blood worm;* though we do not find it mentioned by Walton, Brookes, Best, Sir H. Davy, or any of the other writers upon angling. It is usually less than half an inch long, flat, and jointed like the wire worm, with several small appendages at the tail, which appear to be breathing-tubes, of the nature of gills; for the larva lives under water in streams and ditches, enclosed for the most part in a tube of earth. It is of a fine crimson colour, the origin of its popular name; but it becomes more dark and opaque in the pupa state.

The appendages which are thrown off by the larva



a, *Chironomus plumosus*. *b*, larva of the same, called the *blood worm*. *c d*, pupæ of the same, magnified to shew their plumed spiracles.

are replaced by a brush-like bunch of bristles, the points of which, it is probable, have the power of extracting air from the water; and a similar coronet is produced on each side of the head, disposed in a five-rayed star of plumes. It is not a little remarkable, that a double envelope for the feet projects from each side of the breast, a circumstance which seems peculiar to this insect. In a few days it is transformed into a pretty gnat, with feathered antennæ *(Chironomus plumosus*, MEIGEN).

Such are a few examples of the beautiful contrivances for carrying on the important process of respiration in that stage of life during which few insects take any food. Considering the great difficulties presented to us in the investigation of this subject, we may well wonder that experiments have elucidated and proved so many facts. We are still ignorant, however, of the nature of the effects produced by respiration on the fluids of pupæ.

Chapter XIII.

Transformation of Pupæ into perfect Insects.

The period which pupæ require to come to maturity seems to depend mainly on temperature and size, though there are several other causes at work apparently inscrutable to human research. Those who adopt, after Swammerdam, the untenable theory of evaporation being all that is requisite to bring an insect to maturity, tell us that these two circumstances will account for all the phenomena; but we shall immediately have to record several curious facts quite at variance with such a conclusion. " It is plain," say Kirby and Spence, " that this necessary transpiration, other circumstances being alike, must take place sooner in a *small* than in a *large* pupa. Since the more speedy or more tardy evaporation of fluids depends upon their exposure to a greater or less degree of heat, we might, *à priori,* conclude that pupæ exposed to a high temperature would sooner attain maturity, even though larger in bulk, than others exposed to a low one: and this is the fact. The pupa of a large moth, which has assumed that state in the early part of summer, will often disclose the perfect insect in twelve or fourteen days; while that of an ichneumon, not one-hundredth part of its size, that did not enter this state till late in autumn, will not appear as a fly for seven or eight months. But this is not the whole. The very same insect, according as it has become a pupa at an earlier or a later period of the year, will at one time live but a few weeks, at another several months in that state *."

But though we admit all these facts, which are known to every naturalist, and too well ascertained to be denied, we submit that the inference of evaporation being the exclusive effect, is, upon the whole, inadmissible. Réaumur, though he does not absolutely state his belief in such an inference, shows by his reasoning that he was strongly disposed to adopt notions closely bordering upon it. The theoretical doctrine, it may be perceived, takes for granted that evaporation is the only result of heat; overlooking the no less obvious effect of expansion, besides the disposition it produces in chemical principles to combine or be decomposed. But these are only some of its inanimate results, which would occur upon material objects independently of life; whereas in living bodies, what may be called chemical changes are frequently very different from what can be effected out of the living body, and consequently we cannot trace *all* the effects produced by heat in the two great internal processes of secretion and consolidation. In detailing, therefore, the interesting experiments of Réaumur on pupæ, which he subjected to different degrees of heat and cold, we shall not adopt his inferences respecting evaporation. The accuracy of the experiments themselves is unquestionable.

Reasoning from some of the facts above stated, Réaumur thought it might be possible to hasten or retard the exclusion of insects from their pupæ, in the same way as some flowers are forced to blow early, and others kept back from blowing at their due season; and he commenced a series of experiments to ascertain the facts. In January, 1734, he accordingly placed a great number of the chrysalides of moths and butterflies of various species in one of the royal

* Intr. iii. 263.

hot-houses at Paris. His success was equal to his expectations, for the insects appeared in the middle of winter, some in ten or twelve days, and others in from three to six weeks from the time of their removal into a warmer atmosphere. Five or six days, indeed, seemed to be equal to a month of natural temperature. A week was even equal to a month for the chrysalides which naturally required the temperature of midsummer to bring them to maturity; because the artificial temperature was both high and more uniform, particularly during the night. The butterflies and moths thus forced into premature appearance, were equally full grown, healthy and lively, with those produced in the usual way; and the females deposited their eggs and soon afterwards died, as they always do in summer in the open fields. The life of these insects was, therefore, shortened by some months.

The following November, Réaumur tried a similar experiment, which was consequently begun two months earlier than the former; and the insects were also evolved proportionally sooner. Those, for example, which ought naturally to have appeared in May, he obtained in December. In butterflies which have a double brood, such experiments become still more interesting to the physiologist. The beautiful swallow-tailed butterfly (*Papilio Machaon*) is one of those which are double brooded, the first going into chrysalis in July, and the butterfly appearing in thirteen days;—the second, in the autumn, and the butterfly not appearing till the succeeding June. But if placed in an artificial temperature of due warmth, and properly regulated, the second brood will appear in about the same time as the first.

Réaumur tried some experiments, still more ingenious, with chrysalides, which were suggested by the effects produced by birds sitting upon their eggs in order to hatch them. He concluded, that if chrysalides were placed under a sitting bird, they would be matured in a similar way as he had found them to be in the green-house. The difficulty was to prevent them from being bruised and crushed by the bird, as they are much softer and more easily injured than eggs. This he obviated by enclosing them in hollow glass balls about the size of a hen's egg, which at the same time as readily deceived the bird as a piece of chalk passes with the eggs set to hatch under a hen. The chrysalides which he first tried were those of the small tortoiseshell butterfly (*Vanessa Urticæ*), eight of which, attached to square pieces of paper, were suspended within the glass egg as near to each other as possible, and placed under a hen on the 22d of June. The aperture of the glass egg was closed, but in such a manner as to leave a communication with the external air. The effect of the heat manifested itself the first day, in the moisture exhaled from the chrysalides, all the interior of the glass being covered with minute drops of water, which he allowed to evaporate by unstopping the glass, lest the moisture might spoil his experiment. When it was dry, he replaced it under the hen, and he observed no moisture exhaled on the following days, the chief transpiration having occurred in the first twenty-four hours. In about four days the first butterfly that, perhaps, was ever hatched under a hen made its appearance. He found four more evolved next morning, and one on the succeeding day, the 28th of June. Those of the same brood which were contained in a nurse-box placed in a window, did not appear before the 5th, and some not before the 8th of July, which was ten or twelve days later. Two out of eight of the chrysalides which had been enclosed in the glass egg died. He made a similar experiment with the same success upon several chrysalides of the peacock butterfly (*Vanessa Io*). With the pupæ also of two-winged flies and other insects, he tried all the preceding experiments with very similar results. The heat communicated to the glass egg was very considerable, amounting to 31° or 32° of Réaumur's thermometer *, or about 100° Fahr. It was not surprising, therefore, that some of the pupæ perished: we think it more wonderful that any of them survived.

Réaumur suggests, from these experiments, that those who are curious in obtaining the productions of summer during winter, may add to the gaiety of their forced flowers, by forcing a brood of butterflies into life to sport amongst them; and he records an instance in which a friend of his at Strasburgh in this way hatched, by means of a stove, all the pupæ he could obtain. We have in several instances succeeded in obtaining butterflies in winter, by keeping chrysalides under glasses on a mantel-piece in a room with a constant fire; but during the winter of 1829-30, all which were thus kept died, probably from the fires required by the unusual severity of the season being too great for them. Several, on the other hand, which we found on walls, and which had been exposed to all the rigours of the winter, were disclosed in due time in a perfect state.

Having thus ascertained that heat produced the effects which he had anticipated, Réaumur next tried an opposite series of experiments, by placing chrysalides in diminished temperatures. He accordingly enclosed in nurse-boxes a number of pupæ formed in August 1733, and in the following January placed them in a coal-cellar: their natural period of appearing in the perfect state being July 1734. During the hot months of this year he went from time to time to see whether these pupæ indicated an approaching change, but they remained in their original state during July and August, and continued so till the suc-

* Réaumur, Mem. vol. ii. p. 17.

ceeding August, 1735, at the time he was writing this account, when he found them still living and healthy, but not transformed into perfect insects. We are not aware whether he ever published the termination of the experiment.

In another instance, he placed in a coal-cellar the pupæ of the emperor moth (*Saturnia pavonia*), about a fortnight or three weeks before the usual time of their evolution; and they were in consequence retarded to five or six weeks later than those of the same brood which he had kept in his cabinet. The chrysalides of the large garden white butterfly (*Pontia Brassicæ*), when placed in the cellar in January, appeared two months later than those in the temperature of the atmosphere. A still more decisive experiment was made with the chrysalides of the small tortoiseshell butterfly (*Vanessa Urticæ*), which require fourteen days of summer heat to mature them, and which, when hatched under a hen, had appeared in four days. Some of these he placed in the cellar the 12th of June, and they did not appear till the 2d and 3d of August,—about six weeks later than in their natural temperature.

Réaumur, still haunted by the notion of the exhalation of moisture being the only cause of the development of chrysalides, tried upon them similar ingenious experiments to those which he had successfully made upon eggs, by varnishing them in order to prevent the escape of moisture. His experiments upon varnishing eggs have led to a most useful discovery, now extensively acted upon in practice for the preservation of eggs all over Europe. Those upon chrysalides, however, were not conducted with the same degree of acute accuracy. To prevent the chrysalides from coming to maturity at the usual time, by preventing the exhalation of their moisture, he conceived it would be sufficient to varnish over the envelope, taking care to leave the respiratory spiracles unobstructed. But it is most obvious, that the greater part of all the evaporation which occurs must be through the spiracles, in the same way as a large proportion of the moisture of the human body passes off by the breath. The result, however, of Réaumur's experiments with the varnished chrysalides was, that they were developed several weeks later than when placed in their natural circumstances,—which proves, we think, that the envelope has considerable influence on the transformatory process going on in the interior, even were we to leave the transpiration of moisture out of the question *.

We may remark, that the results of these experiments afford interesting illustrations of the torpidity of both the larger animals and of plants. In the United States of America, for example, many species of animals which become torpid in Pennsylvania, and other more northern parts of the country, remain lively in the Carolinas, and other southern parts of the continent †. Mr. Gough found that the dormouse may be prevented from becoming torpid by supplying it plentifully with food; and Dr. Reeve, of Norwich, observed the same circumstance in a hedge-hog, which being kept warm and well fed, showed no disposition to become torpid even during severe weather ‡. Pallas had a tame marmot, also, which having become very fat during the summer, showed no disposition to torpidity, though exposed to a temperature which threw the whole species into a torpid state in that part of Siberia. In the vegetable kingdom, again, it is a very common phenomenon to see plants revive after exposure to severe frosts. Mr.

* Réaumur, Mem. vol. ii. p. 56.
† Barton, in Amer. Phil. Trans. vol. iv.
‡ Reeve on Torpidity, p. 73.

Gough made some ingenious experiments in proof of this upon several plants, such as the small duck's meat (*Lemna minor*), and the viviparous fescue grass (*Festuca vivipara*), which led to the conclusion that they could accommodate themselves without perishing to the vicissitudes of variable situations*.

We observed a no less marked instance than those recorded by Mr. Gough, in a plant of the geranium, named Prince Leopold (*Pelargonium macranthon*, SWEET), the whole of whose leaves were so hard frozen as to break rather than bend. We immersed the whole of the plant in cold water, a few degrees above freezing, till it was thawed, and it recovered so completely, that not a single frosted spot appeared on any of the leaves†.

Several extraordinary facts relating to insects prove that temperature alone will not account for the variations of the periods of their disclosure. It is stated by Marsham, that Mr. Jones of Chelsea, in one of his excursions, caught a female of the spotted muslin moth (*Diaphora mendica*, STEPHENS), which laid a number of eggs, and he fed thirty-six of the caterpillars hatched from these, till they spun their cocoons and became pupæ. At the usual season only a third of these produced moths, and he concluded the rest were dead: but, to his utter astonishment, twelve more made their appearance the second season; and the remaining twelve were evolved the third season, as perfect and healthy as those which had been first produced‡.

The same extraordinary fact has been observed in the pupæ of the small egger-moth (*Eriogaster lanestris*), the greater number of those which spin up in summer appearing in the succeeding February;

* Manchester Trans. † J. R.

‡ Linn. Trans. vol. x. p. 402.

but others of them requiring two, three, and even four years *. Meinecken kept several pupæ of the emperor-moth (*Saturnia pavonia*) through the winter in a room heated daily by a stove, and others in a cold chamber. Some of both these appeared in March, and others, though evidently healthy, had not appeared in July †.

It is certain, however, that this is not the natural order of things, even in this species; for we have reared several broods of the species respecting which the preceding facts are recorded, without having observed them. In a large brood of the small egger (*Eriogaster lanestris*) five or six of the cocoons did not produce insects, and we consequently anticipated their appearance next year, but we have now kept them five years without any change, and therefore conclude they are dead ‡. The inference deduced, however, from the facts observed, is very plausible, namely, that it is intended by Providence to preserve the species: for were all the individuals of a brood to appear in the same season, it might happen to be so ungenial, particularly in the early months of spring, as to destroy them before they could deposit their eggs; whereas, by their appearing in different seasons, some of them have the chance of coming forth in mild weather §. Yet, perhaps, this may be an unnecessary though ingenious refining upon a final cause: for even in the most ungenial spring weather, there always occur some fine days, and, further, a brood of insects does not all appear on one day, but more usually on many successive days, as may be seen by the experiments of Réaumur recorded at the beginning of this

* Scriba, Journ. i., vol. iii. p. 222; and Haworth, Lepidopt. Brit., vol. i. p. 125.

† Naturf., vol. viii. p. 143.

‡ J. R.

§ Kirby and Spence, vol. iii. p. 267.

chapter. In the instance of the clear underwing (*Ægeria asiliformis*, STEPHENS), we discovered a brood of above a dozen of the pupæ in the trunk of a black poplar; but though, from feeding on the wood of the tree, the caterpillars must have been well protected from the vicissitudes of the seasons, there was nearly a month between the appearance of the first and the last*. This, indeed, is so very common an occurrence that it is almost superfluous to mention particular instances.

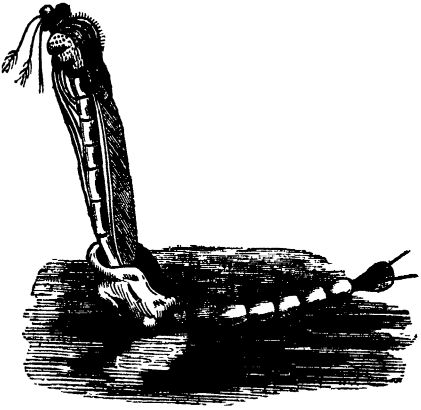
The moths just mentioned, we may remark, were only observed to appear about noon; and many other insects are known to emerge from the pupa only at one particular time of the day, similar to the flowers, such as the goat's-beard (*Tragopogon*), and the night-flowering cereus (*Cactus grandiflorus*), which only blow at particular hours. Some insects are produced at sunrise, others at noon, and others again only at night. Several species are extremely regular in their appearance, such as the orange-tip butterfly (*Pontia Cardamines*), which is usually seen about the end of April, varying but few days in the course of many years. The various species, also, of May-flies (*Ephemeræ*) are confined in their appearance to two or three days; and those observed by Réaumur appear at no other time than between eight or ten in the evening. Those which we noticed on the Rhine in August, 1829, began to appear at sunset, and before morning were all dead. In the great square at Wiesbaden, their bodies were so thickly strewn about that it seemed as if a shower of snow had fallen during the night, their wings being white, and about the size of a broad snow-flake†.

The pupæ of these May-flies, when about to un-

* J. R. † J. R.

dergo their transformation, emerge from their subaqueous galleries and come to the surface of the water. As they must keep their wings dry, the process would appear to be one of considerable difficulty; yet an observer may remark that they perform it with the utmost ease. In the instance of the gnat, this process of emerging from the water is still more conspicuous on account of the difference of form in the pupa and the fly.

About eight or ten days after the larva of a gnat is transformed into a pupa, it prepares, generally towards noon, for emerging into the air, raising itself up to the surface so as to elevate its shoulders just above the level of the water. It has scarcely got into this position for an instant, when, by swelling the part of its body above water, the skin cracks between the two breathing tubes, and immediately the head of the gnat makes its appearance through the rent. The shoulders instantly follow, enlarging the breach so as to render the extrication of the body comparatively easy. The most important and indeed indispensable part of the mechanism, is the maintaining of its upright position so as not to get wetted, which would spoil its wings and prevent it from flying. Its chief support is the rugosity of the envelope which it is throwing off, and which now serves it as a life-boat till it gets its wings set at liberty and trimmed for flight. The body of the insect serves this little boat for a mast, which is raised in a manner similar to moveable masts in lighters constructed for passing under a bridge, with this difference, that the gnat raises its body in an upright direction from the first. "When the naturalist," says Réaumur, "observes how deep the prow of the tiny boat dips into the water, he becomes anxious for the fate of the little mariner, particularly if a breeze ripples the surface, for the least agitation of the air will waft it rapidly along, since its body performs the duty of a sail as well as of a mast: but as it bears a much greater proportion to the little bark than the largest sail does to a ship, it appears in great danger of being upset; and once laid on its side, all is over. I have sometimes seen the surface of the water covered with the bodies of gnats which had perished in this way; but for the most part all terminates favourably, and the danger is instantly over*." When the gnat has extricated itself all but the tail, it first stretches out its two fore-legs†, and then the middle pair, bending them down to feel for the water, upon which it is able to walk as upon dry land, the only aquatic faculty which it retains after having winged its way above the element where it



The gnat (*Culex pipiens*) escaping from the pupa.

* Mem., vol. iv. p. 613.

† Kirby and Spence, by mistake, say it "draws" these *"out of their case,"* vol. iii. p. 288.

spent the first stages of its existence. "It leaves,' says Swammerdam, "its cast skin on the water where it insensibly decays*." Réaumur doubts whether Swammerdam ever actually saw this interesting transformation. We have seen it twice only.

The beautiful pupa formed from the blood worm, as before described, proceeds in its transformation much in the same way as the common gnat. But how, it may be asked, can the insect raise its shoulders above the surface of the water, than which it is specifically heavier, and suspend itself there without motion? "By a most singular and beautiful contrivance, which," says Kirby, "I shall explain, the more particularly because it has escaped Réaumur, and, as far as I know, all other entomological observers. The middle of the back of the thorax has the property of repelling water, apparently from being covered with some oily secretion. Hence, as soon as the pupa has once forced this part of its body above the surface, the water is seen to retreat from it on all sides, leaving an oval space in the disk, which is quite dry. Now though the specific gravity of the pupa is greater than that of water, it is but so very slightly greater, that the mere attraction of the air to the dry part of the thorax, when once exposed to it, is sufficient to retain it at the surface; just as a small dry needle swims under similar circumstances. That this is a true solution of the phenomenon, I am convinced by the result of several experiments. If, when the pupa is suspended at the surface, a drop of water be let fall upon the dry portion of the thorax, it instantly sinks to the bottom†, the thorax, which belongs to the heaviest half, being the lowest; and if the pupa be

* Part i. p. 156.

† But, if so, we may ask what has become of the power of the thorax to repel water? J. R.

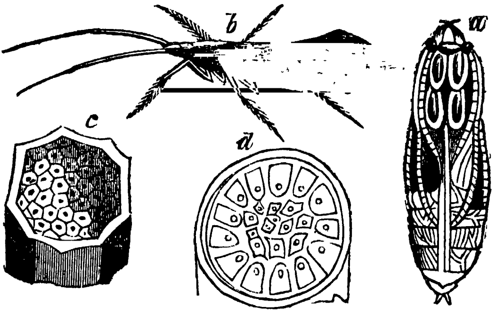
again brought to the surface, so that the fluid is repelled from its disk, it remains there, without effort, as before. Just before the exclusion of the fly (*Chironomus plumosus*, MEIGEN), the dry part of the thorax is seen to split in the middle. The air enters, and forms a brilliant stratum, resembling quicksilver, between the body of the insect and its puparium; and the former pushing forth its head and fore-legs, like the gnat, rests the latter upon the water, and in a few seconds extricates itself wholly from its envelope*."

The grubs of several of the four-winged water flies (*Phryganidæ*, STEPHENS), popularly called case worms and caddis worms, construct a remarkable apparatus for protecting the pupa during its state of inactivity and helplessness. So long as it remains in the grub state it can withdraw itself within its case of shells, stones, or reed-stems; but as soon as it feels its change approaching, it contrives additional security. It weaves, for this purpose, at the entrance of its gallery, a grating of its singular silk, which hardens in water and remains indissoluble, as was first observed by Vallisnieri. The strong threads are made to cross each other, forming a small thickish circular plate of brown silk, which becomes as hard as gum, fitting exactly into the opening, and placed a little within the margin. One of these gratings (described by De Geer) is pierced all over with holes, disposed in concentric circles, separated by ridges running from the centre to the circumference, though not quite so regularly as the spokes of a wheel. Other ridges, again, are made to traverse the concentric rays, following the course of the circles of holes, in such a manner as to form compartments, each having a hole in its centre†. Réaumur found that these holes were for the purpose of

* Intr., iii. p. 290. † De Geer, Mem., vol. ii. p. 519—45.

breathing, by admitting a current of fresh water, effected, no doubt, by the spiracles of the pupa; and he actually saw the grate-work in alternate motion from convex to concave, as the water passed out and in.

Our motive, however, for introducing a notice of these structures is for the purpose of explaining the contrivance by which the pupa makes its exit through the grating. To effect this, it is provided with a pair of curved mandibles, which appear to be applied to no other use, for they are thrown off upon its transformation into a fly, as was observed by Vallisnieri. These facts may be verified by searching for caddis worms during the early spring months, as most of them are transformed in the first part of the summer.



a, Pupa of a case-fly (*Phryganea*). *c d*, grate-works of the same at the openings of the cases, greatly magnified. *b*, the perfect insect.

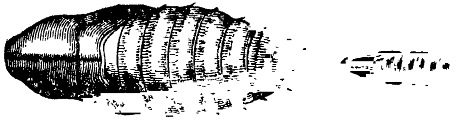
In the common blow-fly (*Musca carnaria*), and many of the same family, the exit of the perfect insect from the pupa case is effected by a very different, but no less admirable contrivance. The head of the perfect fly, it may be remarked, is hard and unyielding; but in the pupa it is soft, and capable of great distension. When the insect, therefore, becomes desirous of escaping from its prison, it blows out the extensile part of its head like a bladder, alternately pushing it forward in the form of a muzzle, and swelling it out at the sides in the form of a ball, till it succeeds in rupturing the pupa case. As this envelope is too opaque to see the process distinctly on the outside, it is necessary to open the pupa just before its transformation, when the movements become obvious. The same mechanism occurs in the pupæ of some of the fibrous gall flies *(Tephrites)*, for the purpose of dissevering the woody fibres which imprison the insects. In the instance of the thistle gall fly (*Tephritis Cardui*), Réaumur found that those kept in his study often became too rigid for the insects to force their passage, and after making repeated efforts they gave up the task in despair and died*. In the open air this accident is prevented by the rain moistening the galls. We have more than once had occasion to make the same remark in the woody galls, such as the bedeguar of the rose, in which the flies have to gnaw for themselves a passage, but which they cannot always effect when the galls are kept through the winter in a dry room†.

In another genus of flies, the pupa does not make use of its head, but turns round and employs its tail to force a passage. This may be observed in the pupa formed from the rat-tailed maggot of the common-sewer fly (*Eristalis tenax*, FABRICIUS), which was observed by Réaumur to push off the lid of its pupa case by means of its tail.

The caterpillar of the clear-wing hawk moth (*Ægeria asiliformis*, STEPHENS), before going into pupa, gnaws away the wood of the poplar tree, where it is lodged, till it leaves only a plate of it as

* Réaumur, iv., Mem. 8. † J. R.

thin as writing-paper. The head of this pupa being obtuse, it cannot of course *cut* through this wooden covering, thin as it is, but can only push against it till it burst it open, which we have more than once seen it actually do*. It is enabled to exert considerable force in this process, by means of the beautifully serrated structure of its rings, resembling in this respect the caterpillars of *cossus* and other wood-borers.



Pupæ of *Cossus*, *a*, and *Ægeria*, *b*, shewing the serratures of their rings.

Lyonnet justly remarks that in the *cossus* there are sharp points upon the head for the purpose of making the first breach, the rest of the body acting as a wedge to tear open the cocoon. Professor Peck has given a very interesting account of similar proceedings in the case of the locust moth (*Cossus Robiniæ*, PECK). "In the silk moth," he says, "and all others which I have had an opportunity to observe, the chrysalis bursts *in* the cocoon, and the fluid which surrounded the new insect in it escaping at the same time, so weakens or dissolves the fibre and texture of the silk†, that the moth is able to extricate itself, leaving the chrysalis behind it; but this is not the manner in the locust moth. After remaining till all its parts are fully grown, and it is ready to quit its prison, a certain quantity of exercise is necessary to break the ligaments which attach the moth

* J. R.

† See some observations on this doctrine, "Insect Architecture," pages 316, 317, and 195.

to the shell of the chrysalis, and to loosen the folds of the abdomen. In taking this exercise, it can only move the abdomen in various directions; as one side of the rings is moved forward, the hooks in the serrated lines take hold of the silk and prevent their sliding back; the next flexure brings forward the opposite side of the rings, which are prevented by the points on that side from slipping back in the same manner, and the chrysalis is forced out of the slightly-woven extremity of the cocoon, and through the silk-lined cavity, till it is protruded for about one-third of its length out of the opening in the bark and into the air*."

A no less ingenious contrivance for escape was observed by Bonnet in one of the leaf-rollers, which feeds on the leaves of young ash trees. It rolls up the leaf into a cone, and is transformed into a small pupa, resembling a grain of oats. The chamber which it forms is not only extensive in proportion to the size of the insect, but is so very compact, that it does not appear in what manner it is to effect its escape. Within the capacious chamber of the leaf it hangs itself up by two lines, after the manner of a sailor's hammock. But, previous to this, it gnaws a circular piece half through the leaf, taking care not to injure the exterior membrane. In order to render this little door easy to be found, the caterpillar, as if foreseeing that the blind pupa could not otherwise discover it, fixes one of the suspensory threads near its margin, guided by which the insect makes its exit with the utmost ease, for the head is uniformly swung up by the door thread†.

A very similar proceeding is recorded of the minute granary moth (*Tinea granella*), which we have before mentioned as destructive to grain. The

* Peck, quoted by Kirby and Spence.

† Bonnet, Œuvres, vol. ii., p. 207.

eggs being laid on the outside of the grain, the entrance of the caterpillar into the interior is not larger than a pin's point, and of course entirely useless as a passage for the moth; but, before its transformation into the pupa, it shapes out a door in the skin of the grain, so that it may be easily broken open from within, while it appears entire on the outside. By pushing it accordingly it at once gives way.

A prospective contrivance of the same kind occurs in the economy of a caterpillar which lives on the dry pith in the seed heads of the wild teazle *(Dipsacus sylvestris)*. The hole by which the newly hatched caterpillar enters is so minute, that in some hundreds of teazle heads, containing full-grown ones, we have never been able to detect it; but its subsequent proceedings are easily traced. From the first it is not contented with the protection afforded by the walls of the seed head, but always spins a gallery of thick silk to cover it while feeding, the outside of which is generally covered with its ejectamenta. Up to the period of its approaching change, the walls of the seed head are left quite entire, as it only eats the dry pith contained in their cavity; but through these it would be impossible for the moth to make its way, inasmuch as it is unprovided with mandibles for gnawing. The provident caterpillar, therefore, takes care before its change to cut a circular hole into the teazle at the end of its own silken gallery, through which the nascent moth may find an easy passage. Bonnet gives it farther credit for a piece of ingenuity which we have not been able to verify. After cutting the hole, he tells us, it carefully fortifies it on the outside by amassing the fibres and seeds of the plant in a loose manner over the hole, to prevent the intrusion of rapacious insects from without; and he gives a very minute detail of his discovery of this fortification*. But we have only to examine the arrangement of the teazle seeds to perceive that he must have been mistaken. In a dozen specimens now before us we find that, besides gnawing through the wall, the insect has eaten about an eighth of an inch into the seeds themselves and the chaff which surrounds them, leaving on the outside the extremities untouched, but lining the whole with a slight tissue of silk,—the circumstance, no doubt, which misled Bonnet. As these are extremely common in the vicinity of London, almost two-thirds of the seed heads of teazle containing a caterpillar, the proceedings of the insect may be easily examined †.

A similar prospective contrivance occurs in the instance of a caterpillar which feeds on the cow parsnip (*Heracleum spondylium*), and makes a circular hole in the stem for the exit of the moth.

In all the preceding instances, the pupa is left to effect its extrication by its own unassisted efforts. But amidst the variety which claims our admiration in the economy of insects, we have to notice proceedings no less remarkable in the case of those pupæ which require extraneous assistance in their transformations. An instance of this is mentioned by Kirby and Spence, on the authority of the Hon. Captain Percy, R.N., who, while he was watching some female crane flies (*Tipulæ oleraceæ?*) busily employed in depositing their eggs amongst the roots of grass, saw one quitting her pupa case. She had already, by her own efforts, got her head, shoulders, and fore-legs disengaged, when two male flies arrived to assist in her extrication. They immediately laid hold of her pupa case with their anal forceps and hind-legs, while with their fore-legs and mouths they seemed to push her upwards, moving her backwards

* Bonnet, Œuvres, vol. ii., obs. xix. † J. R.

and forwards, and shifting their hold till she was entirely extricated, when they left her to recover her strength by herself. "Probably," say our authors, "the extreme length of the two pair of hind-legs of these animals may render such assistance necessary for their extrication*." We, however, imagine that Captain Percy's instance was accidental and anomalous; for the insect having already extricated her head, shoulders, and fore-legs, all the difficulties were surmounted. From the insect being so very common, also, the circumstance of such assistance, if it did happen, must be matter of frequent observation; but we have witnessed a considerable number of several species of this family undergo the change without any assistance whatever†.

The best ascertained case of assistance occurs among ants, and was first observed by the accurate Swedish naturalist De Geer, though the best account of it is given by the younger Huber. "The greater part of the pupæ," says he, "are enclosed in a tissue spun by themselves before their change; but they cannot, like other insects, liberate themselves from this covering by effecting an opening in it with their teeth. They have scarcely the power of moving; their covering is of too compact a texture, and formed of too strong a silk, to allow of their tearing it without the assistance of the workers. But how do these indefatigable attendants ascertain the proper moment for this process? If they possessed the faculty of hearing, we might imagine they knew the fit time, from some noise produced in the interior of the prison by the insects whose developement has commenced; but there is no indication favouring this opinion; it is probable they have a knowledge of it from some slight movements that take place within, which they ascertain through the medium of their

* Intr. iii. 286. † J. R.

antennæ; for these organs are endowed with a sensibility, of which it would be difficult to form a just idea: whatever it be, they are never deceived.

"Let us still follow them in that labour in which are displayed a zeal and attachment that would justly merit our attention, even were they the real parents of these pupæ; how much greater then must be our astonishment, when we consider that they bear no further relation to them than that of being born under the same roof. Several males and females lay in their envelopes in one of the largest cavities of my glazed ant-hill. The labourer-ants assembled together and appeared to be in continual motion around them. I noticed three or four mounted upon one of these cocoons, endeavouring to open it with their teeth at that extremity answering to the head of the pupa. They began to thin it by tearing away some threads of silk where they wished to pierce it, and at length, by dint of pinching and biting this tissue, so extremely difficult to break, they formed in it a vast number of apertures. They afterwards attempted to enlarge these openings, by tearing or drawing away the silk; but these efforts proving ineffectual, they passed one of their mandibles into the cocoon through the apertures they had formed, and by cutting each thread, one after the other with great patience, at length effected a passage, of a line in diameter, in the superior part of the web. They now uncovered the head and feet of the prisoner, to which they were desirous of giving liberty, but, before they could effect its release, it was absolutely necessary to enlarge the opening. For this purpose these guardians cut out a portion in the longitudinal direction of the cocoon, with their teeth alone, employing these instruments as we are in the habit of employing a pair of scissors. A considerable degree of agitation prevailed in this part of the ant-hill. A number of labourer-ants were occupied in disengaging the winged individual from its envelope; they took repose and relieved each other by turns, evincing great eagerness in seconding their companions in the task. To expedite the work, some raised up a little slip cut out in the length of the cocoon, whilst others drew the insect gently from its imprisonment. When the ant was extricated from its enveloping membrane, it was not, like other insects, capable of enjoying its freedom and taking flight; it could neither fly, nor walk, nor, without difficulty, stand; for the body was still confined by another membrane, from which it could not by its own exertions disengage itself.

"In this fresh embarrassment, the labourer-ants did not forsake it: they removed the satin-like pellicle which embraced every part of the body, drew the antennæ gently from their investment, then disengaged the feet and the wings, and lastly the body, with the abdomen and its peduncle. The insect was now in a condition to walk and receive nourishment, for which it appeared there was urgent need. The first attention, therefore, paid it by the guardians was that of giving it the food I had placed within their reach.

"The ants in every part of the ant-hill were occupied in giving liberty to the males, females, and young labourer-ants, which were still enveloped. On being disencumbered of their coverings, the remnants were collected and placed aside in one of the most distant lodges of their habitation; for these insects observe the greatest order and regularity. Some species of ants remove these shreds to a distance from the ant-hill, others cover the exterior surface of their nest with them, or collect them in particular apartments*."

A very interesting experiment upon this subject was tried by Dr. J. R. Johnson, of Bristol. "Among

* Huber on Ants, p. 88.

those ants I kept in confinement," says he, "I observed that considerable bustle prevailed when any of the pupæ were about to quit the cocoon. For the most part two or three stationed themselves on or near each cocoon. From seeing, more than once, two engaged in the operation, I placed in a wine-glass, with a little moistened earth, one of the yellow ants (*Formica flava*), with three or four pupæ; the first object with this little creature was that of excavating a chamber for the deposition of its treasure. The pupæ were then brought up, and laid on the surface of the earth from day to day, to receive the sun's warmth. In a few days I saw the scattered remnants of one of the cocoons, and the worker, with his assistant, engaged in giving liberty to the remaining ants. I did not, at the time, notice whether the pupæ were or were not capable of effecting their own liberation; but according to the statement of De Geer, the pupa dies when neglected by the workers *."

The latter circumstance is contradicted by the testimony of Swammerdam, one of the highest authorities which could be adduced. The species he describes as flesh-coloured, and he was not a little surprised that they spun a cocoon like the silk-worm. "This web," he says, "was of an oval figure, and wrought with delicate and fine threads about the body, being of a rusty iron colour, and when I opened it I found a pupa in the interior. I likewise carried some of these enclosed pupæ to Amsterdam, which after some days gnawed their way out of their webs, and produced some male ants: this happened on the eighteenth of July †." It is obvious, therefore, that at least some species can extricate themselves without assistance; though this seems to be the regular process.

* Notes to Huber, p. 87.
† Swammerdam, Biblia Nat., vol. i. p. 130.

We might have been led by analogy to suppose that bees would adopt a similar method of extricating their young; but observation shows that they do not, for they break through their cocoon by means of their mandibles, at the same time forcing their way through the wax that is fastened down above to the web and bursting it into several jagged pieces, which they throw off on all sides. The other bees carry these broken pieces away, and clear the cells so thoroughly as to make them quite smooth and even. The male, as well as the queen bees, force their way also out of their cells in the same manner as the common or working kind, and all undergo the same change*. But there is one very remarkable difference peculiar to the royal cocoons, first observed by the elder Huber, which well merits to be mentioned.

A hive of bees is so essentially monarchical, that when more queens than one are produced they exhibit mutual and deadly animosity, which leads them to destroy one another. When there are several royal pupæ, therefore, in a hive, the first transformed attacks the rest and stings them to death; though, if these pupæ were enveloped in complete cocoons, this murder could not be perpetrated;—for the silk is of so close a texture, that the sting could not penetrate it; and if it did, the barbs would stick fast in the meshes, and the royal assailant, unable to retract her weapon, would become the victim of her own fury. In order, therefore, that she may destroy her rivals, it is necessary for the hinder rings to remain uncovered, and on this account it is inferred the royal grubs spin only imperfect cocoons, open behind, and enveloping only the head, shoulders, and first ring of the abdomen.

Huber was exceedingly anxious to discover whether the royal grubs spun their cocoons imperfect in consequence of a particular instinct, or of the greater

* Swammerdam, vol. i. p. 187.

width of the cells preventing them from stretching the thread up to the top. To ascertain this he dislodged several royal grubs about to spin their cocoons, and introduced them into glass cells blown of varying dimensions. " They soon prepared to work," he says, " and commenced by stretching the fore part of the body in a straight line, while the other was bent in a curve,—thus forming an arc of which the sides of the cells afforded two points of support. It next directed the head to such parts of the cell as it could reach, and carpeted the surface with a thick bed of silk. I remarked that the threads were not carried from one side to another, which would have been impracticable, for the larvæ, being obliged to support themselves, had to keep the posterior rings curved; and the free and moveable part of the body was not long enough to admit of the mouth reaching the opposite sides. The first experiments obviated the probability of any particular instinct in the royal larvæ, and proved that they spin incomplete cocoons, because they are forced to do so by the figure of their cells. But desirous of evidence still more direct, I put them into cylindrical glass cells, where I had the satisfaction of seeing them spin complete cocoons in the same manner as the larvæ of workers. In fine, I put plebeian larvæ into very wide cells, and they left the cocoon open, as is done by the royal larvæ. I also found that royal larvæ, when lodged in artificial cells, where they can spin complete cocoons, undergo all their transformations equally well. Thus the necessity which nature imposes on them of leaving the cocoon open, is not on account of their increment; nor does it appear to have any other object than that of exposing them to the certainty of perishing by the wounds of their natural enemy;—an observation truly new and singular *."

* Huber on Bees, p. 133.

SECT. IV.—PERFECT INSECTS.

CHAPTER XIV.

Expansion of the Body and Wings in Insects newly transformed.

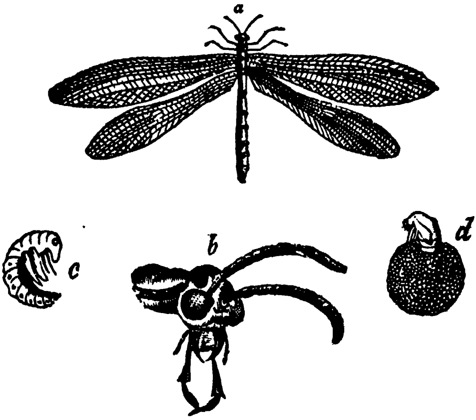
THE mechanism by which winged insects, as well as birds, are enabled to support themselves in the air, is one of the most admirable instances of providential wisdom, to facilitate the locomotion and the distribution of the smaller animals. The great agent employed for this purpose is air, which is made to serve the double purpose of assisting in the assimilation of nutriment by the supply of oxygen and the removal of carbon, and of diminishing the weight of the body in order to render it buoyant. In birds, the lungs have several openings communicating with corresponding air-bags or cells which fill the whole cavity of the body from the neck downwards, and into which the air passes and repasses in the process of breathing. This is not all: the very bones of birds are hollowed out with the design of receiving air from the lungs, from which air-pipes are conveyed to the most solid parts of the body, and even into the quills and plumelets of the feathers, which are hollow or spongy for its reception. As all these hollow parts, as well as the cells, are only open on the side communicating with the lungs, the bird requires only to take in a full breath to fill and distend its whole body with air, which, in consequence of the considerable heat of its body, is rendered much lighter than the air of the atmosphere. By forcing this air out of the body again, the weight becomes so much increased that birds of large size can dart down from great heights in the air with astonishing velocity.

In insects a similar mechanism occurs, though it is more difficult to trace it, on account of the great minuteness of the several organs; but so far as the circumstances can be observed, they well merit our attention. The most remarkable of these is the expansion of the body and wings on the perfect insect emerging from the pupa case. A very striking exemplification of this occurs in the transformation of the ant-lion (*Myrmeleon formicarium*), whose singular stratagems in the grub state are so familiar to the readers of books on natural history*. When it is about to change into a pupa it constructs a cocoon of sand, which it lines with a beautiful tapestry of silk, the whole being less than half an inch in diameter, the pupa itself, when rolled up, filling only a space of about half this dimension. When it has remained in the cocoon about three weeks, it breaks through the envelope and emerges to the outside, as the chrysalides of wood-borers make their way to the exterior of a tree to facilitate the exit of the perfect insect; with this difference, that the nascent myrmeleon-fly makes use of its mandibles to gnaw the cocoon. When it has arrived on the outside it only requires to expand its wings and body to complete its transformation. But this is the process most calculated to excite our admiration; for though it is not on its emergence more than half an inch in length, it almost instantaneously stretches out to an inch and a quarter, while its wings, which did not exceed the sixth of an inch, acquire an immediate expansion of nearly three inches

To the real wonders attending the history of this remarkable insect, it has been fancifully added, that, as it has cast off the spoils and cumbersome weight

* See "Insect Architecture," page 209, &c.

of its first form, so is it likewise divested of its barbarity and ravenous malignity; but the formidable structure of its mandibles, as Réaumur justly remarks, evidently disprove this opinion. A lady discovered that it would eat fruit, and Réaumur actually saw one munch part of a pear; but he thinks that this is not its natural food*. Its close resemblance, indeed, to the dragon-flies (*Libellulina*), except in being more slow in flight, affords a strong analogical indication of its carnivorous propensities.



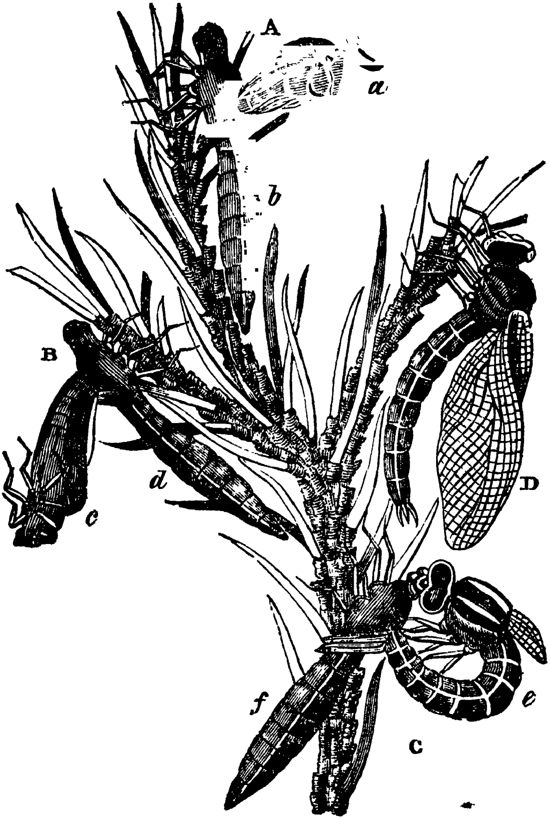
a, *Myrmeleon formicarium*, the fly of the ant lion. *b*, the head magnified to shew the calliper formed mandibles. *c*, the pupa. *d*, the pupa escaping from its cocoon.

A still more striking difference of size may be remarked in the pupa and the perfect insect of a lace-winged fly (*Chrysopa Perla*, LEACH), by no means uncommon near London, and well known by its golden eyes and green wings†. The cocoon of this

* Mem., vol. vi. p. 375. † See page 45.

insect is not bigger than a small pea, while the fly is nearly an inch in length, and the expanse of the wings about two inches.

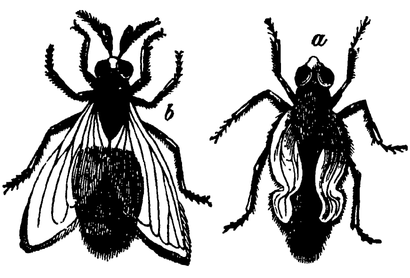
In some aquatic insects this transformation is the more conspicuous from the change of element, the pupa emerging into the dry atmosphere, where the fly is evolved. In the case of the dragon-flies just mentioned, the approaching change is evinced by the increasing transparency of the pupa, exhibiting the growing brilliancy of the large lustrous eyes of the included insect, which may be then brought into view by removing the envelope. At this period it may be seen removing out of the water to a dry place, such as a grassy bank or the stems of aquatic plants, into which it pushes its sharp claws, and remains for a short time immoveable. By the swelling of the upper part of the body the envelope is soon distended and burst asunder on the back of the head and shoulders, and, through the opening, first the head and then the legs of the perfect fly make their exit, whilst the empty slough of the legs continues fixed in its place. After this first part of the process is accomplished, it hangs down its head and rests for a space, as if exhausted by previous exertion, or rather to allow the newly excluded parts to dry and become more firm. It next erects itself, and laying hold of the upper part of the slough with its feet, pulls the parts still enveloped further out, then creeping forward by degrees, it disengages the entire body, and again rests for a time immoveable. The wings now begin to expand themselves, and their plaits and folds become gradually smooth. The body, also, becomes insensibly larger and longer, and the limbs acquire their just size and proportions. While the wings are undergoing this operation of drying and expanding, the insect takes care to keep them from coming into contact with the



A, the dragon fly, beginning to escape from the pupa; *a*, the fly; *b*, the pupa case. B, the process further advanced; *c*, the fly; *d*, the pupa case. C, the fly nearly free, and forming an arch; *e*, the fly; *f*, the pupa case. D, the fly bending back its body, so as not to obstruct the expansion of the wings.

body, by bending itself into the form of a crescent; for if they were obstructed, whilst wet, they could not afterwards be set to rights.

All these changes are perfected, according to Swammerdam, by the force of the circulating fluids and the air, impelled by respiration, a fact of which, we think, there cannot be any doubt. It is very seldom, however, that we can surprise insects at the precise moment of their transformation, as it is for the most part very speedily accomplished, for the whole of the preceding evolutions are usually completed in ten or fifteen minutes. "It happened by mere chance," says Swammerdam, "that I observed them for the first time: one of these vermicles adhered to a stone-wall in the river Loire, and it was so softened by the water dashing up against it, that it could only half perfect its change, so that I took it partly free and partly yet fixed in the skin. I once afterwards saw this change in the large kind of dragon-fly (*Æshna?*) which had crept to land out of a small lake, and cast its skin sitting in the grass *."



a, newly-hatched blow-fly magnified, shewing the pulpy, crumpled state of the wings. *b*, the wings dry and fully expanded.

* Bibl. Nat., vol. i. p. 98.

Some species of flies have their wings shortened very considerably in the pupa state by zig-zag or transverse folds; so that, when newly evolved, it might be supposed, from their moist and crumpled appearance, that they could never become so fine, gauzy, and translucent, as they are actually seen to do. This will be better understood from the above figures than by description.

We have taken the preceding examples of expansion of the wings from those insects in which these are more or less transparent, and consequently the branching of the tubes (*nervures*) through them is more obvious than in moths and butterflies, in which the wings are covered with feathery scales. It is, however, less rare to see the latter transformed than the former, from the greater facility of rearing them, and on that account, it may be proper to take some notice here of their transformation. We cannot in this find better guides than Swammerdam and the celebrated Italian anatomist, Malpighi, in his account of the silk-worm. "At length," says the latter, "within four days, the heart (*dorsal vessel*) of the silk-worm continues moving slowly, and the body growing bigger; having thrown off the outward skin like a slough, the pupa appears a new creature. The throwing off the old and assuming this new form, is completed in the space of one minute and ten seconds; and it is thus done, as I chanced to see it. The motion of the heart (*dorsal vessel*) is very quick at first, and the whole frame of the body appears convulsed; so that the several circular folds of the segments emerge, and by the transverse contraction of the sides, the external skin is separated from the inner; hence, upon making an effort, and thrusting the body, which now appears particularly thick towards the head, the skin is driven backward and downward; and the portions of the windpipe being separated from their external proper orifices, are thrown away with the skin which is then cast off. By this motion, a cleft or opening is made in the back near the head, and through the aperture the body makes its way, the skin being by degrees drawn back towards the tail. This process is assisted greatly by a yellow kind of ichor which exudes from the cavities of the skull; and the pupa appears then free and disengaged.

"While the insect is making its passage out, the antennæ are separated from the body of the pupa, and are torn, as it were, out of two cavities of the skull; and their length, as they become unfolded, occupies the same place which the two muscles of the mandibles formerly occupied. The wings, also, and the legs appear to be circumscribed in their limits; the wings being drawn from their situation near the fore-legs, and the legs from the lateral parts of the back. But as these unfolded parts are yet mucous, they easily stick to each other, and, insensibly growing dry, they become so closely united that the pupa appears like one entire garment. Now as these parts are peculiar to the moths, and are destined for their use, the nature of the moths seems to be to emerge sooner from the state of the caterpillar than is commonly believed, and also to be earlier implanted in it; for evidently, in the silk-worm, the beginnings of the wings may be seen under the second and third ring of the body, before the texture of the web. The antennæ are likewise delineated on the skull, and the web being finished, they have their own termination; nor will it be improper to suppose that the new kind of life in the pupa is only a mask or veil of the moth, which is already perfect within, the intent of which is, that it should not be struck or destroyed by external injuries, but might grow strong and ripen*."

While the little creature remains in this condition, there is produced, as Swammerdam tells us, a violent agitation in its fluids, so that they are driven from the internal vessels through the tubes in the wings, which are likewise supplied with air from the windpipe. The insect, besides, labours violently with its legs, and all these motions concurring with the growth of the wings, it is impossible that the tender skin which covers it should not at length give way, which it does by bursting in four distinct and regular pieces. When the legs become disengaged they much assist in freeing the body and other parts that are yet bound up; at the same time, the skin on the back flies open and uncovers the wings and shoulders. The insect, after this, remains for some time in a state of rest, with its wings drooping down like wet paper, and its legs fixed in the skin which it has just cast off, together with the lining of the windpipe and breathing spiracles. This latter circumstance enables the insect to take more air into its body, and thereby renders it the better able to fly, and perform the other functions dependant on a good supply of air. In consequence of this the wings expand so rapidly, that it is by no means easy to trace their unfolding; for in the space of a few minutes, they increase in dimensions about five-fold. Their spots and colours at the same time, previously so small as to be scarcely discernible, become proportionally extended, so that what but a few minutes before appeared as a number of confused and indistinct points, acquires many varied beauties of colour and form. From the wings extending themselves so suddenly, their soft wrinkled appearance is, in less than half

* Malpighi, De Bombyce.

an hour, no longer visible, and the insect becomes fitted for flight*.

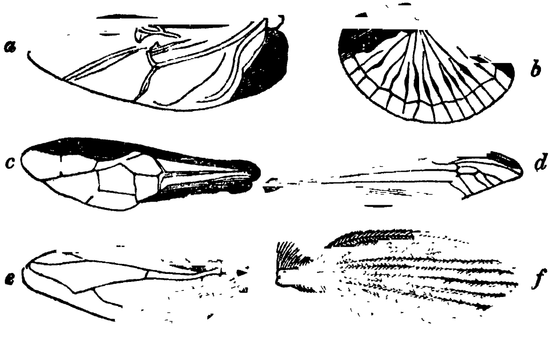
Kirby, in speaking of the swallow-tailed butterfly (*Papilio Machaon*), says, "I had the pleasure of seeing it leave its puparium the 16th of May. With great care I placed it upon my arm, where it kept pacing about for the space of more than an hour; when all its parts appearing consolidated and developed, and the animal perfect in beauty, I secured it, though not without great reluctance, for my cabinet—it being the only living specimen of this fine fly I had ever seen. To observe how gradual, and yet how rapid, was the developement of the parts and organs, and particularly of the wings, and the perfect coming forth of the colour and spots, as the sun gave vigour to it, was a most interesting spectacle. At first, it was unable to elevate or even move its wings; but in proportion as the aërial or other fluid was forced by the motions of its trunk into their nervures, their numerous corrugations and folds gradually yielded to the action till they had gained their greatest extent, and the film between all the nervures became tense. The ocelli, and spots and bars, which appeared at first as but germs or rudiments of what they were to be, grew with the growing wing, and shone forth upon its complete expansion in full magnitude and beauty †."

The probable object of the movements which an insect makes, upon just escaping from the chrysalis, is to impel the fluids that had been compressed during its confinement, and more particularly air, into the various parts of the expanding body and wings. The wings, it may be remarked, are not, on the exclusion of the insect, folded up as are the long wings of an earwig (*Forficula auricularia*), but are

* Swammerdam, ii. 7, &c. † Intr. iii. 293.

of a thick structure and easily expanded. They differ in this from full-formed wings, which cannot be stretched a hair's breadth without tearing them; whereas we have taken the wing of a butterfly on its emerging from the chrysalis, and extended it to four times its original expansion. That the fluids of the body are at this period impelled into the wings, is proved by an experiment first tried, we believe, by Swammerdam, on the wings of bees. "The blood in the bee," he says, "is a limpid fluid, as may be observed, if a little part be at this time cut off from the wings; for then the fluid exudes from the cut part, appearing, by reason of the extreme smallness of the blood-vessels, under the form of little pellucid globules, which insensibly and by degrees increase into considerable little drops."—"The wings of the bee have likewise many pulmonary tubes, which, when the nymph is casting its last skin, have also, together with all the other parts, once more to throw off their exuviæ. After this, when these tubes are again distended by the freshly impelled air, and the air-vessels, which have hitherto been contracted, are inflated and distended with the same air, it follows that the whole wing afterwards expands itself, and becomes thrice, nay, four times larger than it was before. This expansion of the wings depends, therefore, both upon the impulsion of the air and of the blood; for at the same time when the air is impelled into the wings, a considerable quantity of blood is likewise driven into the vessels of the wings."—"The female bees do not, as the common bees and the male, come forth with their wings folded up, but expanded and displayed, and in a state ready for flight. On this account, the all-wise Author of Nature has provided for them a more spacious mansion, in which they may expand their wings conveniently and properly; so that after they have burst from their cells they may be prepared for swarming immediately, if there be a necessity for it, or that the young queen may be in a condition to drive out her royal mother and take her place if there be occasion*."

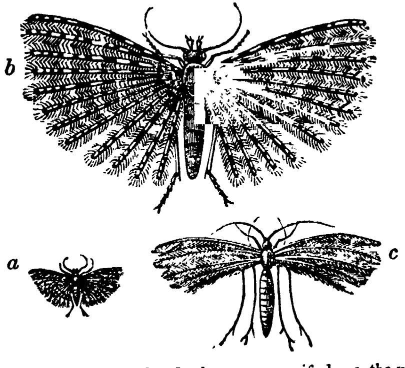
It does not appear, however, that Swammerdam proved by dissection the simultaneous existence of air and blood vessels in the wings, but merely infers this, as Réaumur afterwards did, from the phenomena. But Jurine has since actually demonstrated that every vein (*nervure*) of a wing contains an air-tube, which originates in the windpipe, and follows in a serpentine form, without filling, every branchlet of the nervures. Those who have not paid attention to this curious subject have little conception of the great diversity of forms which are exhibited by the branchings of these nervures, not only in different orders, but even in different species of insects. They differ, indeed, as much in this respect as the leaves of plants do in their mode of veining.



Wings of insects:—*a*, wing of a beetle; *b*, wing of an earwig; *c*, wing of a saw fly; *d*, wing of a crane fly; *e*, wing of a common fly (*Musca*); *f*, wing of a midge (*Psychoda*).

* Swammerdam, i. 187.

In moths and butterflies the nervures are in a great measure concealed by the feathery scales;—but when these are removed they are rendered apparent, and appear to resemble in some measure the arrangement observed in the two-winged flies. To this arrangement there occurs a remarkable exception in the family of plumed moths (*Alucitidæ*, LEACH), of which Stephens enumerates twenty-nine British species. One of the most common of these is the large white plume (*Pterophorus pentadactylus*, LEACH), which may be seen, during the summer, in hedges and gardens, flitting about like a tuft of down or a snow-white feather dropt from the breast of the eider duck. From being slow in its motions it is easily taken; but if rudely handled all its snowy plumage will come off. Another of the family, also very common, is the twenty-plume moth (*Alucita hexadactyla*, LEACH), which may be seen from March



a, the twenty-plume moth. *b*, the same magnified. *c*, the white plume moth.

till October, on windows and the walls of rooms, or, still more probably, on the leaves of honey-suckles, on which its caterpillar feeds. Réaumur, who had never found the caterpillar, thought that so delicate an insect could not exist out of doors during the bleak weather of spring; and concludes that it feeds like the clothes moth in-doors—an instance among hundreds more how frequently our most plausible reasonings are far removed from the facts. This moth is so small that it is not ready to catch the eye of those who are unacquainted with it, and even when it is found it requires a magnifying-glass to perceive all its beauties.

The movements of insects just escaped from the chrysalis appear, then, to be analogous in their design to the restless motions of the young of larger animals. In Darwin's fanciful language, the accumulation of excitability in the sensorium impels the creature to be frisky for the purpose of getting rid of the superabundant stimulus; but whatever the exciting cause may be, we are certain that the final cause and certain effect is the brisker impulsion of fluids, and particularly air, through the vessels appropriated to their circulation, and consequently the more perfect nourishment and speedy growth of the several members. The analogy between the larger animals and insects is, that the latter, when they have undergone their last change from the pupa into the perfect insect, never increase in size, as the former remain stationary soon after puberty.

We notice this the more readily, as those who are but little acquainted with insects are exceedingly apt to think they grow like other animals, and from this cause commit many mistakes, not perhaps of great moment, but which in a work like this it may prove interesting to rectify. "The most common British butterflies," it has been remarked, "most persons may have observed to be those which are white; and all these are usually looked upon as of the same species, differing in nothing, except, perhaps, in the size; the latter being erroneously ascribed to difference of age. But the fact is, that there are a considerable number of species of our white butterflies, as well as several genera, and probably more varieties even of these than have yet been ascertained or described. It is certain, indeed, that butterflies do not, like the larger animals, increase in size as they grow older; for every individual, from the moment it becomes a butterfly, continues invariably of the same size till its death. Butterflies, indeed, seldom live longer than a few days, or at most a few weeks, and during this time they eat little, except a sip of honey: and since this is so, it would be absurd to expect that they could increase in size. It must not, however, be understood from this, that the same species will always measure or weigh precisely the same; for though this will hold as a general rule, there are many exceptions, arising from the accidents the caterpillar may have suffered from which an individual butterfly originated. It is only during the caterpillar state that the insect eats voraciously, and grows in proportion; and if it is, during this stage of its existence, thrown upon short allowance, it cannot acquire the standard magnitude, and the butterfly will be dwarfed from the first. The same remarks with respect to growth apply to insects of every kind, and the fact cannot be better exemplified than in the uniformity of size in the house fly (*Musca domestica*) among which scarcely one individual in a thousand will be found to differ a hair's breadth in dimensions from its fellows*."

We may add, that there are many flies occasionally found in houses both larger and smaller than the *Musca domestica*, but these are of a different spe-

* J. Rennie on the White Butterflies of Britain, Mag. Nat. Hist. vol. ii. p. 225.

cies, and not, as is popularly believed, the old or the young of the house fly; no more than the midsummer cockchafer (*Zantheumia solstitialis*, LEACH) is the young of the common cockchafer (*Melolontha vulgaris*). It would be equally correct to say that an ass is the young of a blood-horse, or a mouse the young of a rat. Nor is this mistake confined merely to popular belief, for we find it not only stated in books of natural history, but reasons assigned for its correctness. "It is held by some apiarians," says Huish, "that the bee, in emerging from its cell, has attained its full growth; I would, however, recommend to those gentlemen to try to thrust either a bee or a drone into one of the breeding-cells, and he will find that the capacity of their bodies is too large for the dimensions of the cell*." This experiment would not, of course, succeed; but that does not prove the doctrine, for the author does not take into consideration the great quantity of air by which the body is distended; and even if this were expelled by putting the bee under the exhausted receiver of an air-pump, the wings and other parts, now become dry and rigid, could not be folded up in the very compact manner in which they existed in the pupa state.

The fact of the expansion of the wings by the impulsion of air and fluids into their nervures, may be illustrated by the accidental circumstances into which chrysalides may fall. We have mentioned in a preceding page, that the thread by which a chrysalis is suspended may sometimes snap asunder. When this happens, and the chrysalis is allowed to remain, it will not usually produce an insect complete in all its parts; for the side upon which it lies being pressed against an unyielding substance by its own weight, instead of hanging lightly suspended

* Huish on Bees, p. 43.

by a silken cord, is prevented from becoming duly expanded, and when the insect is excluded it is found to be deformed. This might by some be imagined to be a mere theoretical view deduced from physiological reasoning; but we can prove it by specimens of moths and butterflies which we have reared. A colony of the brown-tail moth (*Porthesia auriflua*), which we reared during the summer of 1829, spun in the corner of a nurse-box a common web of several chambers for containing the pupæ. One of these chambers being accidentally torn, a pupa fell upon the earth in the bottom of the box, and in due time a female moth was produced from it; but she never succeeded in expanding her wings, which remained till her death shrunk, rumpled, and totally useless for the purpose of flying, though in every other respect she was full grown, and deposited in the box a group of fertile eggs, covered with down from her tail as neatly as was done by her sisters of the same brood. In the summer of 1825, the chrysalis of a small tortoiseshell butterfly (*Vanessa Urticæ*) lost its hold of its silken suspensory, and fell upon the pasteboard bottom of a nurse-box, resting in a sort of angular position, so that the case of the upper wing on the left side pressed upon the box with the whole weight of the chrysalis above it. When the butterfly made its appearance, it expanded its wings as usual, but the wing upon which it had rested was not half the size of the one on the right side which had lain uppermost. Another of the same brood had by some cause not grown so large in the caterpillar state as the rest. It was transformed, notwithstanding, into a chrysalis, which appeared healthy and well formed; but when the butterfly appeared, though it did not differ from the usual appearance, its wings never expanded a single hair's breadth, and remained always in the same state as when it issued from the chrysalis*.

a, *Vanessa urticæ*, with one wing imperfect. *b*, brown-tail moth, *Porthesia auriflua*, with shrivelled wings. *c*, *Vanessa urticæ*, with unexpanded wings.

It is not a little remarkable, that when insects are evolved from the pupa state, they always discharge some substance. It is important to remark, that the matter voided at this period by many butterflies (*Vanessæ*, &c.) is of a red colour, resembling blood, while that of several moths is orange or whitish. It could not readily be supposed that this should become the object of superstitious terror, yet so it has been in more instances than one. Mouffet tells us, from Sleidan, that in the year 1553 a prodigious multitude of butterflies swarmed throughout a great portion of Germany, and sprinkled plants, leaves, buildings, clothes, and men, with bloody drops as if it had rained blood†. Several historians, indeed, have recorded showers of blood among the prodigies which have struck nations with consternation, as the supposed omen of the destruction of cities and the overthrow of empires. About the beginning of July, 1608, one of these showers of blood was supposed to have fallen

* J. R. † Mouffet, Theatr. Ins. 107.

in the suburbs of Aix, and for many miles around it. and particularly the walls of a churchyard were spotted with the blood. This occurrence would, no doubt, have been chronicled in history as a supernatural prodigy, had not Aix possessed at this time, in M. Peiresc, a philosopher, who, in the eager pursuit of all kinds of knowledge, had not neglected the study of insects. It is accordingly related, in the curious life of Peiresc by Gassendi, that he had, about the time of the rumoured shower of blood, happened to find a large chrysalis, the beauty of which made him preserve it in a box. Some time after, hearing a noise in the box, he opened it and found a fine butterfly, which had left upon the bottom a red stain of considerable magnitude, and apparently of exactly the same nature with the drops on the stones, popularly supposed to be blood. He remarked, at the same time, that there were countless numbers of butterflies flying about, which confirmed him in the belief of his having discovered the true cause; and this was further corroborated by his finding none of the red drops in the heart of the city, where the butterflies were rarely seen. He also remarked, that the drops were never on tiles, and seldom on the upper part of a stone, as they must have been had they fallen from the heavens, but usually appeared in cavities and parts protected by some angular projection. What Peiresc had thus ascertained, he lost no time in disclosing to many persons of knowledge and curiosity, who had been puzzling themselves to account for the circumstance by far-fetched reasonings, such as a supposed vapour which had carried up a supposed red earth into the air that had tinged the rain;—no less wide of the truth than the popular superstition which ascribed it to magic, or to the devil himself*. Those who are curious to verify the

* Réaumur, vol. i. p. 638.

discovery, as we may well call it, of Peiresc, may easily do so by rearing any of the spinous caterpillars which feed on the nettle till they are transformed into the butterfly. We have witnessed the circumstance in innumerable instances.

It is a curious and interesting probability, that the crimson snow of the Alpine and Arctic regions, which has recently excited so much scientific inquiry, should be referable to a somewhat similar cause,—a circumstance which will apologize for our taking some notice of it here by way of illustration. According to Professor Agardh, red snow is very common in all the alpine districts of Europe, and is probably of the same nature with that brought from the polar regions by Captain Ross. Saussure saw it in abundance on Mont Brevern, in Switzerland, and elsewhere; Ramond found it on the Pyrenees; and Sommerfeldt in Norway. In March, 1808, the whole country about Cadone, Belluno, and Feltri, is reported to have been covered in a single night with rose-coloured snow; and at the same time a similar shower was witnessed on the mountains of Valtelin, Brescia, Carinthia, and Tyrol. But the most remarkable red snow shower was that which fell on the night between the 14th and 15th of March, 1823, in Calabria, in Abruzzo, in Tuscany, at Bologna, and through the whole chain of the Apennines.

Upon the return of Captain Ross from the Polar expedition some years ago, the specimens of red snow which he brought home were examined by three of our most distinguished observers, Wollaston, Bauer, and Robert Brown, who all came to the conclusion that it was of a vegetable nature, but differed as to its botanical characteristics. Dr. Wollaston supposed it to be the seed of some moss; Mr. Brown was inclined to consider it an algæ, related to *Tremella cruenta*, a common native plant;

while Mr. Bauer thought it was a fungus of the genus *Uredo*. Professor Agardh refers it with Brown to the lowest order of algæ, but standing as a distinct genus upon the very limits of the animal and vegetable kingdoms. Saussure, indeed, from finding that the red snow of the Alps gave out, when burnt, a smell like that of plants, concluded that it was of vegetable origin, and supposed it to consist of the farina of some plant, though he could not trace it to its source. Baron Wrangel, again, who discovered a production similar or identical with Agardh's *Protococcus nivalis* growing upon limestone rocks, mentions that it was easily detached when placed under water, and in three days it was converted into animated globules like infusory animalcules, which swam about and were made prey of by other infusoria. Professor Nees von Esenbeck, of Bonn, is inclined to think that the minute red globules, of which the *Protococcus* consists, are the vegetable state of bodies which had gone through a previous animal existence.

The Rev. W. Scoresby, on the other hand, conjectures that the red colour of the snow may be traced to the same cause as the orange-coloured ice of the polar seas, which arises from innumerable minute animals belonging to the *Radiata*, and similar to the *Beroë globulosa* of Lamarck. It is about the size of a pin's head, transparent, and marked with twelve brownish patches of dots. In olive-green sea water, he estimated 110,592 of these in a cubic foot*.

Agardh remarks, that it is agreed upon all hands that the crimson snow always falls in the night, from which he infers that it has not been actually seen to fall. He thinks it is called into existence by the vivifying power of the sun's light, after its warmth has caused the snow to dissolve, accompanied by the

* Jameson's Edin. Journ., Jan. 1829, p. 55.

incomprehensible power in white snow of producing a colour*.

Réaumur says, with much justice, on another occasion, that an ordinary spectator frequently discovers what has escaped the notice of the best observers, and so it should seem it has happened in the present case,—the learned naturalists just mentioned having gone as wide of the facts, as the philosophers at Aix in accounting for the supposed shower of blood. Mr. Thomas Nicholson, accompanied with two other gentlemen, made an excursion the 24th July, 1821, to Sowallick Point, near Bushman's Island, in Prince Regent's Bay, in quest of meteoric iron. "The summit of the hill," he says, "forming the point, is covered with huge masses of granite, whilst the side which forms a gentle declivity towards the bay was covered with crimson snow. It was evident, at first view, that this colour was imparted to the snow by a substance lying on the surface. This substance lay scattered here and there in small masses, bearing some resemblance to powdered cochineal, surrounded by a lighter shade, which was produced by the colouring matter being partly dissolved and diffused by the deliquescent snow. During this examination our hats and upper garments were observed to be daubed with a substance of a similar red colour, and a moment's reflection convinced us that this was the excrement of the little auk (*Uria alle*, Temminck), myriads of which were continually flying over our heads, having their nests among the loose masses of granite. A ready explanation of the origin of the red snow was now presented to us, and not a doubt remained in the mind of any that this was the correct one. The snow on the mountains of higher elevation than the nests of these birds was perfectly white, and a ravine at a short distance, which was filled with snow

* Loudon's Encycl. of Plants, *Protococcus*.

from top to bottom, but which afforded no hiding-place for these birds to form their nests, presented an appearance uniformly white*."

This testimony seems to be as clear and indisputable as the explanation given by Peiresc of the ejecta of the butterflies at Aix. But though it will account, perhaps, for the red snow of the polar regions, it will not explain that of the Alps, the Apennines, and the Pyrenees, which are not, so far as we know, visited by the little auk. Thus the matter at present rests, till it be elucidated by further observations.

* Mag. of Nat. Hist. vol. ii. p. 322.

Chapter XV.

Peculiar Motions of Insects.

Nothing that has life seems capable of existing long without motion. The oyster fixed upon the rock must open and shut its shell, and the most gnarled oak must wave its branches, otherwise their fluids will stagnate, and disease will ensue. In our own case, we cannot, if we would, put a stop for any length of time to all our motions. We have the power, indeed, of interrupting the nictitation of the eyelids; but if we keep our eyes fixed for a few minutes they become dry and painful for want of the regular supply of moisture spread over them by the process of winking. Breathing, again, being a more important operation, cannot be long interrupted, without serious consequences; and when the motion of any of the limbs is prevented by the accidental injury of its joint, it usually shrinks and dwindles into less than half its natural magnitude, because the proper quantity of the nutritive fluids is not impelled thither in consequence of its deficiency of motion.

We have already seen how indispensable the motions of insects are to the due expanding of their wings upon emerging from the pupa state; and several remarkable circumstances show that, independent of change of place in search of food or of other localities for their progeny, motion is necessary to their well-being. At least there does not seem any other plausible explication of what we may term stationary motions. Kirby and Spence's "motions of insects reposing*," appears to be a phrase which would not apply, for example, to an ox chewing the cud, or a cat washing her face with her paw,—motions precisely similar to many of those of insects

* Introd. vol. ii. p. 304.

mentioned by them under this head. The mode adopted by cats of cleaning themselves with their paws, is, indeed, not a little similar to that of the house fly (*Musca domestica*), which, while it is basking in a window and enjoying the heat of the sun, may be frequently seen not only brushing its feet upon one another to rub off the dust, but equally assiduous in cleaning its eyes, head, and corslet with its fore-legs, while it brushes its wings with its hind-legs *. At the time of writing this, March, 1830, we have just witnessed a similar process in a water measurer (*Hydrometra stagnorum*, LATR.), which we had put into a glass containing water, with a leaf for it to rest upon. Not liking the narrow pool in the glass so well as the brook at Lee, from which it had been taken, it began to climb the edges of the glass, for which its feet were far from being well adapted, and it slipped at every step; but, determined not to be baulked, after several unsuccessful trials, it betook itself to the leaf as if to survey the obstacles before it again attempted the steep ascent. After deliberating for a moment, the thought seemed to strike it that its feet were not in the best trim for climbing; and it forthwith began with great assiduity to clean them somewhat in a similar way to the fly by wiping them upon one another, but with this difference, that it did not, like the fly, cross its legs from opposite sides, the length and rigidity of the thighs preventing such a movement. It did not forget at the same time to clean with much care its long antennæ, in order, no doubt, to fit them the better for exploring an unknown path. It spent several minutes in this preliminary trimming, when it again began to mount, and we were no less pleased, perhaps, than itself, to see its perseverance rewarded; for, aided either by the greater cleanness of its feet, or by

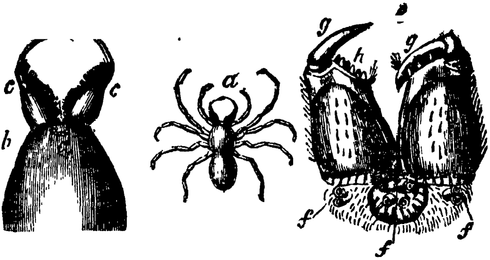
* See Insect Architecture, p. 368.

some particles of slime and sand adhering to the glass, it triumphantly gained the brim, which it began to perambulate with an apparent air of proud exultation *. This insect is figured at *b*, page 382.

The process of cleaning and brushing the legs, as birds are seen to preen their feathers, is, however, the most remarkable, though, perhaps, but seldom taken notice of among spiders. The same process, as we have recently discovered, is employed by the Phalangia. The apparatus for this is admirably contrived. In the common garden geometric spider (*Epeira diadema*), the teeth are used as a comb, the smooth mandible being employed to hold down the limb while it is slowly drawn between the teeth, to free it from flue and dust. In some other species, instead of smooth teeth, there is a thick-set brush of hairs, which is used in the same manner, and must be a still more efficient instrument. The former, if we do not mistake, chiefly occurs among the geometric spiders, whose webs are meshed and thin; while the brush prevails among those which weave thick webs, such as the red spider (*Dysdera erythrina*, WALCKENAER), which we found in the crevice of a chalk rock near Erith, in Kent, but which is by no means common in Britain, though abundant in France. We kept this one for some time in a glass, and observed that it spent the greater part of its time in brushing its legs. The eyes are placed in form of a horse-shoe †.

It must have struck those who have visited a menagerie of wild animals, that, even while they are standing in their cages, they frequently throw their heads, and also their bodies, into a sort of oscillatory movement, evidently not for the purpose of getting through the bars, but to supply the place of their natural exercise which confinement prevents them

* J. R. † J. R.

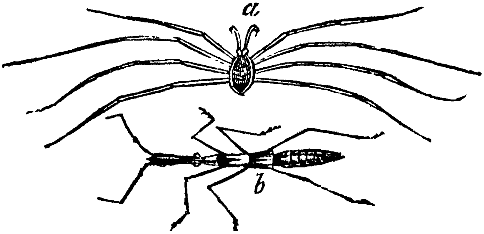


a, red spider (*Dysdera erythrina*). *b*, the head of the red spider, magnified. *c c*, the mandibles, fringed on the inside with hair. *d*, the eight eyes, in form of a horse-shoe. *e*, the head of the garden spider (*Aranea diadema*). *f f f*, the eight eyes. *g g*, the upper mandibles. *h*, toothed comb.

from taking. Perhaps this may help us to account for the singular motions of some of the crane flies (*Tipulidæ*), while stationary upon a window or a wall, their whole body vibrating alternately outwards and inwards from the wall, with a pendulum-like movement, as rapid, or more so, than the clicking of a watch. Kirby and Spence say, this is produced by the weight of their bodies and the elasticity of their legs; and that, unless it be connected with respiration, it is not easy to say what is its object*. To us it appears, like the motion of the caged animals just mentioned, to be for the purpose of exercising themselves and of driving the fluids into their long legs, which may not be effected in the exercise of flying on account of their legs then remaining almost motionless. Others of the same family may be seen hanging from a wall or ceiling by their fore-legs, while the hind ones are perked out into the air, and moving up and down in a slow manner, probably to watch against approaching danger, as they are very timid; and if the door of the room where they are be hastily opened or shut, or if any other agitation of the air be pro-

* Intr. ii. 306.

duced, they immediately fly off*. The long-legged spiders, popularly called shepherds and harvest men (*Phalangidæ*, LEACH), have a similar mode of elevating their legs, particularly the second pair, which they move about in all directions.



a, *Phalangium*; *b*, *Hydrometra stagnorum*, magnified.

It can scarcely have escaped the remark of the most indifferent observer, that when butterflies (particularly those of the genus *Vanessa*) alight during sunshine on a leaf or a pathway, they flirt their wings as a lady does her fan, and perhaps, as has been conjectured, for the similar purpose of cooling their bodies. But to us it appears more probably with the design of impelling air into the tubes of their wings to fit them the better for flight; for we have remarked that they uniformly fan their wings when about to rise, though they had previously remained motionless for an hour together. A pretty family of two-winged flies (*Syrphidæ*†) may frequently be remarked in lanes and on the borders of woods, hovering on the wing for a considerable time without shifting a hair's-breadth from their place, though the motion of their wings is all the while so rapid as to be almost imperceptible, similar to some moths (*Sphingidæ*, *Plusia gamma*‡, &c.) whilst sipping

* J. R. † See p. 4. ‡ See p. 214.

the honey of flowers. The vibratory motion of the wings in these instances is only to buoy them up so as to retain their place; but the instant they are alarmed by the approach of danger, they may be seen to take several long strokes with their wings, and dart off with the rapidity of lightning. This is well illustrated by the motions of birds preparatory to flight, as they may be observed always to take several deep inspirations, at the same time often rising on tiptoe, and puffing out and balancing their bodies to feel whether they have thrown enough air into their bones and feathers to float them along. Birds of prey (*Raptores*, VIGORS) seem to have the greatest power both of filling their bodies with air and of expelling it again at pleasure. Hence the kestril (*Falco tinnunculus*) may be seen floating about for a considerable time without moving a wing, or perhaps drawing a breath, till it can hold out no longer, when it flutters its wings rapidly, not for moving to a different place, for it remains stationary, but to recover its decreasing buoyancy by inhaling a fresh supply of air. For the same reason a trout will oscillate its body when losing ground by the rapidity of a stream. The osprey (*Falco ossifragus*), on the other hand, we have seen, at the Kyles of Bute and elsewhere, shoot down like a thunderbolt from the air into the sea, plunging far into the water upon a fish she had marked for her prey*,—a movement only to be explained by the rapid expulsion of the air which had been the chief agent in keeping her previously afloat in the region of the clouds. Many birds which prey on smaller game have somewhat similar methods of poising and balancing their bodies, of which the water-ouzel (*Cinclus aquaticus*,

* "Super est Haliætos," says Pliny, "clarissimâ oculorum acie, librans ex alto sese, visoque in mari pisce, præceps in eum ruens, et discussis aquis, rapiens."—*Hist. Nat.*

BECHSTEIN) furnishes a good example, putting itself in a constant state of preparation, jerking its pie-bald head up and down as it skips from stone to stone of the brook, to pounce under water upon the first grub it espies swimming. In the same way the red-breast (*Sylvia rubecula*) pops jerking about when on the look-out for caterpillars; and so habitual does this become, that he does not fail to go through the manœuvre when he pecks up a crumb at the cottage door, as well as when he pounces upon a caterpillar in the woods, where it is often indispensable to secure the aim to prevent the insect putting in force some stratagem of escape*.

We may next turn to a small two-winged fly, which, though equally common in gardens and elsewhere with the fanning butterflies (*Vanessæ*) just alluded to, we can scarcely (considering its size) expect to have attracted the notice of those who pay little attention to insects. We allude to the vibrating fly (*Seioptera vibrans*, KIRBY), which is not above a third of the size of the house-fly, but may be known by its shining black body, scarlet head, and transparent wings, tipped with black. This tiny little creature whether it trips over a leaf, or remains stationary basking in the sunshine, is continually vibrating its wings. "This motion," says Kirby, "I have reason to think, assists its respiration;" but as he has not stated his reason, we are led, from an experiment which we tried, to doubt the conclusion. Having always seen the fly vibrating its wings in the sunshine only, as if it enjoyed the warmth and rejoiced in the feeling of existence, we wished to see how it would comport itself at night, and enclosed one under an inverted wine glass for observation. The conjecture which we had formed appeared to be correct; for though, when moving about the glass,

* J. R.

it vibrated its wings as much by candle-light as in the sunshine, probably from the habit of associating the two movements, yet, whenever it remained stationary, it kept the wings motionless. Had the motion been indispensable to respiration, and analogous to the motion of the gills of fish, or the panting in the anal scale of the water-louse (*Asellus aquaticus*, LEACH), this cessation would not have taken place at night.

We are, therefore, perhaps justified in concluding that the vibration of the wings in this little fly is an indication of being pleased; in the same way as a nestling sparrow, when fed by its dam, will half stretch its wings, and, as Thomson finely expresses it, will

"Quiver every feather with desire;"

or as a lamb when sucking will vibrate its tail, as well as the pretty birds popularly termed wagtails (*Motacillæ*), when they perambulate the margin of a stream and find a plentiful banquet of insects to their liking.

It may prove still more interesting, we think, to turn our attention to some other movements of insects which seem to be expressive of pleasure when they are not stationary, and leaving out of consideration, also, their foraging for food. A familiar instance of what we allude to occurs in the aërial dances of the tipulidan gnats and some other insects. These are performed not only in summer, but frequently even in winter and in the earlier months of spring,—in sheltered places, indeed, such as under trees and hedges, in lanes, and when a day chances to be finer than usual, though the mildest day is of course at these seasons comparatively chill. The most common of these winter dancers is called by Harris the tell-tale (*Trichocera hiemalis*, MEIGEN), a troop of which may be occasionally seen gamboling in a sunny nook, though the ground be covered with snow. When the weather is warm and mild, however, the dancing *Tipulidæ* prefer the decline of day; and we have remarked them keeping it up as long as we could distinguish them between the eye and the waning light of the western horizon: how much longer they continued to dance we cannot tell.

It is a very singular fact connected with these gnat dances, that the company always consists exclusively of males. This any person who will take the trouble may verify by enclosing a group of them in a butterfly-net. If this be not at hand, he may procure good evidence by wetting the hand, and passing it quickly amongst the thickest of the crowd; when several will be caught, and will uniformly exhibit the beautifully fringed or plumed antennæ, which in the female are without the hairs or the plumelets. What it may be, besides the same delighted and buoyant spirit which causes lambs to group together in their frolics, that induces those tiny gnats to sport in this manner on the wing, is, perhaps, inexplicable.

Wordsworth's opinion, though adopted by Kirby and Spence, is, perhaps, as we shall presently endeavour to show, more poetical than correct. His words are:—

> " Nor wanting here to entertain the thought,
> Creatures that in communities exist,
> Less, as might seem, for general guardianship,
> Or through dependence upon mutual aid,
> Than by participation of delight,
> And a strict love of fellowship combined.
> What other spirit can it be that prompts
> The gilded summer flies to mix and weave
> Their sports together in the solar beam,
> Or, in the gloom and twilight, hum their joy."
>
> *The Excursion.*

The evening gamboling of rooks on the wing, when they return from their more distant excursions during the autumn, may with more certainty be referred to this cause. White says, they rendezvous by thousands over Selborne Down, wheeling round and diving in a playful manner in the air, and when this ceremony is over, with the last gleam of light, they retire to the deep beech woods of Tisted and Kepley. It may not be improper, however, to distinguish between this and the restless tossing about and flapping of the wings, often exhibited by rooks previous to a storm, which more usually occurs in the morning, and closely resembles the tossing of sea-birds on the billows during a gale*.

The quickness of the vision of tipulidan gnats, and the rapidity as well as the dexterity of their motion, may be considered not a little remarkable, from the circumstance of their flying unwetted in a heavy shower of rain, whose drops—bigger than their own bodies—if they fell upon them, must dash them to the ground †; unless it may be that the drops glide off their wings as they do off the feathers of a duck, while the elasticity of their bodies may save them from accidents, even when they chance to be pelted.

A very pretty species of these choral flies (*Chironomus aterrimus*, Meigen), is exceedingly common in the vicinity of London, appearing about the close of winter, and readily distinguished by its shining snow-white wings, rendered more conspicuous by the contrast of its black body, while the male has his antennæ adorned with beautiful lead-grey plumelets. Though groups of these may be found sporting on the borders of woods and near water, even in January, proving that, though not half the size of the common gnat (*Culex pipiens*), they can brave the bleak winds of winter,—yet they often crowd into our apartments, like many others of the family. We have just been

* J. R. † Kirby and Spence, vol. ii. p. 374.

watching the proceedings of a pair of these elegant little creatures by candle-light, when they are more lively and alert than in the sunshine. We were reading a large quarto book with wide print and very broad margins, the white colour of which seemed not only to attract but to deceive them in the same way as a bird or a blow-fly will mistake a pane of glass for the " viewless air," and dash recklessly against it. Our little snowy-winged flies, apparently from a similar mistake, dashed themselves about on the pages of the book. We have been accustomed, from boyhood, to see gnats and other insects tumbling about in a similar manner when we have been reading at night, a circumstance which few of our readers can have failed to observe; but we always pitied them on the supposition that it was in consequence of their heedlessly singeing their wings in the candle, and thus unfitting themselves to fly. This, no doubt, is a frequent cause of their falling on a book; but it was not so with the two flies which we observed, for they remained quite perfect and uninjured. The most remarkable circumstance was, that they almost uniformly fell on the back, which seems to indicate that they fly with the back downwards, a mode of flight not a little singular, though it has an analogy to the swimming of some aquatic insects (*Notonectidæ*, LEACH). When they felt the paper, they spun round in circles and half circles with great rapidity, and evidently not so much for the purpose of getting upon their feet as of continuing the gyrations they had been performing while on the wing. This we inferred from their being in no hurry to get up, and from their continuing, even when they got upon their feet, to wheel round and round, as if waltzing with the express design of showing that they could dance on the " light fantastic toe," as well as on the wing. Their circular movement is not peculiar to them, being observable in several others of the family, particularly in a still smaller fly with black pellucid wings (*Molobrus?*), and not uncommon in summer, whose extremely rapid motion we have often admired as it performs its minute gyrations on a leaf or the petal of a flower.

It was no less remarkable, that the two snowy-winged gnats just mentioned were male and female, as the latter is seldom seen, and when the males swarm upon a window, a single female can scarcely be found; but though they were flirting about on the same page, they took not the slightest notice of one another, and each went through its gyrations as if unconscious of the other's presence. The female, besides, contrary to what is usual among insects, was by far the most alert and agile of the two; in so much that, though it was early in March, we at first mistook her for the minute summer fly alluded to in last paragraph*.

From all we have observed, we think it probable, that notwithstanding the apparent sociality of the dancing gnats (*Tipulidæ*), they do not congregate in consequence of any gregarious feelings, or for mutual assistance; but merely because they are produced in numbers in the same places, and individually prefer similar haunts. The individual sportive movements of the two snowy-winged flies just described, which were performed on the contiguous pages of a book, or severally at the top and bottom of the same page, prove that they do not consider the presence of numbers indispensable. This position is farther illustrated by the proceedings of an insect of a very different family—the whirlwig beetles (*Gyrinidæ*, Leach), which may be seen on the surface of every pool weaving their eccentric dances, and twinkling their polished corselets in the sun, both in summer and, as we have remarked, throughout the winter.

* J. R.

These are most frequently observed frolicking in parties of from two to a dozen or more; but we have very frequently seen an individual performing his gyrations with the same alacrity when alone as when mingling with his companions. We conclude, therefore, that the apparent sociality of these insects has no closer bond than that of the vultures which crowd to devour the same carcase, or of the unsocial sea-birds which congregate near a shoal of fish*.

Kirby and Spence appear to be of a different opinion:—these "little beetles," say they, "which may be seen clustering in groups under warm banks in every river and every pool, and wheeling round and round with great velocity; at your approach dispersing and diving under water, but, as soon as you retire, resuming their accustomed movements,—seem to be under the influence of the social principle, and to form their assemblies for no other purpose than to enjoy together in the sun-shine the mazy dance†."

The following account of the manners of this beetle, by Mr. Knapp, is well worth extracting; though it is much more lively and interesting than strictly correct:

"Water, quiet, still water, affords a place of action to a very amusing little fellow (*Gyrinus natator*), which, about the month of April, if the weather be tolerably mild, we see gamboling upon the surface of the sheltered pool; and every schoolboy, who has angled for minnows in the brook, is well acquainted with this merry swimmer in his shining black jacket. Retiring in the autumn, and reposing all the winter in the mud at the bottom of the pond, it awakens in the spring, rises to the surface, and commences its summer sports ‡. They associate in small

* J. R. † Intr. vol. ii. p. 4.

‡ We have seen them throughout the severe winter of 1829-30, sporting on the unfrozen springs at Lee, in Kent. J. R.

parties of ten or a dozen, near the bank, where some little projection forms a bay, or renders the water particularly tranquil; and here they will circle round each other without contention, each in his sphere, and with no apparent object, from morning until night, with great sprightliness and animation; and so lightly do they move on the fluid, as to form only some faint and transient circles on its surface. Very fond of society, we seldom see them alone, or, if parted by accident, they soon rejoin their busy companions. One pool commonly affords space for the amusement of several parties; yet they do not unite or contend, but perform their cheerful circlings in separate family associations. If we interfere with their merriment they seem greatly alarmed, disperse, or dive to the bottom, where their fears shortly subside, as we soon again see our little merry friends gamboling as before. This plain, tiny, gliding water-flea seems a very unlikely creature to arrest our young attentions; but the boy with his angle has not often much to engage his notice, and the social active parties of this nimble swimmer, presenting themselves at these periods of vacancy, become insensibly familiar to his sight, and by many of us are not observed in after-life without recalling former hours, scenes of, perhaps, less anxious days: for trifles like these, by reason of some association, are often remembered, when things of greater moment pass off and leave no trace upon the mind*."

"The gyrinus," say Kirby and Spence, "seems the merriest and most agile of all the inhabitants of the waves. Wonderful is the velocity with which they turn round and round, as it were pursuing each other in incessant circles, sometimes moving in oblique, and indeed in every other direction. Now and then they repose on the surface as if fatigued

* Journal of a Naturalist, p. 307.

with their dances, and desirous of enjoying the full effect of the sunbeam: if you approach, they are instantaneously in motion again. Attempt to entrap them with your net, and they are under the water and dispersed in a moment. When the danger ceases, they re-appear and resume their vagaries. Covered with lucid armour, when the sun shines they look like little dancing masses of silver and brilliant pearl *."

The gyrations of the whirlwig are equalled in rapidity by its diving, when its sports are intruded upon by our approach. Its great quickness of sight, indeed, is quite surprising; and is to be accounted for by one of the most striking instances of providential contrivance with which we are acquainted. Land animals see indifferently under water, and aquatic animals imperfectly in air; and an animal with an eye equally fitted for seeing in water and in air, can, on account of the great difference of the mediums, possess but imperfect vision in either. The little whirlwig, to obviate this difficulty, is furnished with two sets of eyes, one pair being placed on the upper part of the forehead for seeing in air, and another pair on the under part of the forehead, exactly under the first, and separated from them by a thin membrane, for seeing in water. As it swims half submerged, the latter pair of eyes must be very useful in warning the insect of approaching danger, from fishes or rapacious larvæ below, while the former watch with equal keenness the approach of enemies above. The hind feet are no less admirably formed for swimming, being broad, thin and elastic; while the fore feet are constructed to answer the purpose of hands for the seizing of prey. The little animal is, besides all these wonderful organs, furnished with a pair of ample wings for transporting itself, should the water of its native

* Intr. vol. ii. p. 372.

pool chance to dry up in summer, and force it to emigrate.

The sporting of butterflies in pairs, trios, or more, has been looked upon by some as pugnacious skirmishing. "A few of our lepidopterous creatures," says Mr. Knapp, "especially the common white butterflies of our gardens, are contentious animals, and drive away a rival from their haunts. We see them progressively ascending into the air, in ardent unheeding contest; and thus they are observed, captured, and consumed in a moment by some watchful bird; but we have few more jealous and pugnacious than the little elegant blue argus butterfly (*Polyommatus Alexis*, STEPHENS), noted and admired by all. When fully animated it will not suffer any of its tribe to cross its path, or approach the flower on which it sits, with impunity; even the large admirable (*Vanessa atalanta*), at these times, it will assail and drive away. There is another small butterfly, the copper (*Lycæna Phlæas*, FABR.), however, as handsome and, perhaps, still more quarrelsome, frequenting too the same station and flowers; and a constant warfare exists between them. We shall see these diminutive creatures, whenever they come near each other, dart into action, and continue buffeting one another about till one retires from the contest; when the victor returns in triumph to the station he had left. Should the enemy again advance, the combat is renewed; but should a cloud obscure the sun, or a breeze chill the air, their ardour becomes abated and contention ceases. The copper butterfly enjoys a combat even with its kindred. Two of them are seldom disturbed, when basking on a knot of asters in September, without mutual strife ensuing. Being less affected by cold and moisture than the argus, they remain with us longer, and these contentions are protracted till late in the autumn. The pugnacious disposition of the argus butterfly soon deprives it of much of its beauty; and, unless captured soon after its birth, we find the margins of its wings torn and jagged, the elegant blue plumage rubbed from the wings, and the creature become dark and shabby*."

We are of opinion, on the other hand, that these butterfly skirmishings are not prompted by testiness nor jealousy, but by the spirit of gaiety and frolic—the buoyant feelings arising from the air expanded in their wings and bodies by the warm sunshine, causing the living principle to increase even to exuberance. Were these, indeed, actual combats among the males, like those which take place among game-cocks or ruffs (*Tringa pugnax*, Linn.), nature would probably have furnished them with weapons suited to such warfare. But butterflies have neither spurs, claws, nor sharp bills, wherewith to assail an enemy; and though they might flap one another with their wings, till their tiny feathers flew about like a snow-shower, yet we never have observed them do so, as Mr. Knapp's description seems to imply. On the contrary, they appear actually to take care that such an accident should not occur while they frisk about one another, rising, falling, and performing zigzag pirouettes in the air, as we see kittens or puppies do on the ground, in their more clumsy but no less frolicksome gambols. Did these skirmishes, besides, originate in rivalry or jealousy, we should always see the butterflies combating in couples, for we never see two or three game-cocks set upon an individual; but it is by no means uncommon to see three and we have observed as many as five butterflies, all equally engaged in these supposed battles, and each bouncing and popping indiscriminately at the others without ever coming to blows. It seldom happens that they actually touch one another, however long they may be at play,—a circumstance which of itself is sufficient to prove our position.

* Journ. of a Naturalist, p. 277.

A more extraordinary display of insect dancing, and which in some instances seems better entitled to the name of a *ball*, than our own dancing parties, occurs amongst the day-flies (*Ephemeridæ*), whose short-lived existence renders it necessary for them to make the most of the few hours at their disposal. The narrative of the observations made by Réaumur upon this subject is too interesting to admit of much abridgment. It is not a little singular, he remarks, that moths, which fly only in the night, and shun the day, should be precisely those that come to seek the light in our apartments; but it is still more wonderful that the ephemeræ—which, appearing after sun-set and dying before sun-rise, are destined never to behold the dawn of day,—should have so strong an inclination for any luminous object.

It is usually about the middle of August that the ephemeræ of the Seine and Marne are expected by the fishermen, and when their season is come they talk of the *manna* beginning to appear, calling the insects by this term on account of the quantity of food for the fish, which falls as the manna is recorded to have done in the desert. On the 19th of August, Réaumur, having received notice that the flies had begun to appear, and that millions of them were coming out of the water, got into his boat about three hours before sunset; but after staying in the boat till eight o'clock without seeing any, he resolved, as a storm was foreboded, to return. He had previously detached from the banks of the river several masses of earth filled with pupæ, which he put into a large tub full of water. His servants, who were carrying the tub home, had scarcely set it upon one of the steps of the stairs leading from his garden to the Marne, when he heard them exclaim, "What a prodigious number of ephemeræ are here!" He immediately seized one of the torches and ran to the tub, where he found every piece of earth above the surface of the water swarming with the flies, some just beginning to quit their old skin, others preparing to fly, and others already on the wing, while every where under water they were seen in a greater or less degree of forwardness. The threatened storm of rain and lightning at length coming on, he was compelled to leave the interesting scene; but, to prevent the escape of the insects, he had the tub covered with a cloth. The violence of the rain ceased in about half an hour, when he returned to the garden, and as soon as the cloth was removed from the tub he perceived that the number of the flies was prodigiously augmented, and continued to increase for some time as he stood watching them. Many flew away, and many more were drowned, but the number which had already undergone their transformation from the earth in the tub would have been sufficient to fill it, exclusively of crowds of others which the light had attracted from a distance. He again spread the cloth over the tub, and the light was held above it: immediately the cloth was almost concealed by the vast multitudes which alighted upon it, and they might have been taken by handfulls from the candlestick. What he had observed, however, at the tub, was nothing to the scene now exhibited on the banks of the river, to which he was again attracted by the exclamations of his gardener.

"The countless numbers," he says, "of ephemeræ which swarmed over the water can neither be conceived nor expressed. When snow falls thickest and in the largest flakes, the air is never so completely full of them as that which we witnessed filled with ephemeræ. I had scarcely remained a few minutes in one place, when the step on which I stood was covered in every part with their bodies, from two to four inches in depth. Near the lowest step, a surface of water, of five or six feet dimensions every way, was entirely covered with a thick layer of them, and those which the stream swept away were more than replaced by the multitudes that were continually falling. I was repeatedly compelled to abandon my station, from not being able to bear the shower of insects, which, not falling perpendicularly like rain, struck me incessantly and in a manner extremely uncomfortable, pelting against every part of my face, and filling my eyes, nose, and mouth almost to suffocation. On this occasion it was no pleasant post to hold the light, for our torch-bearer had his clothes covered with the insects in a few moments, which rushed in from all quarters to overwhelm him.

" The light of the torch gave origin to a spectacle which enchanted every one who beheld it, and altogether different from a meteorological shower; even the most stupid and unobserving of my domestics were never satisfied with gazing at it. No armillary sphere was ever formed of so many circular zones in every possible direction, having the light for their common centre. Their number seemed to be infinite, crossing each other in all directions, and in every imaginable degree and inclination—all of which were more or less oblique. Each of these zones was composed of an unbroken string of ephemeræ, which followed each other close in the same line as if they had been tied together head and tail, resembling a piece of silver ribbon deeply indented on its edges, and consisting of equal triangles placed end to end—so that the angles of those that followed were supported by the base of those which preceded, the whole moving round with incredible velocity. This spectacle was caused by the wings of the insects, which alone could be distinguished. Each of these flies, after having described one or two orbits, fell to the earth, or into the water, though not in consequence of having been burned*."

It is conjectured by Kirby and Spence, that Réaumur, though he was unquestionably a most accurate observer, may have mistaken the rapid movements of single flies, and the deception of vision thence arising, for a numerous troop, following one another in zoned circular lines,—a mistake which they were once upon the point of committing when observing the dances of certain small flies which moved in spirals; closer observation, however, proved that what appeared to be a continuous line of flies, was produced by the rapid motion of an individual. Be this as it may, it will not alter the singularity of the spectacle. Some of our British ephemeræ begin their dances with the dawn, instead of waiting till sun-set,—rising and falling continually over the meadows in May, sometimes beating the air rapidly with their wings, and sometimes skimming about like hawks†. Those again which we observed in August, rising from the Rhine, did not dance at all, but flew in a heavy, unsteady, and lumbering manner above the current of the river‡.

In speaking of what appear to be the sports of insects, we cannot omit taking notice of the very singular proceedings of some species of ants, which, at the intervals of busy industry, amuse themselves with something apparently analogous to our wrestling and racing matches. Bonnet says, he observed a small species of ants, which employed themselves in carrying each other on their backs, the rider holding with his mandibles the neck of his bearer, and embracing it closely with his legs§, the position

* Réaumur, Mem. vol. vi. p. 485.
† Kirby and Spence, vol. ii. p. 373. ‡ J. R.
§ Bonnet, Œuvres, vol. ii. p. 407.

which the renowned John Gilpin may have sometimes been disposed to assume in his famous race through Edmonton. But though the very palpable mistakes committed by Bonnet respecting these very ants* may, perhaps, tend to invalidate his authority with respect to their riding, we have the undoubted testimony of both Gould and Huber for their wrestlings. "You may frequently," says Gould, "perceive one of these ants (*Formica rufa*, LATR.) run to and fro with a fellow-labourer in his forceps of the same species and colony." Mr. Gould observed, that, after being carried for some time, it was let go in a friendly manner and received no personal injury. This amusement is often repeated, particularly among the hill ants, who are very fond of this sportive exercise †.

It was amongst the same species, that Huber observed similar proceedings, which he has described with his usual minuteness and accuracy. "I approached," he says, "one day to the formicary of wood ants, exposed to the sun and sheltered from the north. The ants were heaped upon one another in great numbers, and appeared to enjoy the temperature on the surface of the nest. None of them were at work, and the immense multitude of insects presented the appearance of a liquid in the state of ebullition, upon which the eye could scarcely be fixed without difficulty; but when I examined the conduct of each ant, I saw them approach one another, moving their antennæ with astonishing rapidity, while they patted with a slight movement the cheeks of other ants. After these preliminary gestures which resembled caressing, they were observed to raise themselves upright on their hind legs by pairs, struggle together, seize each other by a mandible, foot, or antenna, and

* Huber on Ants, pref. and pp. 211 and 233.

† Gould on Ants, p. 102, &c.

then immediately relax their hold to recommence the attack. They fastened upon each other's shoulders, or bellies, embraced and overthrew each other, then raised themselves by turns, taking their revenge without producing any serious mischief. They did not spurt out their venom as in their combats, nor retain their opponents with that obstinacy which we observe in their real quarrels. They presently abandoned those which they had first seized, and endeavoured to catch others. I have seen some who were so eager in these exercises, that they pursued several workers in succession, and struggled with them a few moments, the skirmish only terminating when the least animated, having overthrown his antagonist, succeeded in escaping and hiding in one of the galleries. In one place, two ants appeared to be gamboling about a stalk of grass,—turning alternately to avoid or seize each other, which brought to my recollection the sport and pastime of young dogs when they rise on their hind-legs, attempting to bite, overthrow, and seize each other, without once closing their teeth. To witness these facts, it is necessary to approach the ant-hills with much caution, that the ants should have no idea of our presence; if they had, they would cease at the moment their plays or their occupations, would put themselves in a posture of defence, curve up their tails, and ejaculate their venom*."

* M. P. Huber on Ants, p. 203.

Chapter XVI.

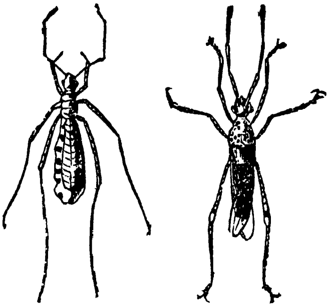
Peculiar Locomotions.

Those who have attended to the paces of the larger animals, are well aware of their almost infinite variety; but the differences between the heavy tread of the elephant or the waddling roll of an overgrown pig, the elegant pace of a blood-horse or the sprightly trip of an antelope, will bear no comparison with the infinite diversities observable among the movements of insects. We look upon the long legs of the giraffe and the crane as inelegant and disproportionate, how well suited soever they may be to their mode of life: but what should we think of a species of giraffe, with legs long enough to enable it to overtop the tallest trees, so as to browse on their tops as oxen do on the grass of a meadow, while it walked at ease through woods and forests; or of a wren or sparrow with legs as long as the hop-poles among which it prowled to prey upon aphides and lady-birds. But animals of such descriptions, wildly imaginary as they must be confessed to be, may be readily matched in the insect world. The pendulum crane fly (*Tipula motitatrix*), formerly mentioned, as well as the shepherd spider *(Phalangium opilio)*, described in the same place, are remarkable examples of this; and we have still more striking instances in the large clouded-winged crane fly (*Tipula gigantea*, Meigen), popularly termed father longlegs, or jenny-spinner, their stilted legs enabling these insects to overtop the grass as they walk in the meadows, in the same way as our imaginary giraffe would overtop the trees in a forest. We have been more struck with instances of this in some of the bug tribe, because here it was least to have been expected. In our earlier entomological researches, we frequently noticed, upon a white-washed wall, a very strange looking insect, if insect it might be called, moving about in the most awkward manner imaginable. It looked, however, more like a slip of gray tree bark, not half the breadth of a wheat-straw, that had been accidentally caught on some straggling films of spiders' web, which allowed it to oscillate irregularly in the air, than a real living creature,—for the long gossamer legs did not, to the unassisted eye, appear to move at all, and the slender awkward body progressed by interrupted jerks (if such slow motions may be so termed), resembling the movement of the minute-hand of a clock. The glass, however, showed that the body was covered by the folds of four membranous wings, prettily mottled, which lay in a hollow groove on the back, while the long slender legs were elegantly ringed with white. It was, in short, one of the numerous family of plant-bugs (*Neides elegans?* CURTIS) which had strayed from the adjacent garden to the wall. Another occurred in the same place somewhat similar, but considerably smaller, and stalked along with equally awkward jerks, upon only its four hind-legs, while it kept its two fore-legs, which were greatly shorter, folded up under its belly, in readiness, probably, to seize on the first luckless mite or aphis that came in its way*. The latter appears to be the wandering plant-bug (*Ploiaria vagabunda*, SCOPOLI).

Many insects are capable of performing a feat which no other animal could accomplish without the aid of the water-shoes lately invented—we allude to walking on the water, as distinct from swimming,

* J. R.

a b



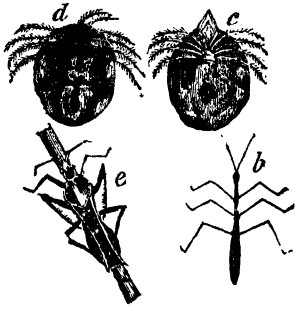
a, Ploiaria vagabunda, magnified. *b, Neides elegans*, magnified.

which most, if not all animals, save man, can do without instruction. The whirlwig beetle (*Gyrinus natator*) can scarcely be said either to walk, run, or swim,—for, as we have taken some pains to ascertain, it appears not to keep its " oary feet" plunged in the water as it flits about, but strikes smartly out, and suddenly folds them flat under its belly; on the same principle as a waterman on the Thames may be seen to give two or three quick pulls with his oars, to put *way*, as he calls it, upon his wherry, and then perking them up out of the water, lets it skim along while he rests motionless. Thus does the little whirlwig glide along the water as if by magic, for we cannot see its feet moving on account of the border of the wing cases (*elytra*) which overlap them; no more than we can discern the feet of a swan, from their dark colour, resembling that of the water, even when she skims about at a small distance from the shore*.

Most people must have been amused by observing the groups of water insects which seem to delight in

* J. R.

swimming against small streams, and apparently more for the purpose of maintaining their place than of making farther progress upwards. The most common of these are two aquatic bugs of different genera—the one (*Gerris locustris*, LATR.) with a long blackish body and legs, and white belly, though more clumsy in form than the water measurer (*Hydrometra stagnorum*) formerly mentioned; and the other (*Velia currens*, LATR.), with short body and feet, black, with a red line running along each side. We have been still more amused with a dark greenish grey spider (*Lycosa Saccata*, LATR.), which, when we approach near its haunts on the margin of a stream, does not take shelter in the grass, nor in the holes of the bank, as most of its kindred would do, but trips away over the water, where it appears to know instinctively that we cannot so easily pursue it. This is not, however, the diving water spider (*Argyroneta aquatica*), for though it can dive and remain under water, it does not seem to relish this, except when driven to the measure *.



b, *Hydrometra stagnorum*. *c d*, *Hydrachna Geographica*, LATR., front and back view, both magnified. *e*, *Velia rivulorum*, LATR.

* J. R.

Some of these water insects have such slender feet, that we can only explain their not sinking in the water on the same principle as that of a small needle floating when very dry and laid exactly level. Others again have their feet fringed with fine hairs which buoy them up; while the tipulidan gnats (*Chironomi*) and other flies, are, perhaps, aided by their wings in keeping them afloat; for we have observed several aquatic flies skimming on the surface of the water, apparently half running, half flying. Linnæus saw one of these little tipulæ, of a black colour, performing gyrations on the water similar to those of the whirlwig (*Gyrinus*): others use their wings as the swan does, by way of a sail.

Other insects walk both through the water, and at its bottom, in a similar manner to walking on land, and not by striking with their feet, as is done in swimming. It is in this manner that the minute pretty water-mite (*Hydrachna geographica*, Müller), may be seen in every ditch and pond around London, pacing along, often in company with a still more showy one (*Limnochares holosericea*, Latr.), whose bright scarlet colour renders it very easily recognised, and may readily lead a young naturalist to suppose that the scarlet satin mite (*Trombidium holosericeum*, Latr.), so frequent on dry banks in the spring, has abandoned the land for the water. The latter, however, is much larger.

The amphibious nature of those winged beetles which can walk at the bottom of water, is matched, if not out-rivalled, by the water-ouzel (*Cinclus aquaticus*, Bechstein), which we have repeatedly seen walk deliberately under water, and continue its pace for many yards, as if it had been on land*. As this

* J. R.

little bird lives on water insects and the fry of fish, its amphibious powers are indispensable.

Some of these aquatic insects, such as the whirlwig, are so highly polished, that the water will not adhere to their bodies; while others (*Hydrophili*, &c.) are covered below with a thick coating of silky hair, which repels the water and usually surrounds them with a globule of air that shines under water like quicksilver. The spider mentioned above is similarly furnished with downy hair for the same purpose.

In walking, insects exhibit endless peculiarities. The hunting spiders, and many of the midges (*Psychodæ*, Latr.), instead of walking straightforwards, most usually walk obliquely, and often at right-angles to the line of their own bodies; while most insects can, when it is necessary, walk directly backwards with almost as much facility as forwards. When the centipedes (*Scolopendridæ*, Leach) walk backwards, they only use their four hind-legs, and these, when they walk in the usual way, are not employed, but dragged after them like the locked wheel of a mail-coach in driving down a steep hill. It was first observed, we believe, by Kirby, that a millepede common under stones, the bark of trees, and the hollow stems of decaying plants, and provincially called maggy-manyfeet (*Julus terrestris*), performs its serpent-like motion by extending alternate portions of its numerous legs beyond the line of the body, while those in the intervals preserve a vertical direction. So long, then, as it keeps moving, little bunches of the legs are alternately in and out from one end to the other of its long body, the undulating line of motion successively beginning at the head and passing off at the tail*. We may add, that the form and structure of this insect are admirably adapted

* Intr. vol. ii. p. 309.

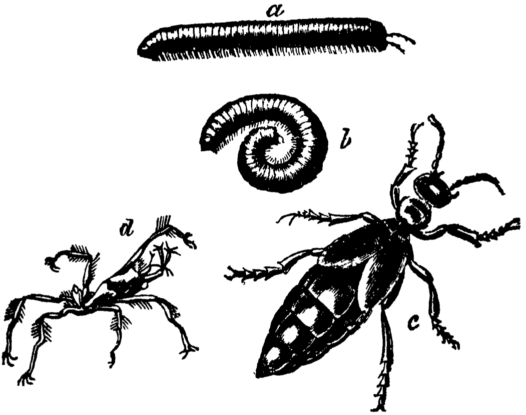
to its mode of life, it being long and of small diameter, to enable it to thread its way through narrow holes; while its covering is highly polished to facilitate its passage, and so hard as to prevent it being lacerated by any splinter of wood which it might chance to encounter, while it is at the same time so flexible, that it can coil itself up into a circle of very small diameter. The hardness and the flexibility, though apparently incompatible, are produced by a similar contrivance to that of the spine in man—the whole body of the julus being composed of small hard rings united by flexible joints*.

Instances have occurred in which a sheep or a cow has come into the world with legs upon its back: this, of course, is a monstrosity out of the usual course of nature; but in a very singular insect, the bat-louse (*Nycteribia Hermanni*, LEACH), the legs appear to have their usual place on the back. "It transports itself," says Colonel Montagu, "with such celerity, from one part of the animal it inhabits to the opposite and most distant, although obstructed by the extreme thickness of the fur, that it is not readily taken."—"When two or three were put into a small phial, their agility appeared inconceivably great; for, as their feet are incapable of fixing upon so smooth a body, their whole exertion was employed in laying hold of each other; and in this most curious struggle, they appeared actually flying in circles: and when the bottle was reclined, they would frequently pass from one end to the other with astonishing velocity, accompanied by the same gyrations: if by accident they escaped each other, they very soon became motionless; and as quickly were the whole put in motion again by the least touch of the bottle or the movement of an individual†."

Many of the beetles run with great velocity, and

* J. R. † Linn. Trans. vol. xi. p. 13.

dart off into holes and corners so suddenly, as often to escape the quickest movements of an insect hunter. It is remarkable, however, that those swift-footed insects seldom run far without making a full pause to reconnoitre their position, as a deer may be seen to arch his neck from behind a tree to examine a stranger, and, after tripping off to some distance, turn round again to take another peep at the intruder. The same habit is observable among spiders, particularly the hunters, and those which run about meadows and the margins of water (*Lycosa saccata*, &c.) Some of the mites are still more rapid in their movements, and we have often admired a very common one (*Gammasus Baccarum*, Fabr.) which frequents strawberry-beds in gardens, and, as Kirby and Spence justly say, appears rather to glide or fly than to use its legs*. Its minuteness adds to the



a, *Julus terrestris*. *b*, the same coiled up. *c*, oil beetle (*Proscarabæus vulgaris*). *d*, *Nycteribia Hermanni*.

* Intr. vol. ii. p. 311.

surprise produced by its movements, for it is little larger than a grain of sand, of a pale reddish colour, with two black dots on the back;—and though the clods of garden-mould are mountains in comparison to its size, it gallops over them at a thousand times greater proportional speed than the swiftest race-horse*.

As a contrast to the quick moving insects just mentioned, we may turn for a moment to those which move very slowly. The hunting spiders, though they can dart with the rapidity of lightning upon their prey, yet take care to approach a victim with such extraordinary caution, that the shadow upon a sun-dial advances not more imperceptibly†. Some of the beetles again move very slowly, particularly the one popularly called the oil-beetle (*Proscarabæus vulgaris*, STEPHENS), on account of the oily-looking fluid which oozes out from it when seized or alarmed. The unwieldy bulk of this animal makes it almost painful to look at the efforts it apparently has to make as it lumbers along. It always reminds us of those bees which, during autumn, may often be seen crawling lifelessly upon flowers, as if so over-gorged with the honey which they had extracted, that they are unfit to fly. How the oil-beetle becomes so fat, it is not easy to say, when we consider that it feeds upon plants, and is seen very early in spring. After the severe winter of 1829-30, we found several, in the beginning of March, feeding on the bulbous-rooted buttercup (*Ranunculus bulbosus*), at Charlton, in Kent, and as plump as if there had not been a day's frost during the winter.

Another very common insect, popularly called the bloody-nosed beetle (*Timarcha tenebricosa*, MEGERLE), from its ejecting a red fluid from its mouth when caught, is one of the very slow walkers; but

* J. R. † Insect Architecture, p. 355.

it is furnished with feet most admirably contrived for taking hold of the catchweed (*Galium Aparine*), and other trailing plants, on which it feeds. This contrivance consists of cushions, formed of a slightly concave mass of thick soft hair, which both adheres by its points, and also produces somewhat of a vacuum, which enables it to walk as easily with its head perpendicularly downwards as upwards.

The most perfect contrivance of this kind, however, occurs in the domestic fly (*Musca domestica*), and its congeners, as well as in several other insects. Few can have failed to remark, that flies walk with the utmost ease along the ceiling of a room, and no less so upon a perpendicular looking-glass ; and though this were turned downwards, the flies would not fall off, but could maintain their position undisturbed with their backs hanging downwards. The conjectures devised by naturalists, to account for this singular circumstance, previous to the ascertaining of the actual facts, are not a little amusing. "Some suppose," says the Abbé de la Pluche, "that when the fly marches over any polished body, on which neither her claws nor her points can fasten, she sometimes compresses her sponge and causes it to evacuate a fluid, which fixes her in such a manner as prevents her falling without diminishing the facility of her progress; but it is much more probable, that the sponges correspond with the fleshy balls which accompany the claws of dogs and cats *, and that they enable the fly to proceed with a softer pace, and contribute to the preservation of its claws, whose pointed extremities would soon be impaired without this prevention †."—"Its ability to walk on glass," says S. Shaw, "proceeds partly from some little ruggedness thereon, but chiefly from a tarnish, or dirty

* See Menageries, Lib. of Entertain. Knowl. vol. i. p. 173.

† Spect. de la Nat. vol. i. p. 116.

smoky substance, adhering to the surface; so that, though the sharp points on the sponges cannot penetrate the surface of the glass, it may easily catch hold of the tarnish*." This is evidently borrowed from Hook†. But it is singular that none of these fanciers ever took the trouble to ascertain the existence of either a gluten squeezed out by the fly, or of the smoky tarnish on glass. Even the shrewd Réaumur could not give a satisfactory explanation of the circumstance.

The earliest correct notion on this curious subject was entertained by Derham, who, upon mentioning the provision made for insects that hang on smooth surfaces, says, "I might here name divers flies and other insects, who, besides their sharp-hooked nails, have also skinny palms to their feet to enable them to stick to glass and other smooth bodies, by means of the pressure of the atmosphere—after the manner as I have seen boys carry heavy stones with only a wet piece of leather clapped on the top of the stone‡." The justly celebrated Mr. White, of Selborne, apparently without the aid of microscopical investigation, adopted Derham's opinion, adding the interesting illustration, that in the decline of the year, when the flies crowd to windows and become sluggish and torpid, they are scarcely able to lift their legs, which seem glued to the glass, where many actually stick till they die; whereas they are, during warm weather, so brisk and alert that they easily overcome the pressure of the atmosphere §.

This singular mechanism, however, is not peculiar to flies, for some animals, a hundred times as large, can walk upon glass by the same means. St. Pierre

* Nature Displ. vol. iii. p. 98. Lond. 1823.

† Micrographia, p. 170.

‡ Physico-Theology, vol. ii. p. 194, note (*b*), 11th ed.

§ Nat. Hist. of Selborne, vol. ii. p. 274.

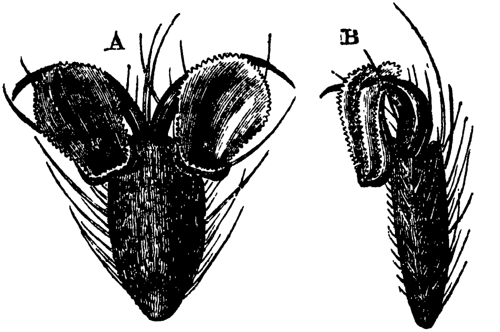
mentions " a very small handsome lizard, about a finger's length, which climbs along the walls, and even along glass, in pursuit of flies and other insects*;" and Sir Joseph Banks noticed another lizard, named the gecko (*Lacerta Gecko*, LINN.) which could walk against gravity, and which made him desirous of having the subject thoroughly investigated. On mentioning it to Sir Everard Home, he and Mr. Bauer commenced a series of researches, by which they proved incontrovertibly, that in climbing upon glass, and walking along the ceilings with the back downwards, a vacuum is produced by a particular apparatus in the feet, sufficient to cause atmospheric pressure upon their exterior surface.

The apparatus in the feet of the fly consists of two or three membranous suckers connected with the last joint of the foot by a narrow neck, of a funnel shape, immediately under the base of each claw, and moveable in all directions. These suckers are convex above and hollow below the edges, being margined with minute serratures, and the hollow portion covered with down. In order to produce the vacuum and the pressure, these membranes are separated and expanded, and when the fly is about to lift its foot, it brings them together, and folds them up as it were between the two claws. By means of a common microscope, these interesting movements may be observed when a fly is confined in a wine-glass†.

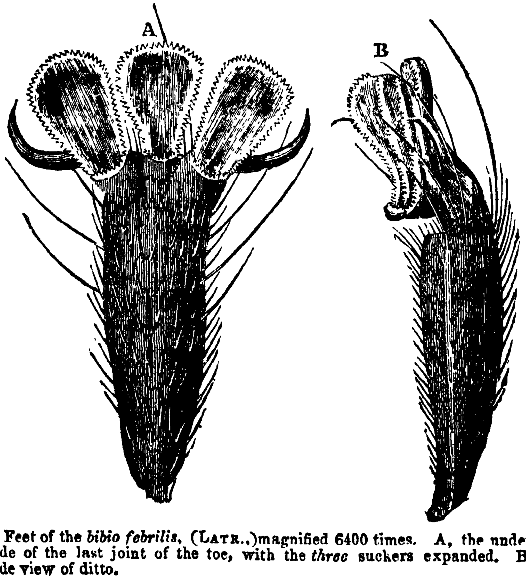
It is a very remarkable analogy, that many flying insects, as well as many birds, instead of walking, leap or hop along somewhat in the manner of a kangaroo or a jerboa. But the most common and best known instance of a leaping insect, is the flea (*Pulex irritans*), whose wings are, according to Kirby, obsolescent. The structure of this annoying

* Voyage to the Isle of France, p. 73.

† Philosoph. Trans. for 1816, p. 325.

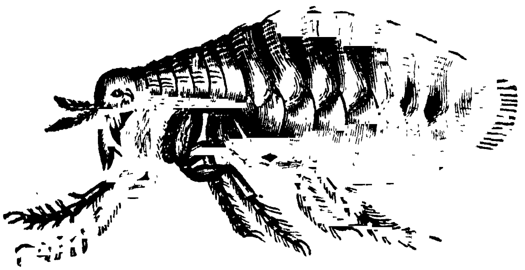


Feet of the blue-bottle fly, magnified 6400 times. A, a view of the under side of the last joint of the toe, with the two suckers expanded, as seen when the fly is walking against gravity. B, side of ditto.



Feet of the *bibio febrilis*, (Latr.,) magnified 6400 times. A, the under side of the last joint of the toe, with the *three* suckers expanded. B, side view of ditto.

creature is well fitted for its mode of life—it being furnished with so tough a skin that it is no easy matter to crush it, while it is so smooth that it would almost glide through a pin-hole. The extraordinary muscular power of the thighs, again, combined with their elasticity, enable it to perform most astonishing leaps, as we have remarked in a preceding page; while its comparative lightness and the toughness of its skin prevent it from receiving any injury, from whatever height it may fall. It is very doubtful, indeed, as it appears to us, whether it observes the good old proverb of looking before it leaps, for we have seen fleas leap from the bottom of a deep pill-box, where they could not possibly perceive whither they were leaping*. It may not be out of place here to mention, that fleas (*Pulicidæ*) undergo similar transformations to other insects, laying their eggs at the roots of the hair of animals, the feathers of birds, or in woollen stuffs. These, in a few days, produce a minute whitish grub, which, in warm weather changes to a perfect flea in about six weeks: as may be verified by whoever will take the trouble of enclosing some female fleas, which are always the largest, in glass tubes, and feeding them with flies or raw beef, as was done by Rösel, De Geer, and many



Flea magnified, to show the muscular structure of the legs.

* J. R.

others. Mr. Stephens enumerates no less than twelve species, from which it appears that those found on the dog, the pigeon, and other animals, are quite different from the common flea, and it is probable these will not readily pass from their natural habit to infest us, as is commonly believed.

The extraordinary power of leaping in grasshoppers and their congeners is matter of common observation. The motion is effected by means of very strong muscles with which the hind thighs are furnished; and it is a similar structure which enables the frog-hoppers (*Cercopidæ*, LEACH), so common on plants during summer, to perform leaps of extraordinary extent, in which, however, they have likewise the assistance of their wings. Some species make use of their faculty of leaping to escape from their enemies, as well as for the purpose of changing place, while others use it to spring upon their prey. Among the former we may mention a family of small insects (*Poduridæ*, LEACH), some of them inhabiting water or damp places, though most of the species are found under decaying bark or vegetable refuse. The one that is most likely to attract attention is a very small gregarious one, the water spring-tail (*Podura aquatica*), which may often be seen, during the summer, crowded upon the rain-water collected in the footsteps of cattle, the ruts of cart-wheels, or by the edges of small ponds, and looking precisely as if one had strewed about a handful of coal-ashes or gunpowder; but, though at first glance they seem inanimated, closer inspection will show that they are in active motion, and particularly if they be alarmed —leaping about and upon one another, and on the water, like so many minute fire-works. Those which are solitary are much larger, among which we may mention the velvet spring-tail (*Podura holosericea*), of which we here give a magnified figure, to shew the spring in the tail, by means of which it leaps, jerking it downwards and outwards from its body as the flea does its legs.

Leaping position of the velvet spring-tail, magnified.

Amongst the insects which spring upon their prey like the cat and the lion, the most commonly observed is the little hunting spider (*Salticus scenicus*), whose zebra stripes of white and brown render it easily discovered on our window-frames and palings *. But all the spiders—even those which form webs—are accustomed to spring in a similar way upon what they have caught; and when we are told of the gigantic American one (*Mygale avicularia*), which even makes prey of small birds (*Trochilidæ*), the necessity of extraordinary agility must be obvious; for these tiny birds are described to move with almost the velocity of light,—the eye, notwithstanding the brilliancy of their metallic colours, being frequently baffled in tracking their flight. The spider itself, however, being three inches in length, one and a half in breadth, and eleven inches in the expansion of its legs, is little less than the bird upon which it pounces, as may be seen from the following figure, taken from the splendid work of Madame Merian upon the insects of Surinam.

All animals which fly are furnished with powerful muscles for moving their wings, in the same way as the limbs of those which leap are similarly provided;

* See Insect Architecture, p. 355.

Mygale avicularia, rom Madame Merian.

and we may, therefore, remark, in passing, that any invention for enabling men to fly must take the comparative weakness of our muscles into primary consideration. Let any one try merely to stretch out his arm as a hawk, or a swift fly (*Volucella*), does its wings, when hovering apparently motionless in the air,—and the quick recurrence of weariness, speedily increasing to pain, will afford unequivocal proof of the apparently exhaustless vigour of their volitant muscles, compared with ours. It would be no very difficult matter to give voluminous illustrations on this curious subject. A French naturalist, M. Chabrier, has actually written an elaborate quarto volume, on the flight of insects*. Though Chabrier has unquestionable talents of the first order for research, it is unfortunate that he permits his fancy to travel somewhat beyond the boundaries of fact; and to this, no doubt, we are to ascribe his retracting his

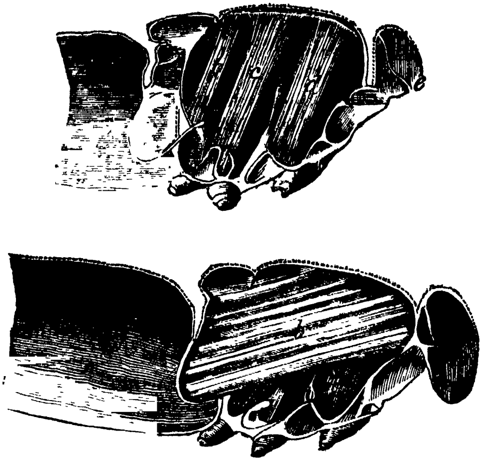
* Essai sur le Vol des Insectes, 4to. Paris, 1801.

former opinions on the flight of insects; yet it might have been supposed, that in writing so voluminously on the subject, he had left no point uninvestigated. Nothing, however, can be more praiseworthy than the candour (not very common in such cases) with which Chabrier corrects his own mistake.

In the two-winged flies (*Diptera*) Chabrier describes two sets of muscular ribbons for putting the wings in play—the *dorsal*, placed lengthwise, and used to lower the wings, and the *sterno-dorsal*, placed obliquely across these for raising the wings. In the dragon-flies (*Libellulina*), again, the disposition is somewhat different, the *sterno-dorsal* muscles being placed intermediate, while another set of powerful muscles, called *pectoral*, are placed lengthwise, and are inserted immediately into the wings. In his first work, our author thought these muscles acted separately, but he now says they act in concert; and he is not now inclined to ascribe, as he at first did, so much influence to the air in the interior of the body, nor to the spring of the harder parts of the back and breast. "Certainly," he adds, "the elasticity of these parts, and the re-action of the interior air have their use: the fluid, particularly, contained in their numerous vesicles, is, perhaps, very light, and contributes to reduce the specific gravity of the insect. Besides, by enveloping the interior organs, it appears to me intended to protect these against the violent motions of flight, and to contribute to the expansion of the chest, dilating immediately after being compressed by the contraction of the muscles in the act of raising the wings*."

It will appear, from this brief abstract, that the subject is not a little interesting; yet it is not so easy to throw it into a form likely to be understood by a general reader. Flying with wings, however, is a

* M. Chabrier in Ann. des Soc. Nat., Avril 1829, p. 505.

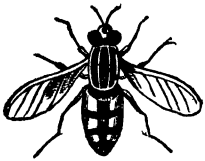


Magnified views of the muscular ribbons for moving the wings in *Syrphus inanis*. *a*, part of the belly. *b*, the *costo* dorsal muscles. *c*, *d*, the *sterno* dorsal. *e*, part of the head.

less difficult subject of investigation than flying without wings, as is practised by the gossamer spider (*Aranea obtextrix*, BECHSTEIN), and its congeners. We do not allude merely to the threads carried out from a spider by a current of air, till it is fixed and forms a bridge, along which the creature can pass, nor to the similar lines which are left to float freely, in the case of the gossamer, without attachment*. We refer to the power which the spider apparently possesses of directing its flight. Let any one endeavour to catch one of the spiders which may frequently be seen dropping from the ceiling of a room, the branch of a tree, or other elevated object, and he will find it no easy task to lay hold of the little web spin-

* See Insect Architecture, pp. 339-54.

ner, for it will not only drop perpendicularly by spinning a longer thread (it seldom tries to escape by remounting), but it will swing itself away from the approaching hand, in a manner which it seems not a little difficult to comprehend, for it does not move a limb to produce an impulse in the air, as the diving spider (*Argyroneta aquatica*) does when it moves through the water. In instances when no escape is intended, when spiders, even of considerable size, drop from a height, we have often seen them swing out of the perpendicular without any apparent aid from the wind. It is highly probable that this movement is effected by some internal apparatus analogous to the swim-bladder of fishes; but at present we are not aware that anything beyond conjecture has been published upon the subject. We may state, however, that they cannot in this manner move far.



Syrphus.

Chapter XVII.

Rest of Insects.

Mr. Brightwell is reported to have once observed an individual living specimen of *Haltica concinna*, which appeared to remain motionless on the same spot of a wall for three successive days*; but though this is given as something unusual, we have made similar observations in the case of numerous insects of all orders and families. The continual stationary appearance, however, is, in most of such cases, quite fallacious. To use a familiar illustration, we might as well think the snail stationary which we see every day, perhaps for weeks together, coiled up in the same niche of the garden-wall, as if it were glued to the spot, and had never moved from it a hair's-breadth,—were it not that the depredations committed upon a contiguous lettuce, prove that it does not always sleep, though its excursions from its chosen niche, as they take place only at night, are seldom, if ever, observed. Like a very large portion of the whole insect world, snails always sleep throughout the day, unless roused by an accidental shower of rain, which tempts them to banquet on the refreshed herbage. Upon butterflies, and some other day insects, again, the occurrence of rain or cloudy weather usually operates like a continuance or a renewal of night; and this seems to happen even in-doors, where the air is warm and comparatively dry. We had a female of the brimstone butterfly (*Gonepteryx Rhamni*) in our study, which we were desirous of

* Kirby and Spence, Intr. vol. iv. p. 193.

having deposit her eggs on a plant of the buckthorn (*Rhamnus frangula*), which we had placed in a garden-pot for this purpose; and we remarked that she manifested no inclination to move from the same leaf, except for an hour or two in the forenoon, and when it was damp or cloudy, not even then. If disturbed in her repose, she would fall down as if lifeless, and continue her sleep—(if sleep it was), without being awakened by the fall, till her regular period of animation returned.

We have used the qualifying phrase—"if sleep it was;" because the rest of insects, though corresponding, in the circumstance of remaining without motion, with the sleep of the larger animals, may not agree in any other respect,—and particularly in the quiescence of the senses. In the important point of the state of the brain, it does not appear how there could be any agreement in the phenomenon; as may be inferred from comparing the structure of insects, as respects their nerves and blood-vessels, with that of man.

Insects, though possessed of nerves, have nothing similar to our brain and spinal cord, the two sources of our nerves of feeling and of motion, as so beautifully explained by the recent discoveries of Mr. Charles Bell. Instead of this, they have a chain of what are called ganglia, or bundles of nervous substance, and from each of these bundles nerves branch out to the parts contiguous,—each ganglion forming the centre of feeling to the parts to which its nerves run; and hence it is that insects will live, and (so far as we can perceive) feel comparatively little general pain and inconvenience from the loss of their limbs or even of their heads. Thus the tail of a wasp or a bee will sting long after it is severed from the body, and the head of a dragon-fly will eat as voraciously after it is cut off, as if it had to supply an insatiable stomach,—phenomena easily accounted for from the want of a brain, and from each ganglion having its own set of nerves. This may be better understood by looking at the central chain of ganglia in the larva of the day-fly before figured *.

Insects again differ from man in having no heart nor circulating blood, at least so far as has hitherto been discovered †. Dr. Carus, of Dresden, is, indeed, at present endeavouring to establish a claim to the discovery of the circulation of the blood in insects; but this circulation, which is most probably only partial, has, we think, been observed by naturalists of a former age. "De Geer," say Kirby and Spence, "whose love of truth and accuracy no one will call in question, saw the appearance of blood-vessels in the leg of the larva of a caddis fly (*Phryganea*, Linn.), as Lyonnet did in those of a flea ‡, and in the transparent thigh of the bird fly (*Ornithomyia avicularia*) he discovered a pulse like that of an artery §. Baker, whose only object was to record what he saw, speaks of the current of the blood being remarkably visible in the legs of some small bugs ||; what he meant by that term is uncertain, but they could not be spiders, which he had just distinguished. This author has likewise seen a green fluid passing through the vessels of the wings of grasshoppers ¶; and M. Chabrier is of opinion that insects possess the power of propelling a fluid into the nervures of their wings, and withdrawing it at pleasure, as they are elevated or depressed **: but

* See page 139.

† See Cuvier, Anat. Comp. vol. iv. p. 478, &c. And Marcel de Serres, Mem. du Mus. pour 1819.

‡ Lesser, vol. ii. p. 84, note.

§ De Geer, vol. ii. p. 505; vol. vi. p. 287.

|| On the Microscope, vol. i. p. 130.

¶ Ibid.

** Sur le Vol des Insectes.

these two last facts must be accounted for on other principles, as *there is clearly no circulation* *."

The statement recently published by one of these authors (Mr. Spence), respecting the alleged discovery of insect circulation by Dr. Carus, is founded on facts which were shown and explained to him by the doctor himself. "The first insect," says Mr. Spence, "to which Dr. Carus directed my attention, was the larva of *ephemera vulgata* (or an allied species), in which, near to the bronchiæ and parallel with each side of the body, was very distinctly visible a constant current, towards the tail, of oblong globules swimming in a transparent fluid, propelled with a regular pulsating motion; and on cutting the body of the larva across near the tail, three globules were most plainly seen pushed out of the divided vessels in a distinct mass, which increased at each pulsation. I cannot express the pleasure which it gave me, to see thus clearly this ocular demonstration of one of the most important physiological discoveries of modern times; and my gratification was heightened by the next object which Dr. Carus placed before his microscope, viz.—a specimen of *semblis viridis* (the green lace-winged fly), in which precisely the same phenomena, but, if possible, more clearly, were seen in the nervures of the wings and in the antennæ, in both which the constant current of globules was most apparent; and in the former, the sudden turning of these globules, at the apex of the wing, out of the exterior nervure into a central one, with which it joins and forms an acute angle, was equally curious and striking. On cutting off the end of the antennæ, precisely the same emission of globules (which soon assume a greenish tint) took place as in the former case, forming a mass, which was increased with a sudden gush at each pulsation.

* Introd. vol. iv. p. 86.

Dr. Carus has observed the same phenomena in the wings of *Semblis bilineata*, and in the *elytra* (wing cases) of *Lampyris noctiluca* (the glow-worm), and *L. Italica*, as well as in the fin-like appendages at the tail of the larva of *Agrion puella* (the damsel dragon fly), in which he first made the discovery, and in which the circulation is remarkably distinct *."

We apprehend, as far as we can collect from this description, that the alleged discovery of Dr. Carus does not advance a step in demonstrating a circulation in insects similar to that of other classes of animals; for it is to be recollected, that the dorsal vessel, the only organ in insects analogous to a heart, although it pulsates irregularly, has no apparent arteries or veins connected with it: and therefore the impulsions described by De Geer, the current mentioned by Baker, and the phenomena exhibited by Carus, furnish no proof whatever of a general circulatory system, though they appear to indicate local movements in the fluids of insects, agreeably to the original views of Chabrier, or those of Swammerdam formerly quoted †.

It may appear to some, that the preceding has but a very remote connexion with the subject immediately before us; but we shall presently show its connexion with the phenomena of insect sleep. We agree with Professor Blumenbach, that sleep in man most probably consists in a diminished or impeded flow of arterial blood into the brain. For example, if, by cold feet, a fit of passion, or a heavy supper, a gush of blood is forced into the brain and stagnates there, the consequence will be the snoring death-like sleep of apoplexy; and the same will happen, if a blow on the head, or a fever, throws a quantity of blood upon the brain. Blumenbach

* Spence in Mag. of Nat. Hist., Jan. 1830, p. 49.

† See page 343.

had ocular demonstration of the fact contended for, with respect to the diminished flow of blood, in a man whose brain was exposed by the accidental removal of a part of the skull; for, whenever this man fell asleep, the brain was seen to shrink and subside, but the moment he awoke a tide of blood was seen rushing through the vessels and swelling the brain. The same is also proved by the fact, that in madness and inflammation of the brain, when the blood flows rapidly, the unhappy sufferer is altogether deprived of sleep, unless the current of the blood is retarded by strong doses of opium, or by taking away a large quantity by the lancet. It will follow, that when the blood-vessels of the brain are gorged, as well as when they are not sufficiently full,—sleep will be equally produced. Force more blood into the brain than can find room to flow, and drowsiness, sleep, perhaps apoplexy, will follow;—diminish the quantity, so that it may lack force to keep up the current, and sleep will also come on. On these principles it it is that thinking, by bestirring the brain and driving thither a brisker current of blood, prevents sleep; while, bathing the feet in warm water, eating a moderate supper, or rubbing the body with a flesh-brush, by drawing a superabundance of blood to the feet, to the stomach, or to the skin, will cause sleep. Again, it is a general law of animated nature, for rest to succeed fatigue, as temporary insensibility succeeds vivid sensations. The pain of a burn, for example, comes and goes alternately; and by holding out the arm from the body, the feeling of fatigue and pain soon become so insupportable, that rest cannot be dispensed with. Sleep, then, seems to be a general consequence of this rest after fatigue.

With regard to insects, it is evident that many of the above facts will not at all apply; for as insects have neither a heart nor a brain, their sleep cannot be proximately caused by a retarded current of blood. We want data also for determining whether similar effects are produced upon the senses of insects during their quiescence, or apparent sleep, as take place in ourselves. The shutting of the eye-lids, next to motionless rest, is one of the most obvious characteristics of sleep in man; but in insects nothing like this can be observed, because they have nothing analogous to eye-lids. The senses of insects, indeed, may not sleep at all—and what renders this the more probable is, that in the case of gnats, crane-flies (*Tipulidæ*), moths, butterflies, &c., however long they may have been observed to be quiescent, or sleeping, in the same place, they are instantly on the alert at the approach of danger, though no noise be made to alarm them*. It may serve to illustrate this state of wakefulness in the senses of quiescent insects, that the senses in man do not all sleep in the same degree of profundity. This very curious fact was first, we believe, observed by M. Cabanis, who also found that some of our senses and members go to sleep sooner than others—in proportion, it may be presumed to their fatigue from their waking exertions, and to the flow of blood through them. According to Cabanis, then, the muscles of the legs and arms are the first to become drowsy, and next those that sustain the head, which, losing its support, falls forward; the muscles of the back follow, and it becomes bent. Among the senses, the eye is the first that goes to sleep; and after it the smell, taste, hearing, and touch, become drowsy in succession. The sense of touch never sleeps so profoundly as the others,—a fact inferred from our frequent change of position during sleep, which must be the consequence of uneasy sensations of touch. Besides this, it is well known that a slight tickling of the soles of the feet

* J. R.

will waken a person whom no noise could rouse. In the order of their awaking again, taste and smell are always last, and sight appears more difficult to awaken than hearing; for a slight noise will often rouse a sleep-walker, who had borne an intense light on his unshut eyes, without seeming in the least to feel its influence *.

The torpidity of insects during winter, which in some of its circumstances is analogous to sleep, will require the less to be discussed here, that we have, under our three former divisions of Eggs, Pupæ, and Larvæ, considered it very amply. The number of insects, indeed, which hybernate in the perfect state are comparatively few. Of the brimstone butterfly (*Gonepteryx Rhamni*), Mr. Stephens tells us the second brood appears in autumn, " and of the latter," he adds, " many individuals of both sexes remain throughout the winter, and make their appearance on the first sunny day in spring. I have seen them sometimes so early as the middle of February †." The commonly perfect state of the wings in such cases might, we think, lead to the contrary conclusion, that the butterfly has just been evolved from its chrysalis. Several other species, however, chiefly of the genus *Vanessa*, do live through the winter in the perfect state; but this, as far as general observation extends, can only be affirmed of the female. Yet will insects bear almost incredible degrees of cold with impunity. Out of the multiplicity of instances of this on record we shall select two. In Newfoundland, Captain Buchan saw a lake, which in the evening was entirely still and frozen over, but as soon as the sun had dissolved the ice in the morning, it was all in a bustle of animation, in consequence, as was discovered, of myriads

* Cabanis, Rapports du Physique et Moral.

† Illustrations, vol. i. p. 9.

of flies let loose, while many still remained "infixed and frozen round." A still stronger instance is mentioned by Ellis, in which a large black mass, like coal or peat upon the hearth, dissolved, when thrown upon the fire, into a cloud of mosquitoes (*Culicidæ*) *.

It has been remarked by most writers upon the torpidity of warm-blooded animals, that cold does not seem to be its only cause, and the same apparently holds in the case of insects. Bees, indeed, which remain semi-torpid during the winter, may be prematurely animated into activity by the occurrence of some days of extraordinary mildness in spring; but, what is not a little wonderful and inexplicable, they are not roused by much milder weather when it occurs before Christmas,—on the same principle, perhaps, that a man is more easily awakened after he has slept six or seven hours than in the earlier part of the night. Immediately after the first severe frost in the winter of 1829-30, we dug down into the lower chambers of a nest of the wood-ant (*Formica rufa*), at Forest Hill, Kent, which we had thatched thickly with fern-leaves the preceding November, both to mark the spot and to protect the ants in winter. About two feet deep we found the little colonists all huddled up in contiguous separate chambers, quite motionless till they were exposed to the warm sunshine, when they began to drag themselves sluggishly and reluctantly along. Even upon bringing some of them into a warm room, they did not awaken into summer activity, but remained lethargic, unwilling to move, and refusing to eat, and continued in the same state of semi-torpidity till their brethren in the woods began to bestir themselves to repair the damages caused by the winter storms in the outworks of their encampments †.

* Quarterly Review, April 1821, p. 200.

† J. R.

The younger Huber has given an interesting account of the hybernation of ants, which differs in some particulars from what we have observed of the wood-ant; but he speaks of ants in general. The subject, indeed, derives importance from the popular opinion, that they amass wheat and other grain as a winter store, having been refuted by the experiments of Gould and other accurate observers. "We have endeavoured," says M. Huber, "to explain their preservation, by supposing them to fall into a state of torpor at this period. They, in fact, became torpid during the intense cold, but when the season is not very severe, the depth of their nest guards them from the effects of the frost: they do not become torpid unless the temperature is reduced to the second degree of Réaumur under the freezing point, (27° Fahrenheit). I have occasionally seen them walking upon the snow, engaged in their customary avocations. In so reduced a temperature, they would be exposed to the horrors of famine, were they not supplied with food by the pucerons, who, by an admirable concurrence of circumstances, which we cannot attribute to chance, become torpid at precisely the same degree of cold as the ants, and recover from this state also at the same time: the ants, therefore, always find them when they need them.

"Those ants that do not possess the knowledge of the mode of assembling these insects, are, at least, acquainted with their retreat; they follow them to the feet of the trees and the branches of the shrubs they before frequented, and pass at the first degree of frost along the hedges, following the paths which conduct to these insects. They bring back to the republic a small quantity of honey; a very little sufficing for their support in winter. As soon as the ants recover from their torpid state, they venture forth to procure their food. The aliment contained in their stomach is, on their return, equally distributed to their companions. These juices scarcely evaporate, during this season, owing to the thickness of the honey rings investing the body. I have known ants preserve, during a considerable time, their internal stock of provisions, when they could not impart it to their companions. When the cold increases in a gradual manner, (and this is commonly what the ants experience, who are screened from it by a thick wall of earth,) they collect and lie upon each other by thousands, and appear all hooked together. Is this done in order to provide themselves a little heat? I presume this to be the case, but our thermometers are not sufficiently delicate to indicate if this be really the fact*."

During the frosts of 1829-30, we opened two nests of the yellow ant (*Formica flava*), in which we found the inhabitants by no means torpid or inactive, although not so lively as in summer; but these nests were in a peculiarly warm situation, being both in the old trunks of willows, rendered quite spongy by the dry-rot, and facing the south-west, where they had the benefit of every glimpse of sunshine. We searched with great minuteness for the eggs of the aphides mentioned by Huber, but without success, and we cannot account for their means of subsistence, unless they fed on the various insects and crustaceous animals which abounded in the trees, (*Onisci*, *Julidæ*, &c.) They were also, in both instances, within a yard of a stream of water, to the vicinity of which we have observed that this species is partial, and it is not improbable that it may form an indispensable part of their subsistence. No species of ants, indeed, can live without drinking. In February of the same year, immediately after the

* Huber on Ants, p. 239. See also this volume, pages 113-116.

breaking up of the first frost, we also observed numbers of the small black ant (*Formica fusca*) running about the sunny sides of hedge-banks; and though we did not trace them to their winter quarters, we think it not improbable, from their very early appearance, that they had never been completely torpid *.

The bee is popularly believed to hybernate, the seven winter sleepers being said to be, "the bat, the bee, the butterfly, the cuckoo, and the three swallows;" but, like many of the popular notions on natural history, this is almost wholly erroneous, for at least, out of these seven, the four birds certainly do not become torpid. With respect to the bee, again, we find some of the most distinguished observers at variance. Réaumur is an advocate for the popular opinion. "It has been established," he says, "with a wisdom, which we cannot but admire,—with which everything in nature has been made and ordained,—that during the greater part of the time in which the country furnishes nothing to bees, they have no longer need to eat. The cold which arrests the vegetation of plants—which deprives our fields and meadows of their flowers—throws the bees into a state in which nourishment ceases to be necessary to them: it keeps them in a sort of torpidity, in which no transpiration from them takes place, or at least during which the quantity of what transpires is so inconsiderable, that it cannot be restored by aliment without their lives being endangered. In winter, while it freezes, we may observe without fear the interior of hives that are not of glass; for we may lay them on their sides, and even turn them bottom upwards, without putting any bee into motion. We see the bees crowded and closely pressed one against the other; little space then suffices for them †."—Again, when mentioning the custom of putting bee-

* J. R. † Mem. v. p. 667.

hives during the winter into out-houses and cellars, he says, "that in such situations, the air, though more temperate than out of doors, during the greater part of the winter, is yet sufficiently cold to keep the bees in that species of torpidity which does away with the necessity of their eating *." He also says, positively, that the milder the weather, the more risk there is of the bees consuming their honey before the spring, and dying of hunger; confirming his position by an account of a striking experiment, in which a hive that he transferred during winter into his study, where the temperature was usually, in the day, 10° or 12° of Réaumur's thermometer above freezing, or 59° Fahrenheit, though the bees were provided with a plentiful supply of honey, that if they had been in a garden would have served past the end of April, had consumed nearly their whole stock before the end of February †.

But the elder Huber records some observations directly opposed to these, affirming unequivocally, that, so far from being torpid in winter, the heat in a well peopled hive is as high as 25° Réaumur, or 86° Fahrenheit, even when the thermometer in the open air is several degrees below zero, the heat thus observed being generated in the hive by their clustering together, and keeping themselves in motion; and even in the middle of winter they may be heard buzzing as they always do when ventilating the hive,—a process which appears to have been originally discovered by Huber, and of which, on account of its connexion with the disputed question before us, we shall give his own description:

"During fine weather," (in summer), says he, "a certain number of bees always appear before the entrance of the hive occupied in vibrating their wings, but still more are found to be engaged in ventilating

* Mem. vol. v. p. 682. † Ib. vol. v. p. 668.

the interior. The ordinary place of ventilation is on the board; those outside of the entrance have their heads towards it; those within have them in the opposite direction.

"We may affirm that they arrange themselves regularly to ventilate more at ease, thus forming files, which terminate at the entrance, and sometimes disposed like so many diverging rays. This order is not uniform, but is probably owing to the necessity for the ventilating bees giving way to those going and coming, whose rapid course compels them to range themselves in a file, to avoid being hurt or overthrown every instant.

"Sometimes above twenty bees ventilate at the bottom of a hive, at other times their number is more circumscribed, and their employment of various duration. We have seen them engaged in it during twenty-five minutes, only taking breath, as it were, by the shortest interruption of the vibration. On ceasing, they are succeeded by others, so that there is never any intermission of the buzzing of a populous hive.

"If under the necessity of ventilating during winter, being then united near the centre of the mass towards the top of their dwelling, doubtless the bees perform this important function among vacuities of the irregular combs, where there is room for their wings to expand, as at least half an inch is requisite for them to play freely.

"The ventilation of the bees, or the buzzing which denotes it, seems to me more active during winter than at any other time. It was easy to prove that this operation established a current of air; for anemometers of light paper or cotton, hung by a thread, were impelled towards the entrance and repelled from it with equal rapidity. The action on them never was entirely interrupted, and its force appeared proportional to the number of bees fanning themselves.

"If some cultivators of bees shut up the entrance of their hives in winter without prejudice to the bees, it must be considered that the air will penetrate through the straw composing them. I confided an experiment on this to M. Burnens, then at a distance from me. Having closed down a very populous straw hive fast on its board, he found that a piece of the finest paper, suspended by a hair before the entrance, oscillated above an inch off the perpendicular line. He poured liquid honey through an opening in the top, when a buzzing soon began, and a tumult increasing within, several bees departed. The oscillations now became stronger and more frequent. His experiments were made at three o'clock, the sun shining and the thermometer in the shade standing at 44° *."

Swammerdam also seems to indicate that bees remain active during the winter, and in order to enable them to bear its inclemency, they both fortify their hive and provide a store of honey. "The order," he says, "in which bees that live in the winter months conduct themselves is this: they first open the cells and eat the honey deposited in the lowest part of the hive, ascending by degrees to the upper parts. This they do in order to preserve a mutual warmth between them; and the female deposits her eggs in the little cells as they are emptied. Therefore I discovered both stock and nymphs about the beginning of March. Let no one be surprised at this, since towards the beginning of August I have seen some thousand eggs enclosed in the ovary of a female bee; so that it is natural for the bees at any time of the year to lay their eggs and increase their family †."

* Huber on Bees, p. 295.

† Book of Nature, i. 160.

John Hunter, whose authority stands as high as any on record, found a hive to grow lighter in a cold than in a warm week of winter, and that a hive, from November 10th till February 9th, lost more than four pounds in weight*, a loss which could not well be ascribed to evaporation.

These discrepancies among naturalists so distinguished as both shrewd and faithful observers, forbid us, we think, to come to any decided conclusion on the subject, till further researches and experiments have been made. It is not improbable, however, that the truth lies in the middle between the two extremes,—for it is quite accordant with what we know both of insects and other animals, that a high degree of cold should render them torpid, while they may continue active if there should be a certain degree of warmth. The following observations by the ingenious Mr. Gough, of Manchester, form an interesting illustration of this curious subject with respect to another insect.

"Those," says he, "who have attended to the manners of the hearth cricket (*Acheta domestica*) know that it passes the hottest part of the summer in sunny situations, concealed in the crevices of walls and heaps of rubbish. It quits its summer abode about the end of August, and fixes its residence by the fireside of kitchens or cottages, where it multiplies its species, and is as merry at Christmas as other insects in the dog-days. Thus do the comforts of a warm hearth afford the cricket a safe refuge, not from death, but from temporary torpidity, which it can support for a long time, when deprived by accident of artificial warmth.—I came to the knowledge of this fact," continues Mr. Gough, "by planting a colony of these insects in a kitchen, where a constant fire was kept through the summer, but

* Phil. Trans. for 1790, p. 161.

which is discontinued from November till June, with the exception of a day once in six or eight weeks. The crickets were brought from a distance, and let go in this room, in the beginning of September, 1806; here they increased considerably in the course of two months, but were not heard or seen after the fire was removed. Their disappearance led me to conclude that the cold had killed them; but in this I was mistaken; for a brisk fire being kept up for a whole day in the winter, the warmth of it invited my colony from their hiding-place, but not before the evening: after which they continued to skip about and chirp the greater part of the following day, when they again disappeared; being compelled, by the returning cold, to take refuge in their former retreats. They left the chimney corner on the 25th of May, 1807, after a fit of very hot weather, and revisited their winter residence on the 31st of August. Here they spent the summer merely, and lie torpid at present (January 1808) in the crevices of the chimney, with the exception of those days on which they are recalled to a temporary existence by the comforts of a fire *."

* Reeve, Essay on the Torpidity of Animals, p. 84.

[The subject of Insects will be completed in a Third Volume, which will comprise many Miscellaneous Facts that were not capable of being classed under the heads of " Insect Architecture," or " Insect Transformations;" with directions for the collection and preservation of Insects for purposes of study; and a popular account of the various Systems of Classification.]

ILLUSTRATIONS.

FINIS.

London: William Clowes, Stamford-street.