The Ramblings of a Shropshire Naturalist

By E.A. Wilson

CONTENTS

FOREWORD

Edward A. Wilson was born in 1904 and educated in Cambridge at Fitzwilliam College where he obtained his M.A. degree and Teaching Certificate. He was senior biology master at Ellesmere College for the last 20 years of his distinguished career in teaching. During that time he visited and studied the natural history of the meres, mosses, canals and hills of Shropshire, and formed a Field Club at the College which accompanied him on many occasions. E.A.Wilson died aged 70 years in 1974.

Wilson recorded many of the natural history outings in his field notebooks and diaries which after his death, were given by his family to Pam Bowen. Pam and her first husband Colin Russell, became friends of Wilson and his wife after Russell succeeded Wilson at Ellesmere College. Shropshire Archives in Shrewsbury hold the original field notebooks and Wilson's other correspondence, written in his beautiful handwriting. In the box of materials was a typed collection of excerpts from his extensive writings, which Wilson himself had prepared, possibly for publication, entitled 'The Ramblings of a Shropshire Naturalist'. John Harding retyped these into electronic form, produced again here. The writings have been edited as little as possible to preserve the originality and integrity of the diaries. It is hoped they will serve to entertain, educate and inspire, much as E.A.Wilson did in life.

Mags Cousins (Editor)

Front cover: *Nuphar pumila* Least Water-lily by Daniel Wrench

THE MYSTERIOUS 'BLOODY POOL' AT BENTHALL HALL

In a letter from Lady Benthall she described a most peculiar happening at Benthall Edge, close to the Iron Bridge Gorge. She wrote – "we have a small pond on Benthall Edge with periodically becomes crimson. There are two little ponds close to each other but only one becomes discoloured. We have noticed it for many years – I have not observed the crimson colouring for about two years, but it sometimes becomes a cloudy olive green and smells horribly.

The last time I saw the water crimson was when snow was on the ground (I think February, 1948) and I walked round the pond. On retracing my footsteps I was amazed to see that each footmark had become crimson. I have seen the whole pond red as if filled with distemper paint. My husband took some water in a glass jar but it soon faded. The pool is in an old quarry."

The infrequency of the phenomenon and the fact that only one of the two adjacent pools was affected would seem to cut out mineral matter being responsible. The most likely organic explanation was that the red colouration was due to the presence of certain specific unicellular algae containing a red pigment.

A search through reference books about algae showed that more than one kind of algae might have been responsible, one being <u>Chlamydomonas nivalis</u> which can exist under very varied conditions of temperature. It can survive prolonged freezing, and it is quite possible to melt out from ice numerous healthy algae which have in no way suffered from their exposure to such low temperatures. In polar regions, and in the Alps and Andes, there exists snow floras consisting principally of algae which pass their entire existence on snow and ice. The members of this community (known as 'cryoplankton') commonly contain a red pigment thus giving rise to 'red snow'.

<u>Haematococcus lacustris</u>, another unicellular green alga, has cells which are bright red due to a red pigment, and are present in 'red rain'. It is said to be quite common in Britain, although in small quantities.

A further communication with Lady Benthall explained that the pool which became crimson was right against the quarry face and got no sun, so that it was frozen over for long periods during the winter. Another strange fact was that of the two adjacent pools frogs were never found in this one, although they were abundant in the other; further, that her dog would not drink from the 'red' pool, although it drank freely from the other one.

On receiving a sample of the water from the red pond I examined it and found it contained several different algae, one being Euglena viridis. In the early part of the year this may multiply to such an extent that unbroken vivid green film forms over the surface of stagnant pools. Euglena is a streamlined algae but its outer 'skin' is so delicate that it bulges and flattens on hitting an obstacle as it swims around by means of a whirling whip or 'flagellum' situated the front end. It has a red eyespot sensitive to light which enables it to swim towards the place where the light intensity is greatest. This can be shown by the following simple experiment:

Put a fairly thick suspension of Euglena viridis in a saucer and place on a window sill. Leave for at least a day. It will be found that the algae have swum towards the light, and have congregated in a narrow, deep green crescent, leaving the rest of the saucer almost colourless.

Another free-swimming alga present was Chlamydomonas. It behaves rather like Euglena, although it has two flagellae for swimming, and a thicker cellulose wall which gives it a more permanent shape. It is much smaller and more rounded than Euglena, but on occasions it can also colour the water in pools a vivid green.

A third green alga present was a species of Chlorogonium, which has the appearance of a rather attenuated specimen of Euglena.

It was unfortunate that the sample of water received came from the pond when it was green, and not red. However, my search did disclose some of the algae which are known to cause snow to go red because of the red pigment they contain; this alga was Haematococcus lacustris. They look rather similar to Chlamydomonas and have two flagellae. All the algae mentioned can lose their flagella, round off, and become non-mobile for a time.

The University of Wales at Bangor verified my observations so that I felt reasonably certain that the red colour of the pool was the result of excessive multiplication of the alga, Haematococcus lacustris; while Euglena, Chlamydomonas and Chlorogonium were the main cause of the green phase – but why the one pond should differ from its neighbour I failed to discover.

December, 1950

THE CLAMPING OF THE JAWS OF CATERPILLARS BECOMES AUDIBLE

A family outing. We cycled along the road from Ellesmere to the village of Lee and then decided to explore a new part of the country by following a lane which appeared to lead to some woods.

Leaving our cycles by a wood we soon came out into a meadow with hilly contours and delightful scenery. To our delight we found we were only about a hundred yards from Whitemere at a spot exactly opposite to the Shewsbury road shore. The approach to the mere was very marshy and a natural habitat for the lovely Marsh Marigold or Kingcup (Caltha palustris) which grew here. Growing in the water beyond them and crowded together were the plants of the Buck Bean (Menyanthes trifoliata) in flower. This plant gets its name from its trifoliate leaves, which are strikingly like those of the Broad Bean in size and appearance. The leaves and flowers arise from a horizontal rhizome floating in the water or lying on the mud, with roots arising from its under surface. The spikes of the flowers are most attractive, the individual flowers being bell-shaped. With furry petals of white or pinkish colour. Another marsh plant growing near to the Kingcups was the Greater Spearwort (Ranunculus lingua) a member of the buttercup genus which has strong, juicy stems and leaves which are shaped like lance-heads, quite different from the dissected leaves characteristic of the meadow buttercup.

When we entered the woods bordering the mere we noted that many trees had their leaves almost completely eaten away, and we soon became aware of a rustling sound, and of liquid dripping from the trees like a fine drizzle of rain. The sky was a pure azure with not a cloud in sight, and it was a still, sultry day. We soon came to the conclusion that the ‘rustle’ was due to the clamping jaws of thousands of caterpillars, and the ‘drizzle’ was due to their excreta.

It is not often that one gets an immediate verification of ones ideas, but the very next morning we read in the ‘Times’:

“in oak woods there is now a sound like steady rain, a pattering which goes on ceaselessly all night and all day. It is, inconceivable though this may seem, the feeding of thousands – nay millions – of caterpillars that make this quite loud rustling sound; caterpillars which are munching, munching, munching every hour of the twenty-four.

There is, as yet, no very noticeable effect on the foliage of the trees, but soon the oaks will be in rags, and so will be the hazels growing in their shade. Then there will be no pleasure in a woodland walk, for everywhere the full-fed caterpillars will be hanging by silken threads, an army corps of insects who seem to dangle at just the height where they will become entangled with passers by."

17. May, 1948.

WEBBED FEET PERCHERS IN TREES

On my way past the Mere to collect up our Christmas 'chicken' I saw three large grey cygnets standing near the refreshment kiosk much frequented by lorry drivers; no doubt these cygnets get plenty of scraps all through the winter. Far out on the Mere was a huge flotilla of seagulls, many of which were black-headed gulls - there must have been at least two hundred.

The three mooring posts in the Mere near to the Island had the inevitable cormorants perched on them, often with their wings outspread to catch the warmth of the sun, looking like some heraldic emblems. I was surprised and delighted to see thirteen cormorants perched high up in the branches of a tree at the south end of the Mere. They were perfectly motionless and when viewed through binoculars their long, hooked beaks were easy to see. The general colour was black but I thought I could detect a white colour underneath. They must have remarkable powers of balance, because, in spite of their webbed feet some of them were perched on the ultimate twigs.

When they take off from the water their large wings hit the water quite audibly, leaving 'puddles' behind them until they become airborne. In flight their bodies are remarkably straight and slender, earning them the name of 'flying pencils'.

23. December, 1948.

A CIRCUMNAVIGATION OF THE MERE AT ELLESMERE

The Ellesmere College Field Club decided to make a preliminary survey of the Mere, studying its fringing vegetation and birdlife by making a circuit fairly close inshore in boats. This was quite a task as the Mere is three quarters of a mile from north to south, and over half a mile from east to west, and has an area of 116 acres. Our flotilla consisted of three boats.

Just before embarking it was pointed out that most of the trees growing at the water's edge were willows or alders, trees which are able to flourish even when their bunches of reddish rootlets project into the water itself. These rootlets provide a micro-habitat for many minute creatures, and if some of the rootlets are placed in a jam-jar and left for a day one may often find the minute polyp Hydra (about ½" long stretched out) attached to the roots or to the sides of the glass jar.

Although a common green species is Chlorohydra viridissima most of the Hydra we obtained by this method were the brown Hydra oligactis. Hydra is fascinating to watch as its seven long, thin tentacles hang down in the water, and move about slowly searching for prey. They remind one of the fisherman's lines, but differ in being abundantly supplied with stinging cells, deadly weapons which fire a poisonous thread into any small creature, such as a water flea, which happens to come into contact with them. Some of the cells, which are fired off, are sticky, and others have a thread which quickly coils into a close spiral around any projecting part of the victim. Having caught its prey the latter is pushed through the mouth into the sac-like body, killed and gradually digested. Later the indigestible parts of the meal are ejected through the same mouth.

The slaying of the Lernaean Hydra was one of the twelve labours of Hercules, no easy task as this water-serpent had nine heads and every time Hercules struck one off two grew in its place. Why is our little polyp called 'Hydra'? The reason is that it can be cut into several pieces and, with care, each piece will regenerate a complete Hydra. In the laboratory we cut a Hydra into two just below its mouth and tentacles and were successful in obtaining two Hydra. This experiment was first recorded as long ago as 1744 by a Swiss tutor, named Abraham Trembley. During the summer many Hydra will have several smaller Hydra growing out from the main tube, a method of reproduction known as 'budding'.

A common plant growing by the Mere is the Amphibious Bistort (Polygonum amphibium). This is a plant which adapts itself to the amount of water present; on land it is quite short, vertical, with leaves coming off quite close together; in shallow water it is longer, with a few oval floating leaves as well as some above the water; but it also covers quite large areas where the water may be five feet deep - here there are no leaves at all below the surface of the water, although the floating leaves are so crowded that they cover the water completely, forming a convenient platform for coots and moorhens to run over with their semi-webbed feet. When the pink flower spikes rise up above the leaves the effect is most attractive.

Many of the leaves of the Bistort were found to be badly pitted with holes, and a close examination showed the culprit to be a small, yellowish-green, leaf-eating beetle, known as Galerucella saggitariae. All stages in its life story were present, including small clusters of pale yellow eggs; rather blackish larvae and pupae; and adult beetles whose wing-cases spread out enough to hide the body underneath. There were literally thousands of these beetles present.

We started our survey by going in a northerly direction and soon came to a fairly extensive fringe of vegetation showing a definite zonation according to the depth of the water. On the landward side the lovely Yellow Irises (Iris pseudacorus) were in flower; further out were reeds and rushes; and finally the floating leaves of the Amphibious Bistort covered an extensive area. A short stretch adjacent to the Shrewsbury-Ellesmere road was free from plants; this is the location frequented by visitors because of the clear view across the Mere, and the fact that it is here that the birds come to take advantage of food provided by the visitors. The birds, which become extremely tame, include Swans, Canada Geese, Mallards and Coots.

Our course was now bounded by the Cremorne Gardens where willow and alder trees, and small patches of reeds, fringed the shore. On reaching the picturesque and ornamental boathouse (now gone) we ran into an extensive bay covered by the leaves of the Yellow Water Lily (Nuphar lutea). The boats were ‘called to a conference' in order that certain facts about this interesting plant could be explained; particularly the method by which it obtained an adequate air supply. The leaf stalks and flower stalks arise from rhizomes situated in the mud at a depth of about five feet. All parts of the plant, including the rhizome, must receive a supply of oxygen, and the way this is done is as follows: the large, glossy, floating leaves possess hundreds of thousands of minute breathing holes (stomata) on their upper surface only which is in contact with the atmosphere; the long, pliable leaf stalks possess air channels which are continuous throughout their entire length, forming a spongy tissue called aerenchyma. The purpose of this tissue is twofold as it not only supplies oxygen to the rhizomes, but it makes the plant buoyant so that the leaves can reach and remain at the surface more easily.

The under surface of these leaves is always in contact with the water and forms another micro-habitat inhabited by a variety of creatures such as the vegetarian snails and caddis worms, and the predators which feed on them such as leeches, Tanypus larvae (these eventually turn into gnat-like flies), and flatworms; egg mass various kinds are also found.

The yellow flowers, although not so attractive as those of the white waterlily, show a neat arrangement of their floral parts. The outermost whorl of five, fleshy, greenish-yellow parts form the cup shaped calyx - this is the showy part of the flower. The petals form a much smaller whorl of some twenty parts hidden away inside with the yellow anthers of the numerous stamens surrounding the central rather bulbous pistil. The stamens are upright at first with their anthers closely pressed together around the stigma but as the stamens ripen and dehisce they bend back and curve downwards. When pollination is over the pistil enlarges to form a flask-shaped fruit, familiarly known as a ‘brandy bottle’; when ripe the fruit splits and liberates floating seeds.

There was another large patch of amphibious bistort just beyond the waterlilies, whilst near the shore rushes formed a thin fringe, varied here and there by small patches of yellow iris.

At the northern extremity of the Mere there is a narrow island with an interesting history as its construction was artificial. During the years 1847 - 49 the church was enlarged, the nave being lengthened, and two side aisles added. The excavated soil was carted to the Mere to make a small slip of an island connected to the shore by two rustic bridges. The local inhabitants of the town maintained that as some of the soil came from the churchyard it probably contained human bones, thus they called the island ‘Resurrection Island’.

At the time of our visit the Island was covered by trees and bushes and so fringed with rushes that it was difficult to detect. The rushes extended for quite a distance into the Mere forming a large bed. We charged this bed at high speed hoping to set well into it, and possibly find a coot's nest, but none were found. The leaves of the reeds were stripped to show the brick-like aerenchyma; later, leaves of the common rush were sectioned, using a razor, to show that their interior was filled by star-like cells which formed yet another type of aerenchyma. Not far ahead there were two fairly large areas occupied by yellow waterlilies.

Having passed the northernmost point of the Mere we continued southwards along the eastern shore, passing willows and rushes and a swampy verge; then an open field; and a second wood before reaching another field which sloped down to a more sandy shore. This shelved so gradually that it was a favourite place where the local people bathe.

The remainder of the eastern shore was private property, being part of the grounds of Oteley Manor, the residence of Capt. Mainwaring. The large house was used as part of an army camp during the Second World War, and later as a Nunnery (later still it was demolished and a much more convenient, modern house built in its place. The shore line was fringed by willow trees for a quarter of a mile, and there was a substantial, stone-built, double boat house at one point, while a mixed patch of rushes and amphibious bistort was growing just beyond it. A bird was seen perched on a mooring post in the Mere not far away - it was a cormorant. On rowing towards it, it left its perch and settled on the water, but soon afterwards took off with powerful beats of its large wings. Soon afterwards a heron was seen flying, and then a second one; these birds have a mode of flight which seems almost effortless - almost lazy - when compared with the flight of the cormorant.

We had now reached the southernmost bay, and saw one of the herons perched on a tree on rounding the corner. This corner had an extensive mantle of amphibious persicaria, and many other plants grew in the bay itself which ended in a long tongue of marshy ground, some 230 yards long by 100 yards wide. There were more yellow waterlilies, rushes, irises, and quite a large patch of buckbean which had finished flowering and was now in fruit.

Tying up at the edge of the marsh we landed and collected a bouquet of yellow irises which were growing in the boggy ground. Further in, where the ground was less boggy, there were plants of the Celery-leaved Buttercup (Ranunculus sceleratus), Bog Stitchwort (Stellaria alsine) and Marsh Cinquefoil (Potentilla palustris) in flower, and the leafy plants of Water Mint. We only had time for a short visit before embarking once more.

One of the boats made an interesting capture amongst the reeds, namely a young Great Crested Grebe, whose colouration differs markedly from that of the adult bird, having parallel black striping on a whitish background. All three boats examined it and photographs were taken before it was returned to the water. For some time it seemed loath to leave us and followed us around.

Our last activity was to visit the island opposite to the Boathouse Restaurant. In the water there was another patch of buckbean and a large area of amphibious bistort where a Great Crested Grebe was nesting. The grebe nests amongst vegetation growing in shallow water, and uses weeds, rushes and reeds to make a floating nest which will rise and fall with the level of the water, although here there is little change in level as the water supply comes from ground drainage only. When the parent bird leaves the nest it pulls bits of weed over the eggs to hide them from predators. Landing on the island we came across a swan nesting. Normally swans build their nests as piles of weed, which are both high and wide, in swampy places, but our swan was unable to obtain suitable nest-building material close at hand, and its nest consisted entirely of sticks and twigs (some twelve years later it was still making a similar nest). This island, like ‘Resurrection Island’, is an artificial construction. During the winter of l8l2 there was a very severe winter over the whole of Europe, a fact painfully obvious to Napoleon's armies in their retreat from Moscow. The ownership of Ellesmere and the estates surrounding it at this time was in the hands of the Countess of Bridgewater, who was well known for her good works (these included the provision of a Town Hall, a Boy's School and a Girl's School for Ellesmere. All the meres and canals and many rivers were frozen over, and the Countess decided to provide the 'bargees' with paid work to alleviate their distress. Thus she got them to terrace the sloping garden of Ellesmere House and transport the excavated soil to the Mere. Here it was dumped on to the ice at a point where the water was only some three feet deep. When conditions returned to normal the earth sank to the bottom of the Mere, but there was still enough remaining above water level to provide an island. A boat-dock was dug out of this earth and lined with bricks, and trees and bushes were planted to improve its appearance.

Because the work took place in the winter when Napoleon's troops were in retreat from Moscow, the island was called 'Moscow Island’. Later this was shortened to 'Go Island', and finally, as its origin was forgotten, it just became 'The Island'.

We had now reached our starting point having rowed 1.75 miles over a period of two hours.

9.June.1948.

THE WATER VIOLET AND HETEROSTYLY

On a visit to Hardwick Pool when the Buckbean was in flower, and I was just able to wade out to collect some without getting water over the top of my gumboots. Further along the Pool was a piece of flooded grassy meadow backed by 'bulrushes', with more bog bean growing on the nearside, and closer still to the dry land was the lovely Water Violet (Hottonia palustris) in full flower. The feathery, pinnate leaves form rosettes just underneath the water, and these are quite decorative in themselves; while the flowers are borne on leafless stalks about one foot high. The pale, mauve-pink flowers with yellow centres occur in clusters at each node along the stalk. It is a really handsome flowering display, but the name, which refers to the colour of the flowers, is misleading as it is not related to the Violet family, but belongs to the Primulaceae. Like the primrose itself it shows the feature of heterostyly, some flowers being ‘pin-eyed’, having long styles to bring the knob-like stigma level with the mouth of the flower, the anther of the stamens being halfway down the corolla; whilst the arrangement is reversed in the thrum-eyed, flowers. This device increases the chance of cross-pollination when bees visit the flowers.

May.20.1950.

The largest quantity of Water Violet plants in flower which I have ever seen was at Val Hill, near to the village of Tetchill. The canal makes a sharp curve around its base, and has three accommodation bridges, i.e. bridges to give access to land divided by the canal, called Val Hill, No.1, Val Hill, No.2 and Val Hill, No.3. Crossing the second bridge, which is close to the road, there was a grazing field with a tall hawthorn hedge in full flower, and this led to the top of Val Hill by an easy gradient. Rabbit burrows formed extensive warrens under and near to the hedge, and many rabbits scuttled for the safety of their burrows as we approached. The top of the hill was all the more conspicuous because of the presence of a row of trees, but we were not prepared for the sudden change from the gradually rising ground to the wonderful vista over the steep, hilly ground immediately below us, leading over flat country to the high point of Frankton Brow and its church in the distance.

It was no wonder that our bronze-age ancestors took up their habitation here (as proved by the finding of a bronze-age sword).

The ground descended almost precipitously and was resplendent with bluebells in parts of the slope. Not far ahead a large, marshy pool could be seen on the lower ground with whitish flowers growing in abundance.

Intrigued as to what these might be we made our way forwards and discovered a multitude of Water Violet - the massed effect of these beautiful flowers was unforgettable.

Not having been prepared for this discovery I had no gumboots and could not get near enough to find a suitable vantage point for taking a photograph. Three days later I went well prepared but still had considerable difficulty in finding the best view point, having to wade out into the water for some distance. Further the flowering period was drawing to a close and there were more seed capsules than flowers.

On the previous occasion we found one flower only of a plant belonging to the Liliaceae just over the summit of Val Hill, amidst the bluebells. It was the Star of Bethlehem (Ornithogalum umbellatum) which has white petals with a broad green stripe along the back of each petal. As the specific name suggests, it usually has an ‘umbel’ consisting of several flowers, but our specimen had only one flower and the stump of a second.

Another plant with a wonderful flower display also shows heterostyly in an even more complex fashion. By the shore at Whitemere I took coloured photographs of the Purple Loosestrife (Lythrum salicaria) with its crowded spikes of reddish-purple flowers extending for more than a yard along the five feet of flowering stem, looking so exotic that it was difficult to realize that it was a native plant of the English countryside.

There are three types of flowers present, the style and two sets of stamens having different positions in different plants. The first has a short style ending in a knob-like stigma close to the bottom of the corolla, and then one set of stamens further up, with the second set at the entrance of the flower. The second has one set of stamens at the bottom, the stigma halfway up, and then the second set of stamens again at the top. The third has the two stamen sets at the bottom and halfway up the corolla with the stigma at the top.

15.Aug.1949.

THE LLANGOLLEN CANAL IN PRE-CRUISING DAYS

For six months in the year the ‘Llangollen Canal’ which runs through Ellesmere is a scene of great activity. This is due to the policy of the British Waterways Board to encourage pleasure cruising on those canals which otherwise would be of little use.

Originally all boats were horse-drawn. These rarely exceeded 4 mph., so that they did little damage to the banks, and hardly stirred up the mud from the bottom. Later, diesel-engined boats were introduced, and their propellers caused greater disturbance so that the water became more muddy, and this had an adverse effect on plants and animals which lived in the canal.

However, with the run-down of the canals during the present century, and the partial or complete abandonment of some, conditions changed once more. During a family cruising holiday in 1951 from Christleton, on the old ‘Chester Canal’ we passed six pairs of commercial narrow boats before entering the old ‘Ellesmere Canal’, but this was enough to make and keep the water muddy.

The effect on plant life was to discourage the growth of fringing reeds and floating plants. On passing through the four locks at Hurleston Junction we found conditions which were startlingly different, due to the fact that no commercial boats used this stretch, and few pleasure cruisers ventured along it; we passed one pleasure cruiser in our week's holiday afloat.

Firstly the water was crystal clear, so that one could see right to the bottom of the canal (about 3 feet deep) where it was not covered by weeds. Bur-reed (<u>Sparganium ramosum</u>) and Reed-grass (<u>Glyceria maxima</u>) formed extensive fringing vegetation, in fact, between Platt Lane and Bridges the growth from each bank almost met in the middle, that our boat brushed the plants as it edged its way through. There were also floating plants, such as the Yellow Waterlily and Pondweed, and, so much Duckweed that the filter in the system for circulating water around the engine was constantly being choked up, necessitating frequent stoppages in order to clear it.

This state of affairs was mainly due to the lack of maintenance on the canal, so that there were leaking lock gates, some with broken beams or paddles which had become useless; silting up owing to lack of dredging;

and reeds growing out from the bank as fewer ‘lengthmen’ were employed to keep the banks tidy.

In recent years the encouragement of pleasure cruising has meant a reversal of all this neglect, with the overhauling of lockgates, putting in concrete or steel piling to strengthen the banks where needed, cutting the weeds and dredging periodically. The result of this work is the remaining part of the ‘Ellesmere Canal’ now called the ‘Llangollen Canal’ has been invaded by boats. A census on one day in August, 1971 showed that 234 boats were present on the stretch from Hurleston Junction to Llangollen. Boat hire firms usually fix their boats so that 4 mph. is not exceeded, but there are privately built boats which do exceed this speed, and their wash tends to erode the banks; while the propellers of all boats produces a constant state of muddiness in the water.

In the notes which follow the canal was visited in the period when only an occasional boat travelled along it and conditions favoured the growth of both plants and animals. One more point needs explanation, although the canal is wide enough for two narrow boats to pass, consideration of expense led to the bridges being made only wide enough for one boat to pass at a time. Further, considerations of stability led to the brickwork of the bridge arch continuing as vertical walls under the water for about five feet, the sides being joined by a flat brickwork bed. On either side of the bridge the brickwork curved outwards to meet the earth banks, being covered by large coping stones, and called the ‘wing-walls’.

Our School Field Club visited the canal, first examining the under-water parts of the bridge and its wing-walls. We found plentiful growths of the Pond Sponge (<u>Spongilla lacustris</u>). Many people are surprised to learn that sponges occur in fresh water - actually we only find two kinds, the Pond Sponge just mentioned, and the River Sponge (<u>Spongilla fluviatilis</u>) – the later, however, is not confined to rivers, occurring more often in lakes and still waters.

The Pond Sponge forms horizontal, finger-like extensions from a basal incrustation fixed to the wall, as it is a <u>sedentary animal</u>. It is bright green in colour, but this colour is not due to the sponge, which is colourless, but to a multitude of microscopic, green, algae contained in its transparent outer layers which are <u>symbiotic</u>, i.e. live in partnership with the sponge. The greenest sponges were well out on the wing-walls of the bridge, but when we looked well under the bridge we found they were not green, but a very pale brown.

Using a lens we saw that the surface of the sponge was punctured by many holes, the majority very minute, but a smaller number being somewhat larger. These holes lead into a system of internal canals lined by cells, each equipped with a beating hair or 'flagellum'. The action of the flagella causes water to enter the sponge through the small holes and finally leave it via the larger holes, bringing both oxygen and food. The food is all microscopic and is caught by the same cells which cause the current of water.

Another feature revealed by the lens is the presence of minute spines projecting from the whole surface. They are the pointed ends of colourless, siliceous spicules, which occur in bundles inside the sponge and make up its skeleton. An interesting way of finding out which species of sponge you have is to boil a piece of it in a test-tube with concentrated nitric acid. This destroys everything except the spicules, and after washing once or twice with water and allowing to settle, a small amount of the deposit can be pipetted on to a slide and examined under the microscope. If it is the River Sponge the spicules will be all of one kind - slightly bowed, smooth and pointed at both ends; but if the Pond Sponge, a second type of spicule will also be present, namely a smaller, roughened one.

The sponge, being a 'filter-feeder' can doubtless obtain sufficient food from the water, but it is thought that they supplement the carbohydrate which they need by digesting some of the green algal cells. The algae are situated in the outer layers of the transparent animal, where the light needed for photosynthesis can easily reach them, and they obtain a supply of nitrogen compounds from the metabolism of the sponge. Under these favourable conditions their rate of increase exceeds their losses.

1.July.1950

In spite of the sponge's spiny defences there are creatures which feed on it, and during the next year I obtained some sponges attached to stones on the bottom of the canal adjacent to Blakemere, and examined these to see if I could find the aquatic larva of the Sponge Fly (<u>Sisyra fuscata</u>). I found three in different stages of development. One was small and very pale in colour the second dark brown, whilst the third was fully grown and mainly green, but with some brown mottling, they were only ¼" long.

In the immature specimen the eyes consisted of groups of ocelli-like black dots, but these had increased in size and fused to form two well defined eyes in the full grown larva.

The general appearance, tubercles, etc., reminded me strongly of the lacewing fly larva which I drew some years ago; and I found that Sisyra does indeed belong to the-same group of insects.

Sisyra is not the only aquatic insect which inhabits the sponge, others being:

1. Corixa minutissima, a tiny water boatman, only 1 mm long, which makes a distinct stridulation
2. Leptocerus, a caddis-worm which burrows into the sponge.

I must look out for these.

To return to 1.July.1950, sponges were not the only interesting creatures present under the canal bridge. One of the boys spotted a small, greyish-white, gelatinous object moving slowly over the sponges. It was detached with a knife and put into a glass tube. It was only about one inch long by a quarter of an inch wide. This was my first specimen of <u>Cristatella mucedo</u>, a member of the Polyzoa (meaning 'many animals') or Bryozoa (meaning 'moss-like animals'). So called because they consist of scores of zooids projecting from the upper surface, each having a row of tentacles arranged in a horseshoe-shaped curve; it is difficult to decide whether it is one animal, or many animals joined to act together.

Under the microscope the tentacles can be seen to be furnished with rapidly vibrating cilia, and even under a hand lens any particles in the water can be seen to be dashing about in the neighbourhood of the tentacles. The scene is an animated ballet enlivened and varied by the movements of the tentacles themselves.

Most Polyzoa are sessile and thus I was most surprised to find <u>Plumatella fungosa</u>, attached to a marker buoy used by yachtsmen on Whitemere. This buoy was in the middle of the mere, and I used it in order to moor my boat when making regular collections of plankton. How had a sessile form spread to this buoy where the water was over twenty feet deep? The answer was that thousands of floating <u>statoblasts</u> are produced on the approach of winter, and these hatch out during the following spring, some of these statoblasts must have come into contact with the buoy at the right time and grown into new animals.

The growth forms of Plumatella show much variation, some forms having spreading branches, but the present form consisted of spongy tube packed together and adhering to the underside of the buoy to form a spongy mass, some ten inches across and over two inches in thickness. As with Cristatella tentacled zooids project from the tubes if undisturbed, but Plumatella is far more sensitive, quickly retracting its tentacles and only expanding them again after a long period.

After this second digression let us return to our original canal outing. The same boy who discovered Cristatella also discovered an interesting caddis-worm, Molanna angustata. It makes a case out of sand grains, but this is overspread by a sandy shield which projects over the head and sides of the larva, thus giving it the name of the 'tortoise shell larva'. It was almost impossible to see on the muddy bottom owing to its flatness and a certain amount of clay which had become scattered over it; only when it moved in sudden short jerks was it visible at all - a good example of protective camouflage.

Water mites were plentiful in the canal, some bright red ones being the size of a split pea. An interesting fact about the life-history of the water mite is that it has a parasitic larva, and we found water boatmen and a water skater with red spots on them, which closer examination proved to be larval mites attached to their hosts.

1.July.1950

PINK ROOK'S EGGS

We had one boy at school who was a keen ornithologist. Although poor at almost all the normal school subjects, including English, Languages, and even the formal aspects of Biology, he had a flair for ornithology. It was no trouble for him to learn and memorize the Latin names of birds, or to write interesting accounts of his observations. At his own request he took over the bird section of our card index of local plants and animals and produced a most comprehensive list.

In 1958 he found some erythric ('pink') rooks eggs, and wrote to the British Museum (Natural History) about them. He was told that this occurrence was very rare, only one case having been reported previously.

In the Spring of 1959 two more boys argued that if the same bird was still alive it might repeat the performance, so they climbed all the 'climbable' trees in the neighbourhood where rooks were nesting and found that their theory was correct, as they obtained further eggs of the same type.

30.March, 1959

LIZARDS

(a) The Viviparous Lizard (Lacerta vivipara)

We found our first lizard on Fenns Moss. Lizards move in short dashes and are so well camouflaged that although we saw one move, we immediately lost sight of it until it moved again, when it stopped for the second time, however, it remained clearly in view, and obligingly kept perfectly still so that we were all able to inspect it.

We tried to get it to enter a glass tube placed in its path, but it avoided the tube and rapidly ran up a silver birch tree close by. It was delightful to watch the grace of its quick, lithe movements. Fortunately for us it stopped at a height of about four feet, and this time obligingly entered the glass tube when its tail was touched; from the tube it was transferred to a tin.

Although they bask in the sun they dislike too much heat; they are easy to keep in captivity and are quite long lived.

20.April.1950.

On a later occasion, when the College Field Club was visiting Fenns Moss, a lizard was found in one of the peat ditches with only its head above the water; a further one was seen on Clarepool Moss. On one visit to Fenns Moss I tried to catch a lizard but only managed to catch it by its tail - which promptly came off. This is a well-known escape mechanism, but strangely enough the fracture is not between two vertebrae, but at a prepared weak place in the middle of a vertebra, when I found myself holding the tail I was so fascinated watching the stump oscillating to and fro like a metronome, that the lizard made an effective escape. In time a new tail is grown, although it is never as good as the original one.

Vipers are said to be quite common on the Mosses, but yet in more than twenty years I have not seen one.

(b) <u>The Slow-worm (Anguis fragilis)</u>

One of my pupils asked me to keep some ‘slow-worms’ for him; none of them had been obtained locally. Slow-worms look like snakes, having no legs, but actually they are legless lizards, and like the Viviparous Lizards are able to shed their tails when attacked, in fact, one had already done so.

Three of the slow-worms were of a light bronze colour, and were shiny, smooth and metallic-looking. The fourth was rather fatter than the others, and had a silver-grey colour beautified by blue spots, especially near to the anterior end; this variety is said to be the male of a type common in Europe, but rare in England.

We placed the four reptiles in a vivarium with two small turves of grass, and fed them with flies, woodlice, worms, etc. It was not long before we found the exuvias consisting of the transparent cuticles; they showed the impressions of the scale quite well.

Slow-worm, are not very active, often remaining motionless as if cast out of bronze. From time to time a forked, or rather notched, tongue darted in and out of its mouth in a quivering fashion. It is the longest lived of all the lizards, some having lived for more than thirty years.

31.May, 1951

A Mr. Bevan from Erbistock gave us three slow-worms which he had found when lifting up an old paving stone, and we kept these in the vivarium for a time.

31 May, 1959

<u>THE OIL BEETLE</u>

At least once every year, and sometimes even more frequently we have found the Oil Beetle (<u>Meloe violaceus</u>). Our first find was in a field at Erbistock. Although a rather bloated, ugly beetle it has a most fascinating life story which includes an incident reminiscent of Sinbad’s escape from a valley by tying himself to the leg of the giant bird called the Roc.

Imms has a good account of this which I will quote:

"they are large creatures, an inch or more long, which crawl about in a sluggish manner in grassy places during the sunny days in Spring. The female beetle lays several large batches of minute yellow eggs in the ground - there may be over 3,000 eggs laid, so obviously the chances of survival are poor.

The young larvae are minute yellow objects that are very active and have long legs, and projecting bristles at the hind extremity. Their life is a precarious adventure because survival depends upon their coming across Anthophora bees.

These larvae wander in swarms over the herbage, generally climbing upwards.

In this way some of them manage to reach flowers that are visited by the bees in question. The larva now has its chance to make good and it tries to hang on to the hairy coat of the bee. If it succeeds it becomes carried to the Anthophora nest where it undergoes a complex metamorphosis. Once there, the first thing it does is to raid one of the cells and feed upon the contained egg. Having thus refreshed itself it appropriates the food store intended for the bee larva and completes its growth on this pabulum.

The Meloe larva seems to be very careless as to the kinds of insects to which it may attach itself, and a vast number come to a miserable end through clinging to the wrong kind of Bee, or by mistaking a hairy fly for a bee. An even greater number never come into contact with a carrier of any sort.

18.April.1949.

THE 'BREAKING OF THE MERES'

I had not been long at Ellesmere before I heard about a local phenomenon called the ‘breaking of the meres’. This usually occurred in all the meres in late summer, but its timing was uncertain, and there might be more than one ‘break’ during the year.

The descriptions given of it by local people were most vague, and its cause did not seem to be known to them. When the time of the ‘break’ drew near the water became filled with innumerable green cells which were individually microscopic, but were visible as a green ‘dust’ because the cells were clumped together in various ways. After anticyclonic periods of warm, still weather these clumps of green cells would rise to the surface of the water covering it with large patches of unbroken green. As soon as the weather changed - even a light breeze was sufficient - the green clumps would vanish leaving the water clear once more.

I wrote to Mr. L.C.Lloyd, who was then the Secretary of the Caradoc and Severn Valley Field club, to find out if he could supply me with any information on the subject, and he wrote that William Phillips, a member of their club, headed a committee which investigated this phenomenon as long ago as 1884. As a result of their work the causative organisms were identified as various members of the <u>Cyanophyceae</u> or <u>Blue-green Algae</u>.

Mr. Lloyd was kind enough to supply me with a copy of Phillip's paper.

Both the name <u>Cyanophyceae</u> and its translation, <u>Blue-green Algae</u>, are inappropriate names. The Algae proper are sub-divided into Green, Brown and Red Algae, but the Blue-green Algae is the 'odd man out', as they resemble the Bacteria far more closely than the algae. This is shown in the following table:

BACTERIA		CYANOPHYCEAE
Cells microscopic		Cells microscopic
Non-cellulose walls		Non-cellulose walls
No nucleus		No nucleus
Cells often grouped together		Cells often grouped together
Groups of cells (colonies) have various colours		Groups of cells have various colours
Only reproduce asexually		Only reproduce asexually
Survive adverse conditions as spores		Survive adverse conditions as spores
<u>Never</u> possess chlorophyll		**<u>Always</u>** possess chlorophyll

It will be seen that all characteristics are shared except point 8.

To the naked eye the Cyanophyceae found in the meres appear to be a <u>yellow-green colour</u>. Nevertheless a blue colour is present besides the chlorophyll, and this can be shown by putting a dense suspension of these algae in a tube and leaving until the algae die. The green chlorophyll is not soluble in water and remains inside the cells, but the blue <u>cyanophycin</u> is soluble and diffuses out from the cells as soon as they die, so that we have a clot of green cells and a blue solution in the rest of the tube. The same thing occurs in Nature when the floating algae get washed inshore and become stranded. I have seen what looks like a film of blue paint around the bases of the reeds and other plants on these occasions.

When the 'breaking' occurs it results in an unpleasant taste being acquired by the water; the fish go off their feed; and bathing is not much fun. Why the term 'The Breaking of the Meres'? As far as I know this term is restricted to Ellesmere, elsewhere it has such pleasant names as 'Water Bloom', 'Water Blossom' and the ‘Flowering of the Meres', and similar names occur on the Continent, for this is a very widespread phenomenon.

The explanation is connected with the malting and brewing industries. One hundred and fifty years ago, Ellesmere had two breweries, thirty malt houses and over twenty public houses, while many of the 2,000 inhabitants brewed their own ale. To ferment the ‘wort’ in the making of ale yeast is added. Yeast is a very tiny microscopic fungus, which tends to form minute clumps; during respiration carbon dioxide is produced, and this buoys up the clumps of yeast so that they float to the top of the wort, and ‘break’ surface; the gas being liberated the clumps sink once more. It was this continual rising and sinking of the yeast which was compared with the rising and sinking of the blue-green algae in the meres.

One difficulty when talking about the Cyanophyceae is they have no common names, so that the Latin scientific names have to be used. However, with practice, most of the Cyanophyceae involved in the ‘breaking’ can be recognised with the naked eye, and with greater certainty using a hand lens.

One of the commonest is <u>Anabaena circinalis</u>, in which the cells are joined together to form loosely coiled springs. Several of these springs become entangled to form visible clumps. Another species sometimes occurs called <u>Anabaena spiroides</u>, in which the cells and 'springs' are considerably larger and are much straighter. An individual spring is known as a ‘trichome'.

All the Cyanophyceae found in the meres have larger, clear cells at intervals along each trichome called <u>heterocysts</u>, and no one is quite sure what their purpose is, although I have noticed that the trichomes tend to break more easily at these points - could this be a method of asexual reproduction by fragmentation?

Another example is Aphanizomenon flos-aquae, which consists of straight trichomes adhering in silver-like masses by means of their gelatinous walls. Cyanophyceae are a great nuisance to water engineers and often occur in reservoirs. The American water engineers have shortened Aphanizomenon to 'Fanny'!

Gloeotrichia pisum forms little balls, and has the rather distinctive feature of having all its trichomes ending in heterocysts grouped together at the centre of the ball; further the cells taper towards the outside, so that the result is a fluffy ball, easy to distinguish with a hand lens.

Microcystis aeruginosa has its cells in one flattened plane, which has an irregular outline, and needs to be identified under the microscope, but once seen is easy to recognise.

Yet another member of the Cyanophyceae takes the form of a gelatinous ball with the individual cells scattered through it. It is known as Coelosphaerium naegelianum.

The phenology (times when it occurs) of the 'breaking' has not been studied systematically, and I found it difficult to keep track of the times because of the irregularity and composition, so that my observations were rather scattered.

There are eight meres in the neighbourhood of Ellesmere, and they all show 'breaking' on occasions, but these times are not the same for all the meres, nor is the alga responsible always the same in each case. Some may not 'break' in a particular year, while others may 'break' three times – and not always with the same alga! It is all very confusing.

However, a detailed scientific study has recently been carried out by Dr.C.S.Reynolds, and many of the problems have been solved satisfactorily, but I will leave an account of this work to a later section.

17.June.1949

FENNS & WHIXALL MOSSES AND THE PEAT INDUSTRY

When the Ellesmere Canal was cut in the year 1795 to 1805 under the supervision of Thomas Telford he had quite a few problems to solve, and not the least was the crossing of the northwest Shropshire Mosses.

The term ‘Moss’ is an alternative for the much more descriptive term ‘Morass’ which indicates the boggy nature of the ground. Whereas the deeper depressions around Ellesmere became filled with water to become ‘Meres’, the shallower depressions were filled with bog vegetation to become ‘Mosses’, and the largest ‘Moss’ around Ellesmere is the Fenns Moss – Whixall Moss complex.

The boundary between Shropshire and the detached portion of Flint (Maelor) in Wales here is just a ditch across the two parts of the complex, the English portion being called Whixall Moss and the Welsh portion Fenns Moss. There is little information about the cutting of the canal across this Moss, other than the canal was six feet below the level of the Moss, so that drainage ditches had to be dug first to lower the level of the Moss along the line of the canal, in spite of a number of breaks in the banks the canal still runs successfully across the Moss after 170 years. In 1861 - 62 there was a legal battle in Parliament between the G.W.R. and an independent local railway company, when a railway was proposed to run from Oswestry through Ellesmere to Whitchurch. The independent company planned their railway to cross Fenns Moss, but the GWR's plans avoided the Moss as they said it was an impossible task to take a railway across it. The independent company won the day and we read that soundings showed the average depth of the Moss near to the proposed railway was twelve feet. To quote from G.P.Gasquoine 'Story of the Cambrian Railway':-

“Mr. George Owen first drained the site of the line by means of deep side and lateral ditches, filled with brushwood and heather. He then laid strong faggots three feet thick and from eight to twelve feet long, and over these placed a framework of larch poles extending the entire width of the rails. The poles were then interlaced with branches of hazel and brushwood, and upon this the sleepers and rails were laid, the whole being ballasted with sand and other light materials.

In the end it proved a triumph of courage and ingenuity. Though there might be some slight oscillation, heavy trains have been running over this interesting stretch for many years [exactly 100 years when the line was closed in 1964] without the slightest mishap".

When crossing this large area of wild, uncultivated land between Bettisfield and Fenns Bank railway stations, one can appreciate its flatness and desolation. Apart from birch trees there is hardly another tree that grows here, and even the birches remain as stunted bushes over most of the area owing to the periodic burning which takes place.

If it is Spring you may notice considerable patches made conspicuous by the white 'cotton-woolly' tufts of the Cotton Grass.

If it is Autumn you cannot fail to see the purple of heather and ling which grows everywhere. That vigorous invader, the Bracken Fern, is also much in evidence.

From the train one used to see signs of human activity in this region, as extensive deposits of peat are found all over the Moss, and this is utilized commercially, even today. On a visit in 1948 we found peat being dug up by about twenty men employed by a firm from Bathgate in Scotland. The methods and speed of work was positively medieval - sometimes no one was visible; sometimes one man would be working on his own; at most there would be two or three. We talked to one man who told us that he had previously worked in a factory in Glasgow, but preferred working on his own in the open air with no one to bother him! He had three spades (a) the 'ridding spade' used to remove the top growth of heather, moor-grass, etc., (b) the 'striker' which has an oblong-shaped blade and is pushed vertically into the peat to its full depth repeatedly to make long parallel cuts, and then cuts at right angles, thus marking out the size of the peat blocks,(c) the 'bat', this has a long, narrow blade equal in width to the width of a peat block, and is used to remove the separate peat blocks. Although the uppermost blocks may be fairly dry and light brown in colour, those underneath are almost black and saturated with water like a sponge. As they are cut out the blocks are built up into low, loosely built walls along the edge of the wide, excavated ditches and left to dry. These 'wind-rows' are dug out at eleven-yard intervals. The wind-rows themselves run at right angles on either side of a wide road called a 'stackway'. As digging proceeds the whole area takes on the appearance of an elaborate grid, especially when viewed from the air. When the peat in the wind-rows has undergone its preliminary drying it is loaded on to a barrow and taken to the stackway where it is neatly stacked and undergoes its final drying. These stacks form a prominent feature in such a desolate landscape.

When the peat i.e. needed at the 'factory' the tramway lines are extended along the stackway and a train consisting of slatted wooden trucks drawn by a small diesel engine arrives. Having loaded up with dry peat blocks from the stack it travels across the Moss to the factory. Here it runs into a siding, and the peat is unloaded by being thrown directly into hammer mills which disintegrate much of it into a fine powder. It then passes through a large, revolving, cylindrical sieve to separate the various grades of peat. The graded peat goes into a hopper, and in the final stage is emptied into a press that compresses and bales the peat. The compressed bales then go on a moving belt to be emptied into railway trucks waiting in a siding from the railway.

This peat is not used for burning, but as litter for stables, hen houses, etc., owing to its absorbent qualities. It is also used in making up potting soils by horticulturalists and as a packing material.

Peat was dug at Whixall Moss, but not on a commercial scale, in fact, it was a local cottage industry. Small areas of the Moss were rented by people living near to Whixall, and they worked them in-their spare time, just as people work on allotments.

This industry goes back several hundred years, and its purpose was to build up a stock of peat blocks during the summer to serve as fuel during the winter. The tools used were similar to those already described but had their own local names, namely; the 'Skinner', the 'Sticker' and the 'Uplifter'. The size and the shape of the blocks was different. A square block of medium thickness was known as a 'Whixall Bible'.

26.April.1948

THE FLORA OF FENNS - WHIXALL MOSS

Where boggy conditions occur we nearly always find the Bog Moss (Sphagnum sp.). It is an extraordinary plant in many ways, and is the pioneer plant in the production of peat. Like many mosses the individual stems are weak, and it only maintains an upright position when crowded together in dense masses or cushions. In water the straggling stems may reach a length of many feet, but on boggy ground the lower parts of the stems die off, while the rosette-like apices continue to grow on almost indefinitely.

As the dead parts persist a thicker and thicker deposit of dead Sphagnum accumulates. As the acid conditions do not suit the microbes which cause decay, the alteration in the dead Sphagnum is very slow, so that a great many of the plants which grow on it, and even pollen from the trees bordering the Moss in past ages, can be recognised by the experts. Pollen analysis from the lower levels of the peat can even tell us what plants were growing nearly as far back as the end of the last Ice Age.

However, slow alteration of the plant remains does occur, and it becomes deep brown in colour and much compressed by the weight of the upper layers - in other words, it becomes converted into peat.

The arrangement of the leaf cells is most remarkable. As with other mosses the leaf is only one cell thick, but its cells are of two kinds, those containing the green chlorophyll alternating with empty cells. The walls of the latter are strengthened by spiral fibres to prevent their collapse, and they are perforated by rounded pores.

These empty cells soak up rainwater like a sponge, passing it on to the living green cells. Even in dry weather it is usually possible to squeeze water out from a handful of Sphagnum. In the First World War it was collected, washed and sterilized as a substitute for the usual wound dressing owing to its absorbent properties. The water in peat bogs is acidic and only certain plants can grow under these conditions. Sphagnum with its absorbent leaves relies on rainwater, and after a shower it may appear quite green. When the water in the outer leaves evaporates off, its porous cells are then filled with air which makes them appear white and moribund. However, the porous cells deeper down act as a reservoir and supply those above by capillarity.

A whole variety of mosses occur on the Mosses besides Sphagnum, of which the genus Polytrichum is prominent, especially P.commune. This will be dealt with later.

The Cross-leaved Heath (Erica tetralix.L.) is commonly found flowering in July, and the Ling (Calluna vulgaris), commonly called 'Heather', in August. Both these plants manage to grow on the peat because they contain a fungus (invisible to the naked eye) which can utilize the nitrogen contained in the air to manufacture nitrates and other nitrogen compounds which; are almost completely lacking in the peat. Thus a partnership is set up between the flowering plant and the fungus in which both benefit, such partnerships being known as mycorrhiza (literally 'fungus-roots'). When the fungus is completely internal the mycorrhiza is said to be endotrophic (inside-feeding), but when external, ectotrophic (outside-feeding). An example of ectotrophic mycorrhiza which is plentiful on the Moss is the Silver Birch tree, whose roothairs have largely been replaced by fungal threads projecting from its roots.

A plant, somewhat similar to the Heath, but not nearly so common is the Bog Rosemary (Andromeda polifolia). Its pale pink, bell-like flowers may be found on Fenns Moss with little difficulty from early Spring onwards, although it is at its best during the Spring. Most floras state that it is rare, but on Fenns Moss its occurrence could be described as frequent.

Whereas the aid of a fungus is used to supplement nitrogen compounds needed by the higher plants, there are other plants which actually catch and digest insects for the same purpose. The easiest to find is the Round-leaved Sundew (Drosera rotundifolia) which occurs in countless numbers during the summer months. It is sometimes found growing on cushions of Sphagnum, or on rather soggy peat, and consists of a rosette of leaves, the whole rosette being no larger than a 10p piece. About the end of July it may be found with a slender flower stalk, some two or three inches high, bearing small white flowers. Each leaf has a leaf stalk with a circular leaf-blade bearing glands which are almost sessile in the centre, but having progressively longer stalks towards the outside, so that stalked outer glands form moveable tentacles. The name of the plant refers to the fact that the glands are surrounded by a shining drop of liquid which looks like dew or nectar, but is in reality a drop of gum.

Any insect which is deceived pays dearly for its mistake as it gets stuck on the tentacle; gradually neighbouring tentacles bend over so there is no escape; then a digestive fluid is poured over the insect. Later the products of digestion are absorbed into the tentacles which then remain dry for a time until the indigestible parts of the insect blow away.

The two other British sundews, The Great Sundew (Drosera anglica) and the Long-leaved Sundew (Drosera intermedia & Heyne) do not seem to occur on Fenns Moss-Whixall Moss, but I have found them on Wem Moss which lies on the southern side of the canal.

Another 'insect eating' plant occurs in some of the pools on Whixall Moss. It is the Lesser Bladderwort (Utricularia minor) so called on account of the very numerous bladders which are borne on this much branched, submerged, floating plant. The word 'insect-eating' is rather a misnomer. The larger species of Bladderwort may capture some aquatic larvae, but their more usual prey consists of waterfleas (i.e. Crustaceae); while Utricularia minor could only manage microscopic forms of life.

It has no roots, the whole plant consisting of branching 'stems' extending horizontally which themselves branch repeatedly to end up in innumerable hair-like leaves. The leaves bear a host of minute bladders, only about a millimetre in length, which form most ingenious traps for the capture of 'Infusoria'.

The mouth of the bladder consists of a thin flap which rests on a thickened lower lip. Two hair-like processes project from the bladder close to the mouth, and each bears about a dozen finer hairs. The inside of the bladder is covered by four-pronged, multicellular hairs. One of the functions of these hairs is to absorb water from the inside of the bladder, so that with the mouth closed a state of tension is set up inside the bladder. Under the microscope the bladders can be seen to be compressed laterally, with a tendency for the walls to become dimpled.

When any minute creature blunders into the hairs around the mouth, or are attracted there by the mucilage glands present, the delicate state of equilibrium of the 'trap door' entrance is upset, and water rushes into the bladder carrying the creature in with it. The flap can only open inwards, so that the victim is unable to escape.

As any digestive fluid produced would become diluted by the water present, captured creatures may remain alive for some days before they finally die; it is possible that the bladders may not produce any digestive fluid, but just absorb the products of decomposition through the abundant internal hairs.

During the late summer yellow flowers are produced on stalks above the water level, and these produce fruit and seeds; but before the winter descends upon the Mosses the leaves at the ends of the floating stems cluster to form ‘winter buds’. The older parts of the stem and leaves die, their cavities, previously filled with air, become filled with water, and the whole plant sinks to the bottom of the pool. After the winter the 'winter buds' become detached and ascend near to the surface, rapidly expanding and forming a fresh plant body with a further series of bladders.

Other flowering plants found on Fenns Moss - Whixall Moss are the Cranberry (<u>Oxycoccus palustris</u>); two species of the sedge known as 'Cotton Grass' because of the resemblance of the fruiting heads to a miniature cotton boll - they are <u>Eriophorum angustifolium</u> which has several spikes of cotton-like heads; and <u>Eriophorum vaginatum</u>.L. (also known as Hare's-Tail) which has only one; the White Beak-Sedge (<u>Rhyncospora alba</u>); Purple Moor Grass (<u>Molinia caerulea</u>); Wavy Hair-grass (<u>Deschampsia flexuosa</u>)

1947-50

6,320 MIDGES COMMIT SUICIDE

The fresh green leaves of the Wild Arum or Cuckoo Pint (Arum maculatum) appear in the hedgerow verges as the first welcome signs of Spring, although its flowers are more tardy and do not appear for another month or so.

The inflorescence has a most complex structure. An expanded spathe narrows down to a closed, oval compartment which contains both male and female flowers, both reduced to an absolute minimum. The male flowers consist of anthers only, packed tightly together around the base of the columnar spadix; while the female flowers below them consist of ovaries having short stigmas, also packed closely together. Above the staminal flowers there are stout hairs which project slightly downwards and close the compartment. The spadix continues upwards and ends as a purplish poker, set against the green background of the spathe.

The way in which this apparatus is said to work is as follows:-

Tiny midges enter the flower by pushing aside the barrier of hairs, and then feed on any pollen which has already been shed. Actually the stigmas become receptive before the stamens are ready, but when the midges try to leave they find they cannot push past the hair-barrier, as the hairs can only be pushed downwards, and so they are forced to stay. As they crawl around the stamens shed their pollen; some drops on to the stigmas while more is transferred by midges. When pollination is completed the barrier of hairs withers and the midges escape. As with so many 'sensible' explanations this is only partially true, because the flies can come out, and do so when the growing plant is tapped, so that it seems more probable that intoxication may be the cause of many of them remaining below.

If the Wild Arum inflorescences are examined it will be found that the majority of insects present are 'Owl Midges' (Psychoda phalaenoides). One strange fact is that they are all females, which suggests that they may be parthenogenetic, i.e. the eggs develop without the need for fertilization.

On one occasion I found an inflorescence in which the closed chamber was completely filled by a solid, black ball, composed of dead owl midges. These were washed out with alcohol into a Petri dish and counted - there were 6,320: C.H. Wallace Pugh kindly wrote about this to Dr. H. Jung of Dusseldorf, the leading authority on the family, who replied that he also had two spathes of Arum maculatum which were absolutely filled with females of Psychoda phalaenoides but agreeing that these numbers were rare. The only explanation which would seem to fit the case is that these Owl Midges decided on a mass suicide.

THE DISUSED TREFLACH WOOD LIMESTONE QUARRY

The College Field Club decided to visit Treflach Wood limestone quarry, near Trefonen, which ceased to be worked from about 1945. On the geological side we were fortunate enough to have the expert knowledge of Mr. O.H.Chapman, so that on arrival he was able to explain the main points of interest and direct operations.

The rock face was attacked with an assortment of hammers, but the rock was so hard that it was very difficult to get any fossils out unharmed. One fossil present in this Carboniferous Limestone was the large brachiopod bivalve, Productus giganteus, which may reach six inches or more in length, and several specimens were obtained with the side 'wings' of the shell intact. Two specimens of another fossil, Orthoceros, were seen partially exposed - this is a straight-tube ancestor of the later coiled ammonites.

One of the most interesting features of this quarry was a bed of corals one foot thick, where corals abounded, some being seen end on and others from the side or obliquely. This bed was even harder than the remainder of the rock, and only with great difficulty were we able to get out samples containing the coral Dibunophyllum. Later on these were cut and polished to show the cross-section of the 'stem' with its radiating septa reminding one of the gills of a toadstool.

Veins of calcite were common showing its characteristic rhomboidal cleavage.

The Geological Memoirs for the district mentioned Treflach Wood Quarry was the source of a great many square-sectioned stone gate-posts, and after reading this I kept a lookout for them. They were really abundant in the neighbourhood, and they had become well-weathered, being covered with the bright orange lichen, Xanthoria parietina.

The sweltering heat led to a slowing down of the hammering and to more attention being paid to the plants which were growing in the quarry.

Limestone has its own particular flora, although more generalized plants occur here too. Present were:

Dog Rose (Rosa canina)
Wild Strawberry (Fragaria vesca) - in fruit
Hairy St. John's Wort (Hypericum hirsutum)
Marjoram (Origanum vulgare)
Buttercups
Cinquefoil (Potentilla reptans)
Common Rockrose (Helianthemum chamaecistus)
Wild Thyme (Thymus serpyllum agg.)
Self-heal (Prunella vulgaris)
Vetches
Bird's Foot Trefoil (Lotus corniculatus)
Willow Herbs

The Mouse-ear Hawkweed (Hieracium pilosella) was present here, as it was on the trodden pathways on Whixall Moss, as it is a plant which grows successfully on infertile ground, it spreads by means of stolons which spread out like runners each ending in an over wintering rosette so that it effectually covers the ground with a close carpet of leaves. These are covered with soft white hair, with sparse, long, stiff, white hairs on each side.

Ferns and mosses were common amongst the remains of limestone walls and buildings, including the ferns, Wall Rue (Asplenium ruta-muraria) and Maidenhair Spleenwort (Asplenium trichomanes). In the same place there grew the Feverfew (Chrysanthemum parthenium) and the Marguerite (Chrysanthemum leucanthemum). An orchid quite frequent in limestone regions was found, it was the Pyramidal Orchid (Anacamptis pyramidalis). Its pollination mechanism is a marvel of adaptation, being wonderfully suited to the visits of butterflies and moths. Like all orchids, in place of the normal stamens, the pollen is contained in a pair of pollinia. These are shaped like Indian Clubs, the pollen being held in a net-like bag, connected by a stalk to a viscid basal disc. The stigma is found underneath this.

In many orchids when a bee visits them and pushes its proboscis into the flower to obtain nectar, the sticky base of one pollinium, or of both pollinia, attaches itself to bee's proboscis, and sets solid in a matter of seconds. Then a remarkable event happens; the pollinia bend forward quite rapidly through a right angle until they are horizontal, so that when another orchid flower is visited, the pollinia will now hit the stigma, burst, and so pollinate the flower.

Lepidoptera have mouth parts which consist of a fine tube I coiled up under the mouth like the hairspring of a watch when not I in use, but straightened out when needed. In the Pyramidal Orchid there is an adaptation to suit this type of mouthpart, namely the two pollinia are joined to the same short, thin bar; when the bar comes into contact with the insect's proboscis it not only sticks but curls round it.' this has the effect of splaying out the two pollinia. The pollinia also move forwards through a right angle so that when a second flower is visited the stigmas are positioned in the exact position to receive a direct hit from the two pollinia.

As many as eleven pairs of pollinia have been observed on the proboscis of a single moth. Darwin observed and wrote about pollination in British orchids many years ago in his book 'The Various Contrivances by which Orchids are fertilised by Insects'.

There were one or two pools in the quarry, and a shallow one right up against the quarry face contained masses of the aquatic stonewort (Characeae) and rushes; while another deeper pool was partly covered by the floating leaves of the Amphibious Bistort. A plant of the Yellow-wort (Blackstonia perfoliata Huds.) was in flower nearby.

25.June.1949

On another visit to the quarry we found some local boys fishing with nets in quite a small pool by the rock face. They had caught a considerable number of newts.

On examining their catch we were interested to find that all three species of British newts were present, namely:

The Great-Crested Newt (Triturus cristatus)
The Common or Smooth Newt (Triturus vulgaris)
The Palmate Newt (Triturus helveticus)

The first is the largest, having a jagged crest in the male only which extends from just behind the head to the tail, and then extending in a less jagged form around the tail. It has a warty skin and is coloured bright yellow underneath with black blotches. The female is similar but lacks the crest.

The Smooth Newt is smaller, is not warty, and has a crest extending in one continuous curve from the head to the tip of the tail in the male. As before the crest is lacking in the female. The colour underneath tends to be more pinkish-orange, with more diffuse spotting.

The Palmate Newt is about the same size as the Smooth Newt and could be mistaken for it at a casual glance, but a closer look reveals that the toes on the hind feet are webbed, and that tail is abruptly truncated at the tip, but is continued backwards as a central black filament.

5.June.1963

LEECHES ATTACK THE RECTOR'S GEESE

In October,1954 the Rector of Whittington, near Oswestry, reported that he had seen leeches crawling up the necks of some of his Chinese Geese, and that the affected geese became blind. I wrote a short article about this is the local paper, and not long afterwards received a letter from Mr. H. E. Roberts, Veterinary Investigation Officer of Wolverhampton.

The leeches proved to be Theromyzon tessulatum, which is quite common in the meres around Ellesmere, and Mr. Roberts wrote that leeches were present inside the eyes of the affected geese, causing a reaction in which a cheesy cast was formed, with large numbers of immature, blood-filled or unfed, parasites present. Blindness was complete in some birds due to these casts, or to the closure of the third eyelid, or to the opacity of the cornea.

He suggested that the baby leeches entered the eyes at the anterior corner where the flicking action of the third eyelid would be avoided. The alternative route by way of the lachrymal duct from the nose would be a most difficult one, only negotiable by the smallest specimens.

No similar cases have been reported from the British Isles, and Mr. Roberts could only find one case from the Continent in 1939, so that this is a most unusual occurrence.

As leeches go, Theromyzon tessulatum can be said to be one of the prettiest, having an almost transparent body, but with an olive-green tinge, and six longitudinal rows of yellow spots down the back. Its life story is interesting, especially as the female leech shows maternal care of her young. She lays a large number of eggs in capsules which remain attached to the underside of the body. On hatching, the tiny baby leeches fasten on to the mother's body by means of their hind suckers, and as many as 200 may be carried around in this way. When danger threatens, the mother shortens and curls up into a ball sheltering the young inside.

After leaving the mother the young leeches may feed on small snails (all leeches are 'blood-suckers') but sooner or later they enter the nasal cavities of ducks or other water-fowl while these are feeding off the bottom in shallow water. They fasten themselves inside the nose or throat of the bird, obtaining blood from their victims, occasionally with fatal results.

When grown to a sufficient size they leave their temporary hosts, and as this may occur in some distant pond, this feature in their life story helps to distribute them widely in places inhabited by water-fowl, such as the meres at Ellesmere.

23.October.1954

GIFTS TO A MUSEUM

It often happens that one finds some plants or animals which one is unable to identify, and on occasions I have sent these queries to the National Museum of Wales to enlist their expert knowledge.

Sometimes it happened that the Museum did not have a specimen of the particular organism, so they retained it, sending me a letter of thanks for the ‘gift’. Here are some typical examples, all headed:

AMGUEDDFA GENEDLAETHOL CYMRU

Dear Sir,

19.October,1949

I beg to acknowledge the receipt of: a hepatic (Blasia pusilla) and a moss (Dicranella cerviculata) for inclusion in the collections of the National Museum of Wales, and am desired by the Council to tender their best thanks for the gift.

Yours faithfully,
D. Dilwyn John,

Director

Dear Sir,

I beg to acknowledge the receipt of: 11.May.1950
a spider (Dolomedes fimbriatus) for inclusion .....etc.

Dear Sir, 5.June,1951

I have to acknowledge the receipt of 4 beetles:
1 Phytonomus arator; 1 Tachyporus solutus; 2 Harpalus aeneus; and 1 plantbug, Rhacognathus punctatus for inclusion.......etc.

Dear Sir,

I beg to acknowledge the receipt of: a specimen of Goranus subapterus for inclusion ………etc.

I never visited the Museum, but have promised myself that one day I will go, and see if I can find my 'gifts'!

HARDWICK POOL

This 'pool' or small 'lake' is quite near Hardwick Hall. To reach it one has to leave the road and walk alongside a ditch which runs along the edge of a meadow. This ditch is rather small and sluggish, but during wet summers marsh plants grow so profusely that they almost hide the water. Growing out from the water we found Hemlock Water Dropwort (Oenanthe crocata), Water Plantain (Alisma plantago-aquatica), Fool's Watercress (Apium nodiflorum) and Water Crowfoot (Ranunculus aquatilis). Plants growing on the muddy margins at the side of the ditch included Water Forgetmenot (Myosotis palustris), Meadowsweet (Filipendula ulmaria), the large Birds' Foot Trefoil (Lotus uliginosus), Marsh Bedstraw (Galium palustre) and Tufted Vetch (Vicia cracca). Although growing in a damp situation, the willow herb on the bank proved to be the Rose-bay Willow Herb (Chamaenerium angustifolium). Foxgloves were also present, while on bare patches in the field the Rayless Mayweed (Matricaria matricarioides) flourished.

The ditch led to a fairly extensive, silted up portion of the Pool, dominated at its outer edge by the Great Reed Mace (Typha latifolium) whose familiar brown heads were breaking down into untidy masses of ‘cotton wool’ consisting of seeds, each with a tuft of hair to help in wind dispersal. On the landward side of these plants the Yellow Iris (Iris pseudacorus) was fruiting, but most of this area was covered by plants of the Buckbean (Menyanthes trifoliata) - this was common in several places around the pool where the mud was just covered by water.

On the exposed mud and wet soil by the edge of the Pool we found Water Mint (Mentha sp.) not yet in flower, Brooklime (Veronica beccabunga), Lesser Spearwort (Ranunculus flammula), the unbranched Bur-reed (Sparganium simplex), Marsh Pennywort (Hydrocotyle vulgaris), water crowfoot and water forgetmenot. There were a few plants of the Amphibious Bistort (Polygonum amphibium) in flower here, but some distance out from the shore there were two large patches of this plant, its spikes of pinkish-red flowers standing upright amongst its floating leaves, producing a most delightful effect. After passing by a corrugated iron boathouse, built to hold a fishing punt, we found the Pool backed by a wood, but as the conifers which had been planted in it were quite young, there was an untidy undergrowth of bushes, brambles and nettles – and a plentiful supply of persistent, pestering flies!

The water contained an abundance of Cladoceran water fleas. We identified Simocephalus vetulus, Eurycercus lamellatus, Scapholeberis mucronata, var. cornuts, Sida crystallina, Pleuroxus aduncus, Ceriodaphnia pulchella. They were swimming around amongst the delicate foliage of the Whorled Water Milfoil (Myriophyllum verticillatum) and the Water Moss (Fontinalis antipyretica).

In the wood itself were other bryophytes; a hard, perennial bracket fungus was present on fallen willows; the flowers of the Skullcap (Scutellaria galericulata) were plentiful; and the ‘bean gall' was common on the willow leaves, and the leaves of the alder were peppered with minute galls. At one point we walked through a dense, whirling swarm of winged greenfly.

Emerging from the wood we continued our circuit of the shore which was now rather open, being bordered by only a few marsh plants and a single line of trees. The shoreline was littered with fairly large shells of the Swan Mussel (Anodonta cygnea), and by walking into the water a short way out from the shore we were able to get live specimens out from the mud where they live with their shells more than half buried. We had a good view of a Heron (Ardea cinerea) flying over the Pool demonstrating its powerful, unhurried wing beats.

Our last find was the beautiful green alga, the Water Net (Hydrodictyon reticulatum). It looks anything but beautiful at a distance, appearing as a yellow to green, frothy mass of scum at the surface of the water, but at close quarters it can be seen to form a fine oval network; through the low power lens of the microscope it looks like fine lace, and at greater magnifications it resembles wire netting. The 'cells' forming the sides of each mesh form even more minute nets when they reproduce, so that there is a colossal increase in numbers at this time. Before the influx of pleasure cruisers it was very plentiful in the Ellesmere Canal, almost choking it up and necessitating its removal by workmen from the Canal Depot.

July, 12, 1952.

THE VICISSITUDES ATTENDING THE LIFE OF THE LARGE WHITE BUTTERFLY

The Large White Butterfly lays its eggs in batches on the undersides of the leaves of plants in the Cabbage Family. Although well hidden quite a number are discovered and devoured by birds, or are killed by the spraying activities of man. The caterpillars become more conspicuous as they get larger and suffer from the attacks of birds, but even those who escape are by no means safe.

As they are defenceless in the pupal state, the caterpillars start climbing up fences, posts, walls, etc., to find a safe hiding place for pupation. They are able to negotiate rough or smooth surfaces, and it is fascinating to watch them climbing up a window by spinning a silken ladder; moving their heads from side to side they spin a close, zigzag path for a short distance; then they climb up this; and continue in this way across several feet of glass. When they get to the eaves of the roof or the cross bar of a fence, the caterpillar sheds its skin for the last time, and suspends itself as a motionless pupa.

However it is by no means certain that all the caterpillars will pupate, because some 10% are attacked at a younger stage by an ichneumon fly parasite called Apanteles glomeratus. The female parasite possesses a long, flexible ovipositor, and with this she-pierces the caterpillar's skin and lays up to a hundred eggs inside the body of the caterpillar. From these eggs hatch out grubs which feed on the fat bodies of their host, but avoid any vital organs until they are full grown. At this latter stage the caterpillars would normally pupate, but the parasites now eat everything and emerge from an empty caterpillar skin.

I have watched the emergence of the grubs, and also watched while the parasites spin golden yellow cocoons around themselves as they pupate, so that finally we find the caterpillar skin in the midst of a pile of silken cocoons. If some of these are put into a tube stoppered with cotton wool, the adults of Apanteles glomeratus may eventually emerge - but, on the other hand, they may not!

While the Apanteles grubs are busy feeding inside the caterpillar they are likely to be attacked themselves by another, even smaller ichneumon fly called Hemiteles fulvipes. This also has an ovipositor and it uses it, not only to pierce the caterpillar's skin, but the bodies of the Apanteles grubs within.

We might imagine that when the large white butterfly had successfully pupated its troubles would be over, but not a bit of it! A tiny Chalcid wasp called Pteromalus puparum may be waiting nearby. It will not attack the caterpillar, but waits patiently for pupation to take place, and then lays her eggs inside the pupa.

Even when the adult butterfly emerges, a number of them fall prey to the attacks of birds, and it has been calculated that out of every 10,000 young caterpillars only about 32 butterflies result.

15.Sept.1955.

ELLESMERE'S GREAT PLANT RARITY - THE LEAST YELLOW WATERLILY

The British Botanical Society undertook the long, laborious task of mapping every flowering plant in the British Isles. The resulting large book had four maps of the British Isles on each page, each map representing the distribution of a particular flowering plant species by means of dots. In some cases the plant was so common that the whole map was virtually covered by dots, but in the case of the Least Yellow Waterlily (Nuphar pumila) there was only one dot for the whole of England, and that was at Ellesmere. There were a few other dots which showed that it occurred also in Merionethshire in Wales, and in some Scottish lochs.

Naturally this was a rarity which must be visited, so I and my son obtained the use of a boat from the boathouse on Kettlemere with the idea of making a thorough survey of the neighbouring Blakemere, the two meres being connected by a narrow channel.

We negotiated the channel, passing under a wooden footbridge (now no longer present) and arrived at Blakemere in the midst of a patch of yellow waterlilies having such small flowers that we thought they must be those of Nuphar pumila. However, they were not, and I am inclined to believe that they were the hybrid form Nuphar x intermedia. None of the waterlily flowers found on Blakemere were larger than 3.8 cms. and there were flowers of every size between this and the 1.5 – 3.5 cms. range, typical of Nuphar pumila. The flora gives the size of the normal Yellow Waterlily (Nuphar lutea) as 4 - 6 cms.

Going southeast we started our circuit of the mere, and it was not long before we came upon our first patch of undoubted Nuphar pumila. Besides its tiny, relatively inconspicuous flowers, looking somewhat like fleshy buttercups, it has leaves which are quite characteristic. They are small, not exceeding 5" in length, and the two lobes of the leaf do not overlap as they do in Nuphar lutea. The flower and leaf stalks are at least 5 feet in length, and are very flattened, like thin straps.

The chief characteristic, however, is a floral one; 8 - 10 stigmatic rays reach the ends of the scalloped lobes on the upper surface of the pistil, whereas in Nuphar lutea there are 15 - 20 stigmatic rays which finish before reaching the circular edge at the top of the pistil.

It was noticed that Nuphar pumila generally occurred in deeper water than the other kinds of waterlilies, growing on their outer margins. The largest patch occurred in the mere close to the point at which the canal towpath changes its direction.

August.7.1951

Not only is Nuphar pumila restricted to Ellesmere, but it only occurs in two of its eight meres, the second being Colemere. As it grows further out than the ordinary yellow waterlily, it cannot be obtained by wading, but only by swimming or in a boat. The meres at this date were privately owned, and we had to obtain permission in order to use the very heavy fishing punt needed to reach the waterlilies. However, it was worth the effort because we found two very extensive areas covered by Nuphar pumila in flower, and were able to photograph them at our leisure.

In the interests of conservation these sites must be protected. Fortunately, the flowers are not particularly beautiful, and so do not attract attention. Further, as a boat must be used to reach them, and as the boat and the mere are privately owned at the moment, this is a further deterrent. On the other hand, a yachting club has been established on Colemere, but the course marked by buoys avoids the plant sites, and most yachtsmen are more keen on sailing than on collecting wild flowers, so that we hope this rare plant - which may have grown in the meres almost from the Ice Age - will remain and even increase in numbers.

1958

'FAIRY RINGS' ON THE COLLEGE LAWNS

The 'lawns' of the inner quadrangle at Ellesmere College had not been cut for some time, and various fungi began to appear. An interesting feature was that many of them formed well-marked 'fairy rings', some only a few yards from the Biology Laboratory, about six feet in diameter, with other smaller and more irregular rings or segments scattered around on the lawns.

The formation of a 'fairy ring' needs undisturbed lawns or meadows, with a soil containing sufficient humus to provide food for the fungi. As the original toadstool grows it puts out threads ('hyphae') which radiate equally in all directions, provided that the soil varies little in composition, and thus cover a circular area completely by the end of the season. In Autumn the vigorous outer hyphae give rise to toadstool 'fruit' arranged in a small circle. The hyphae at the centre die off as they have exhausted the available food.

The next year the circle expands as fresh hyphae are formed, and another circle of 'fruits' are formed during the next Autumn; and this process is repeated year after year.

It often happens that the 'fairy ring' is made more conspicuous by consisting of three zones; an outer zone where the grass is more vigorous and greener than usual; a middle zone which is paler in colour and may be almost bare; and an inner zone also vigorous and green. In these cases it is suggested that the outer zone is caused by the fungal hyphae feeding on the organic matter in the soil, and during this process changing some of the protein into amino acids and ammonia, and by bacterial action into nitrates. These nitrates stimulate the growth of the grass. The same results are obtained in the inner zone by the bacteria acting directly on the dead hyphae. The bare middle zone contains a weft of dead hyphae so dense that the rain does not penetrate and so provides unfavourable conditions for the growth of the grass.

There were about ten different kinds of toadstools present and not knowing any of them I decided to send specimens to Mr.Wade at the National Museum of Wales, hoping that they would arrive in a recognisable condition for identification. It is one of the disadvantages of studying fungi that a large number of them soon putrify, making it impossible to store them in an easy fashion. However, I had a prompt reply, and learnt that there were four different species of Hygrophorus present amongst the fungi sent. These were:

Hygrophorus pratensis - the skin of the cap ('pileus') was light brown with cracks, and the gills almost white and decurrent, i.e. running down a little where they joined the stalk ('stipe').

H. virgineus - pure white, with pileus reflexed in an upward direction to form almost a cup. The gills markedly decurrent.

H. coccineus - bright red, small, and waxy in appearance.

H. obtusseus - like the former, but dull egg-yolk in colour.

The other species were:

Lactarius deliciosus - fairly large, brown pileus, with concentric, scale-like markings. Gills decurrent and yellowish-brown.

Russula sp. (possibly alutacea) - pileus fairly large, dull purplish-red in colour. Gills yellow, and stipe white

Pluteus cervinus or (Entoloma sp.) Large, dull grey-brown pileus, forming a 'fairy ring' close to Lab.

Clavaria fastigiata - This was not a 'cap-fungus' like the others, but formed tiny clumps of bright yellow branches only a few inches high, resembling miniature stag’s antlers.

30. Sept. 1950

A VISIT TO THE CHIRK FISHERIES

Another visit by the college Field Club, this time to the Chirk Fisheries, which are situated in the lovely valley of the river Ceiriog not far from the place where its wide meadows are spanned by Telford's canal aqueduct (opened in 1801) and Robertson's railway viaduct (opened in 1848). The river Ceiriog forms the boundary here between England and Wales, and as the valley narrows quite suddenly we find the hilly slopes are wooded on the Shropshire side, and bracken covered on the Welsh side, with Chirk Castle partly visible over the brow.

In the space between the road and the river Ceiriog we find a series of fish ponds. Water leaves the river at a weir, and flows along a level, prepared channel until it reaches the fisheries. After entering the first series of ponds, the water overflows into the second series, and further series, until, its work done, it enters a stream which leads it back to the river at a much lower level. Gravity supplies the motive power, so that a continuous flow of water is maintained without the need for any pumping machinery.

This concern has been in existence for over seventy years, and is now a Limited Company, with a number of branches in other parts of the country. The foreman took us round, informing us that they hatch out and care for only three kinds of trout - Brown Trout, Loch Leven Trout and Rainbow Trout.

Fish from Chirk are sent by lorry to restock rivers, lakes and ponds in many localities in the British Isles. To keep them alive on the journey the containers are fitted with carbon tubes through which oxygen is forced from a cylinder in order to aerate the water adequately. No food is needed en route, although they have to be fed daily while in the fish ponds.

The rapidity of modern air transport enables developing eggs to be sent all over the world, to such destinations as India, Canada, Australia and South America. Although not sent from Chirk these eggs are sent from other branches by packing them in shallow trays with damp moss on the bottom' one, then a tray with eggs on top of this, and the upper tray packed with moss and ice. As the ice melts slowly it keeps the eggs supplied with well-aerated, ice-cold water, so that they can 'cross the line' quite safely and arrive none the worse for their experience on the other side of the world.

The ponds teem with fish, one pool containing over three thousand. When our guide wanted to show us some fish at close quarters he had some chopped fish thrown into the water; at once the water 'boiled' with surfacing fish, and on pushing a net quickly underneath he was able to lift out a flashing, frenzied mass of trout, lashing their tails and arching their bodies this way and that so rapidly that the eye could hardly follow their movement.

A strange fact is that trout of the same age often differ markedly in size, due to the prevalent habit of cannibalism, and periodically the ponds are emptied and the fish sorted out for size before returning, in an effort to keep the fish in any one pond approximately the same size.

The food of the trout differs with their age. At first finely divided liver gives the best results; later, freshwater shrimps and water fleas; and later still coarsely mashed fish; also pellets of biscuit-like material.

Next we entered the Hatchery. This building contains shallow concrete troughs arranged in a step formation, so that water flows down through them in succession. Each series is at table height, and we walked on duck-boarding raised off the floor owing to the inevitable wetness.

The water needed for hatching purposes must be fairly cool well aerated and fast flowing; it is obtained from a spring across the road, and is quite pure, maintaining an even low temperature during the whole year.

Trout spawn when they are three years old during November and December. When the 'hen-fish' is 'ripe' the eggs can be gently squeezed out from her, some 750 eggs being produced for each pound of body weight. Then the 'milt' from several 'cock-fishes' is squeezed out over the eggs, and the whole well mixed. Water is added, and after standing a while the eggs are washed free from any adhering milt.

The fertilized eggs are now placed in rectangular containers made of perforated zinc which have been coated with pitch. These containers, each containing about three thousand eggs, are placed in the shallow concrete troughs so that the running water flows through them and over the eggs. They are covered by canvas frames until they hatch, to keep out most of the light. The eggs of the Brown Trout are pale yellow; those of the Loch Leven Trout light orange; while the Rainbow Trout's eggs are reddish-brown. The time of hatching varies with the temperature but at 46 F. the first two kinds take seven weeks, while the Rainbow Trout hatches out in six weeks.
When almost ready to hatch the eyes show through the translucent egg membrane as two dark spots; the name 'eyed-ova' is given to this stage.

Any unfertilized eggs turn opaque white and these, and the empty membranes shed after hatching, are easily seen against the dark background of the blackened perforated zinc of the containers and are removed daily.

We purchased eyed-ova and kept them in flowing water in the Biology Laboratory so that we could study the early stages of development. The newly hatched trout, called 'alevins' are strange little creatures, with a heavy food bag or 'yolk sac' attached. At first they can hardly get off the bottom and their greatest exertions result in their 'taxi-ing across the tarmac', for all the world like some over-loaded bomber aeroplane unable to become airborne. As the days go by the yolk sac becomes smaller and the young trout larger as the food is transferred from the sac to the body and they can make rapid dashes through the water.

Another fascinating feature is the alevin's transparency at this stage. The complete circulation of the blood can be seen under the microscope, the red corpuscles tumbling along the fine capillaries of the yolk sac into the larger vessels leading the blood to the heart; on to the pulsating gills to be aerated; and then down the body to the tail where it is returned to the heart by another vessel.

Highly branched black pigment cells are present in the skin, very few at first, but increasing rapidly in number until their interlacing branches form an opaque screen completely hiding the interior from view.

The yolk sac suffices the young fish for three weeks, but then they have to be fed on finely minced liver. After three months in the hatchery they are put into the ponds outside.

Under natural conditions the 'hen' trout makes a hollow in the gravelly bed of the stream, and empties her eggs into it. After fertilization of the eggs by the 'cock' fishes, the gravel is flicked over the eggs until they are hidden. However, there are many enemies; eels may wriggle into the gravel 'redd' and devour the eggs; the dipper may submerge and devour her quota as well. The young fish may be eaten by herons, kingfishers and otters, and no doubt the human poachers may catch some of the larger fish. If they escape all these hazards the trout may expect a life of about seven years. In one pool we saw some trout of this age which were about two feet long, and a fisherman's dream!

December, 1957

HOW DEEP ARE THE MERES?

Although Ordnance Survey maps on the scale of 1:2500 (approximately 25 inches to 1 mile) give accurate outlines of the meres, they do not show any depths. The only information about depths came from local fishermen. The College Field Club thus had a ready-made project to tackle, namely a bathymetric survey of The Mere. To gain a rough idea of the depths we used a rope on which coloured wools were tied at one yard intervals; a weight was attached and the weight lowered at various locations in The Mere; the results obtained did serve to show that there was a very deep hollow at one place, and that the bottom was very uneven.

The problem of getting accurate figures involved two problems: (a) devising a convenient and rapid depth-sounding apparatus, and (b) fixing our position on the map.

The first problem we solved by visiting the local cycle shop and obtaining an old cycle wheel and front-fork. The heads of the spokes which projected slightly into the hollow rim were filed flat. Then a length of telephone wire was marked in feet and inches and bent tightly round the hollow rim; these markings were transferred to the underside of the rim with white paint. The foot intervals were numbered and the '0' indicated by a broad band of white.

The fork was firmly fastened in a block of wood, and short lengths of board fastened to each side of the block and projecting below it, so that the gap left allowed the whole assembly to be slid over the end of the square-ended boat then available. Two tapering wedges held it securely in position.

To use this apparatus one boy had a spool of telephone wire (borrowed from the C.C.F.) and he let this out over the cycle wheel, until the attached 10 lbs. weight just touched the water. The wheel was then adjusted until the '0' band on the rim was situated between the forks. At the word 'Go' the wire was run out from the spool until the sudden slackening announced that the weight had hit the bottom. The number of complete revolutions of the wheel were counted and any extra distance read off from the scale.

Now for the second problem. Our solution was to have a second boat alongside the first, in which two boys were equipped with prismatic compasses. At the word 'Go' they took bearings on predetermined points, such as the Church, a boathouse, the corner of a field, etc., chosen so that the bearings were as nearly as possible at right angles to each other. To avoid errors due to drifting when a strong wind was blowing, we let down the weight in a matter of seconds.

Using this apparatus we spent a number of afternoons getting data, and twenty depths was the average for any one occasion. Having recorded our data we had to plot it on the map. To do this we had first to correct the magnetic north readings to true north readings; and then convert these to back bearings so that we could draw lines from our two reference points - where these two lines crossed on the map was the position of our sounding. Although we did not get as many results as we really needed owing to considerations of time, we did show quite definitely that there was a very deep hollow where our deepest sounding was 65 feet. The depths at the southern bay end and on the near side of the island were only about 3 feet to 9 feet, but the depths elsewhere were very irregular, often varying between 9 feet and 30 feet within a horizontal distance of 30 feet. The general picture which emerged for most of the mere was a hummocky bottom with depths of 20 feet to 30 feet quite common.

Not only was Preston Montford Field Centre interested in our findings, but so was Liverpool University, and in 1965 M. Birley and his assistant brought an echo-sounding apparatus and verified our findings.

Summer 1964

LEAVES AND LEAF MINERS

In olden times coal miners often had to work narrow seams of coal, hardly wider than themselves, so that they had to lie flat and wield a pickaxe in front of them. A procedure originated by man? No, insects had been evolved long before man appeared on the scene, whose larvae lived in similar conditions; the main differences being that it was ‘food’ which was excavated, and built in mouthparts replaced the ‘pick’. These insects are so small that they can live the whole of their larval life inside a leaf, thus they are referred to as leaf miners.

In order to understand their mode of life some information must be given about the structure of a deciduous leaf. First it must be realised that leaves are 'food factories', food being manufactured from water, salts and carbon dioxide gas in the green cells of the leaves. The cells must contain green chlorophyll and receive an adequate amount of sunlight.

To spread out the chlorophyll to catch the maximum amount of light, the leaves are paper-thin. Further the green cells are much more closely packed at the upper surface of the leaf which faces the light; here they are covered by a single layer of transparent cells (the 'upper epidermis') which also tends to cut down the loss of water from the leaf. Most of the food making takes place in this upper 'palisade layer' of cells.

The lower part of the leaf is occupied by a more open meshwork of cells called the 'spongy layer' which has plenty of airspaces to allow for the free transference of gases. It is bounded below by the transparent lower epidermis which has hundreds of thousands of adjustable pores called ‘stomata’ for controlling the entrance and exit of gases.

Obviously, such a thin and delicate structure needs support, and this is where the veins come in. Entering the leaf we have the main vein or midrib; this has branches which branch and branch again, until the finest branches reach small packets of a dozen or so cells. Not only do the veins provide support but they act as conduits bringing water with salts in solution up from the ground to the leaves. They nearly always are confined to the spongy layer where there is more space and less resistance for them to spread.

Now for the leaf miners. There are four main groups of insects to which they belong; these are the <u>Lepidoptera</u> (tiny moths), <u>Diptera</u> (two-winged flies), <u>Coleoptera</u> (beetles) and one section of the <u>Hymenoptera</u> (sawflies). Those members which have adopted a leaf mining existence are naturally very small, and they have become modified in various ways to suit this mode of life.

Some miners feed on the palisade layer, others on the spongy layer. Some may start off in one layer and later transfer to another. Their activities remove the green cells, but leave the transparent epidermis. If both palisade and spongy layers are removed, then we can see an almost colourless 'mine', although this will be less clear if only one of these layers is removed. The mines are of two types, (a) the <u>'blotch mine</u>' which occupies a patch-like area, and (b) the <u>'serpentine mine</u>' which starts off as a tiny mine near the point where the larva hatches, and then wanders about the leaf in a snake-like fashion, getting wider all the time, and finishing up in a 'pupation chamber'. During the early stages of growth if a large vein is encountered the mine will run alongside it until it has become thin enough for the larva to slip by. Most serpentine mines are made by single larvae, but blotch mines may result from the communal activities of several larvae.

Now for those leaf miners which I have encountered. One of the commonest mines is made by a dipteran insect in the leaf of the Dock. Its larva resembles an ordinary housefly maggot in miniature, and has eleven segments to its body which is almost transparent, apart from its mouthparts which are black, horny structures. The very tiny toothed portion can rock on the next rod-like portion which ends in three projections to which the muscles are attached. Putting a leaf with its mine under the microscope one can see through the transparent epidermis sufficiently well to see these mouthparts oscillating rapidly to and fro like a metronome, as the larva scythes its way through the green cells ahead. The cells are ingested, and the excreta (called 'frass') is left behind as tiny black pellets, whose arrangement in the mine is a help in the identification of the miner.

It is fascinating to watch the feeding process and the rapid disappearance of the green cells, and on one occasion I saw three larvae side by side, inevitably reminding one of the song ‘Three men went to Mow’! The extraordinary flexibility and restlessness of the head movements was most noticeable as the head advanced, retreated and probed like a wobbly jelly.

At Whitemere I noticed the leaves on some beech trees had mines in them which started at the midrib of the leaf, and at first were serpentine mines with a central line of frass particles; then they broadened out forming blotch mines which reached the edge of the leaf. These were full-depth mines, reddish brown in colour, which showed up clearly against the dark green of the rest of the leaf. Inside the blotch portion of the mine a number of leaves had whitish cocoons, and on keeping these for a time I finally obtained the adult leaf miners. These proved to be little beetles known as <u>Rhynchaenus fagi</u>. Three days later I found the same leaf miner, again in beech leaves, from trees on the Wrekin.

16.June,1967

Another dipteran miner occurred in my garden on culinary peas. They formed serpentine mines which started at the upper surface of the leaf where the palisade layer was being eaten. At first sight I could see no larvae in these mines but on holding the leaf up to the light it could be seen that a short while before pupating the larva left the palisade layer and continued its mining activities in the spongy layer. Several pupae were present in the terminal enlargement of the mine. An interesting feature was that the lower epidermis was punctured to allow the pupa's 'breathing horns' to project into the air.

30.June,1953

Again at Whitemere I found a microlepidopteran moth, Lithocolletis messaniella which was responsible for the mining of the leaves of the evergreen Holm Oak (Quercus ilex). The tree was completely disfigured by the abundant mines, as the epidermis had gone brown and dead over the mines, the rest of the leaf being a blackish green. The light green new growth was only just beginning.

Many of the mines had empty, black, split pupa capes projecting at right angles to the surface, but in some mines I found black pupa, which wriggled their abdomens as soon as I extracted them, although the rest of the pupa remained still. Obviously I had come across these mines at a late stage, as most of the owners had already emerged. Consulting an expert, Mr. E.H.Wallace Pugh, I learnt this moth's identity. The few adults which had emerged had tufted fringes on their heads, while the forewing had narrow, but typical lepidopteran scales; there was also an abundance of hail-like scales, and long antennae.

I did find one larva. It was rather flattened and tapering with a black, horny head projecting forwards. The thorax was whitish with three pairs of stumpy legs, each having two joints.

There were only three pairs of prolegs on the yellow abdomen which consisted of nine segments.

In three cases the mines contained a white silken cocoon quite different from the normal black pupal case, and from it emerged a hymenopterous parasite. This enemy must have pierced the wall of the mine by means of its ovipositor and laid eggs inside the body of the leaf miner caterpillar.

8·June,1967

In conclusion I might mention that the lilac tree in my garden also housed a leaf miner called Gracilaria syringella. Again it was the caterpillar of a tiny moth, several being present in each blotch mine. The affected parts shrivel and turn brown. However, after a while, the caterpillars leave the mine and continue to feed outside the leaf, which they roll so as to form a funnel like shelter.

BELL ANIMALCULES

The Victorians had no radio, T.V. and even a show of lantern slides was a rare event. There were no motorcars or aeroplanes, so that travel was restricted to horse-drawn transport. This meant that there was a greater emphasis on home entertainment of a more personal kind. One activity which became popular was the examination of pond life and 'infusoria' under the microscope by those who could afford to buy one.

The discovery of a complete new world beyond the reach of the naked eye takes us back to the time when the Royal Society ordered the printing of a book by Robert Hooke entitled 'Micrographia' or some physiological descriptions of minute bodies made by magnifying glasses with observations and inquiries thereupon'. This book was published in 1665.

Hooke had a virgin field to exploit, and we find his observations range over such subjects as 'Of the point of a sharp, small needle', 'Of the edge of a razor', 'Of fine lawn or linnen cloth', 'Of some phenomena of glass drops', 'Of fiery sparks struck from a flint or steel', 'Observations in figur'd Snow', ‘Of charcoal, or burnt vegetable’, ‘Of the texture of Cork’, 'Of blue mould', ‘0f moss, and several other small vegetable substances', 'Of the surfaces of rosemary, and other leaves,' etc., etc.

Hooke's microscope was of the simplest construction, as were those used by the Dutchman Antony van Leeuwenhoek, a draper with a scientific bent who became a 'Corresponding Member of the Royal Society' so that most of his discoveries have come down to us in the form of letters, one of the earliest being written in 1674. Letter number 18 is in Dutch and covers 17 ½ folio pages closely written. It contains observations on rain water, river water, well water and sea water; on pepper water; on vinegar; ginger water; and nutmeg water; describing the ‘animalcules' he saw with the aid of his microscope, which was only a tiny, single, biconvex lens.

One of the ‘little animals’ Leeuwenhoek observed in rain water was undoubtedly Vorticella. This belongs to the primitive Protozoa (meaning ‘first animals') which are microscopic, unicellular and transparent. Vorticella is shaped like a bell attached to a long, delicate stalk which anchors it to some support. Around the rim of the bell there are vibrating protoplasmic hairs or -cilia- giving the appearance of a rotating wheel. With our modern microscopes it is easy to see particles and minute plant cells becoming caught up in the ‘vortex’ at the centre and getting engulfed.

When disturbed two things happen. Firstly, the rim of cilia is tucked in so that the bell becomes globular, and secondly the long, thin stalk suddenly coils up into a tight spring, thus bringing all the bells down quickly into close contact with each other. However, the stalk soon uncoils once more, and then the rim of cilia reappears. This was described by Leeuwenhoek as follows:

"whereby their whole body then sprang back towards the pellet of the tail, and their tails then coiled up serpentwise, after the fashion of a copper or iron wire that, having been wound close about a round stick, and then taken off, kept all its windings"

Many books were published during the Victorian era, and in an attempt to popularise the subject, these Protozoa were referred to as ‘animalcules’ and named according to their resemblance to common objects. Thus <u>Vorticella</u> was known as the ‘Bell Animalcule’, <u>Paramecium</u> the ‘Slipper Animalcule’ and <u>Lionotus</u> the ‘Swan Animalcule’; while those microscopic creatures which appeared as a result of making ‘infusions’ of hay, dead leaves, etc., in water, were lumped together as ‘Infusoria’.

<u>Vorticella</u> is ubiquitous, and is found in large numbers forming white, furry coatings on dead twigs, or attached to clumps of planktonic algae, and is often found completely smothering waterfleas or rotifers. It has been described as being ‘so long beloved of the amateur microscopist’, and it is certainly a most attractive sight to watch the scene of constant activity presented by these animated bells.

On one occasion we noticed that the leaves of the water violet in the school aquarium had patches of white ‘mould’ growing on them, but on examining a portion of the 'infected' leaf we saw that the 'mould' was a colonial form of the bell animalcule known as <u>Carchesium</u>, and not a mould at all. It was even more fascinating to watch than a bunch of individual <u>Vorticella</u>, as the colony formed an extensive system of branches radiating out from one stalk, each stalk bearing several 'bells', and these stalks were all contractile. When expanded the colony was over ½ inch across, and thus visible to the naked eye, but a sudden contraction of all its branches makes it almost disappear. It can be found in foul smelling ponds or sewage effluents where few other organisms can survive, and obviously must be feeding on the abundant microbes present in these situations.

Yet another 'bell animalcule' is found in the clean water of the meres. This is <u>Epistylis</u>, and consists of a small number of bells attached to a system of branching stalks. It may be attached to dead twigs, stones, etc., but I have found it in the meres attached to waterfleas or free swimming. Apart from its smaller size it differs from Carchesium in that its stalks are not contractile, and that it branches by equal dichotomy.

NATURE THOUGHT OF IT FIRST:- THE SUBMARINE, DIVING SUIT AND DIVING BELL.

(a) NATURE'S SUBMARINE - THE PHANTOM MIDGE (CHAOBORUS)

This midge frequents the edges of the meres and ponds, and its minute eggs are embedded in a thin, circular, transparent disc, about ¼” in diameter. To the naked eye these discs look like drops of dirty oil floating on the water, but under the microscope it can be seen that a large number of minute, oval eggs are present, arranged in a spiral formation - I counted 267 eggs in one disc.

When the eggs hatch they give rise to larvae which are so transparent, that they have earned the name of 'phantom larvae'. This invisibility both helps the larva to avoid attack by predators and to capture its prey more easily, for it is of a carnivorous nature and quite fiercesome for its size.

It is very difficult to spot in an aquarium as it remains quite still for long periods, but when it does move it does so in a flash, and it can then be detected.

The only part of the larva which is not transparent is a small pair of air sacs towards each end of the body, which have dark, star-like markings covering them. They form part of a remarkable adaptation which allows the larva to float at any depth, so that it can please itself whether it preys on water fleas near to the surface of the water, or descends some thirty feet to catch bloodworms.

This alteration of flotation level is brought about by an alteration in density, air from the air-sacs being dissolved in the blood to increase the density, and being released from solution into the air-sacs to decrease it. We might refer to the larva as 'Nature's submarine' because a submarine rises when compressed air replaces water in its ballast tanks, and sinks when the reverse operation occurs.

This effect can be shown by a toy named the 'Cartesian Diver' (named after its originator, Descarte). All that is needed is a small tube in a bottle of water. The most difficult part is to introduce the right amount of water into the tube by trial and error. Once this is done, a slight pressure on the bottle's cork will be transmitted to the tube compressing the air in it, so that a minute amount of extra water enters the tube; this increases the density so that the tube sinks; releasing the pressure has the opposite effect. Once I managed to get everything so delicately balanced that I was able to make the tube sink by squeezing the glass bottle itself.

In all the cases mentioned the alteration in density is brought about by the alteration in the amount of air, although the way this is done differs in each case.

26.July.1949

(b) NATURE'S DIVING SUIT - THE RAT-TAILED MAGGOT, OR LARVA OF THE DRONE FLY (TUBIFERA; FORMERLY ERISTELIS)

Sometimes one finds stagnant pools, filled with rotting vegetation, and smelling to high heaven, and it comes as a surprise to find this situation has been chosen as a suitable habitat by the Drone Fly larva.

The Adult fly is a big two-winged fly, somewhat larger than a bee. Both fly and bee may commonly be found on such autumn flowers as michaelmas daises and other composites. Its scientific name is Tubifera, but until recently it was known as Eristelis.

It lays its eggs in the stagnant pools mentioned above, and these hatch out into maggots which feed on the rotting material present. In such situations the amount of oxygen dissolved in the water is virtually nil, and the question arises - how does the larva manage to breathe?

The answer is a most extraordinary one. It has a telescopic breathing tube at the tail end of its body which can be lengthened or shortened in order to reach the surface where it is kept in contact with the air by five plumose setae which cling to the surface film of the water. Thus it is able to obtain a supply of fresh air while living in a habitat in which air is absent.

The level of the shallow, stagnant pool may become altered quite suddenly after a storm, but the air tube will extend for several inches to allow for the difference, although the body of the larva is only 2/3rds" long. If the alteration is too great then the larva will have to move towards the edge of the pool where it is shallower.

The possession of this air-tube has resulted in the name 'Rat-tailed Maggot' given to this larva, and it reminds one of the standard diving suit with its air-tube down which air is pumped to the diver working on the bottom under water.

<u>(c) NATURE'S DIVING BELL - THE WATER SPIDER (ARGYRONETA AQUATICA)</u>

This spider, although an air breather, spends more of its time under water than in air. Its body is covered with very fine downy hair which water cannot penetrate, so that when it dives under water its body looks a shining, silvery-white owing to the layer of enclosed air. This air will enable the spider to breathe for some time under water, but it has to come to the surface occasionally for fresh supplies of air.

For a permanent residence below the surface, an air-filled shelter is made in which it can live for months, because, as the oxygen is used up by the breathing of the spider more oxygen diffuses in from the surrounding water; similarly the carbon dioxide breathed out will diffuse outwards.

To make this air-chamber a platform of silk is spun and anchored to the surrounding weeds by threads of silk. Then the spider makes repeated journeys to the surface returning with a supply of air which it releases under the platform. Slowly the platform bulges upwards until it becomes bell-shaped, strikingly resembling an engineer's diving bell.

Sorties are made from this bell, and captured prey taken back to be consumed, while in summer the female lays fifty to one hundred eggs, enclosing them in a white egg sac at the top of the bell, and partitioning this part off. The young spiders thus have no difficulty in obtaining oxygen although they are under water - in any case they soon leave after hatching. A bell is also made near to the bottom of a pond where the spider remains in a torpid condition all winter until the following Spring.

The female spider is about half an inch long, the male being slightly larger. If kept in an aquarium, care should be taken not to include predators, and only one male and female should be present as they tend to be cannibalistic. They must be fed regularly on dead flies, waterfleas, and small aquatic worms and insects; and plenty of weed must be present if we are to have a chance of watching their ‘diving-bell activities’. Further a close fitting cover is needed to prevent their escape.

THE BRYOPHYTES (Liverworts and Mosses)

When the word ‘moss’ is mentioned what picture arises in your mind? Almost certainly you will think of a lowly kind of plant which never has flowers, is green in colour and covers the floor of damp woods, or is found growing on tree trunks, wooden fences, walls, damp rocks, or even submerged in water.

It is true that many mosses fit in with this picture, and Charles Darwin in his ‘Voyage of the Beagle’, described the wet forests of Tierra del Fuego where trees fell down when they died, and were not removed; where the heavy and constant rainfall encourage mosses to flourish, forming, huge, dense carpets over their remains.

On the moors and bogs of Scotland we find the heavy rainfall encourages the development of the Bog Moss (Sphagnum) so that it covers large areas of the ground; it is also found in pools, sometimes covering them completely so that they present a hazard to the unwary walker.

Mosses have a nuisance value when they flourish on a badly drained lawn, or round the edges of crazy paving. On the other hand the larger ferny types are often collected as interest to a potted plant or to keep moisture inside a hanging basket.

Their evolution goes back so many millions of years that they have had ample time to adapt themselves to many and varied conditions of life. I remember my surprise when walking amongst the coastal dunes at Ynyslas (near Aberdovey) to find areas of sand covered by a sward of mosses of more than one species. Other species can exist on bare rock where the sun beats down relentlessly and almost bakes them; while special adaptations are found in the genus Polytrichum so that it can grow in such inhospitable situations as peat bogs, or on mountain rocks.

While the group attracted me I was deterred by the absence of any known expert whom I could consult, and of any useful book on the subject, when I decided to make a serious study of bryophytes I wrote to the Secretary of the Caradoc and Severn Valley Field Club, L.C.Lloyd (now deceased) to find out if the Club possessed a ‘moss expert’. He replied that Mr. Wade of the Botanical Department of the National Museum of Wales (now retired) would be likely to help me. I joined the British Bryological Society and was helped to obtain a copy of ‘Dixon’s British Mosses’ – at that time the indispensable aid to the identification of mosses.

To start the ball rolling I examined a high, roadside bank, and it yielded a moss and a liverwort; and these I sent to Mr. Wade. It turned out that the moss was <u>Atrichum undulatum</u>, which has fairly large, delicate, undulate leaves. The microscope revealed that the leaf had pairs of teeth along its margin. The second specimen was a liverwort, <u>Plagiochila asplenioides</u>, the specific name referring to a superficial resemblance of the leaf arrangement to that in the Spleenwort Fern. From the top of a stone parapet of a railway bridge, I obtained the third specimen, a moss called <u>Grimmia pulvinata</u>, which formed small compact cushions; it had capsules on short stalks which were so bent over that they hardly projected from the cushion. To the naked eye it had a silvery appearance, due to the fact that the vein in every leaf was continued beyond the apex as a colourless 'hair point' for quite a distance.

These three specimens began my collection (which now amounts to over 150 different specimens) and I started collecting in earnest. One of the earliest places I visited was Boathouse Wood, alongside Colemere (since clear felled). My search yielded the following mosses:

<u>Thuidium tamarascinum.</u> A handsome moss with fern-like foliage, making it useful for decorating hanging baskets or floral displays.

<u>Mnium hornum.</u> One of the commonest of mosses, forming large clumps around the base of trees and the surrounding ground in woods. At first it is rather difficult to distinguish its different stages of growth, as it starts off with almost bud-like growth, and then opens out into rather broad leaflets, giving a somewhat feathery appearance to the fully-grown plant; some patches and large capsules on long stalks.

<u>Plagiothecium denticulatum.</u>

<u>Tetraphis pellucida.</u> Common on rotten tree stumps and logs. Capsules are uncommon and the plant spreads by means of 'gemmae' i.e. tiny bodies consisting of only a few cells, and borne in leafy cups at the ends of upright shoots. This feature is easy to recognise so that one can be certain of its identity.

<u>Polytrichum formosum.</u> This is one of the 'hair mosses', so called because the hood-like covering of the capsule is hairy. It is common in woods. The stiff, spirally arranged leaves stand out from the stalk, so that when a great many plants are massed together the appearance is that of a multitude of dark green stars.

Dicranella heteromalla. A small, delicate, rich green moss with very narrow leaves, easy to recognise when it is covered with an abundance of orange-brown capsules.

Funaria hygrometrica. When trees have been felled, and the chippings around their bases burnt, this moss is bound to turn up the following year. It has a rather pear-shaped capsule, and its cover (calyptra) is long and bent over sharply, reminding one of a bird with a long beak.

Ceratodon purpureus. Somewhat like Dicranella, but the stalks of its capsules are purplish-red in colour, and very numerous.

Dicranoweisia cirrata. A common moss on the bark of trees and on old fences as a rule. It forms close patches which have a close-cropped appearance; on the canal bridge at Colemere names have been carved out of the stone parapet, and this moss had filled the depressions with some green growth,

Identification may be difficult at first, as one had to work through dichotomous keys, and one mistake will bring you to a wrong conclusion. However, with practice, one can usually identify the genus, and this saves, a great deal of time. I find small, self-seal, polythene packets useful for collecting mosses in the field, and they can be obtained with a panel for writing on; they have the additional advantage that the specimens will keep for a week without deterioration, if one cannot attend to them immediately.

It is useful to keep a moss herbarium and keep a record book of one's finds. In time one gets to know how to relate a given moss to a particular habitat, and this avoids making bad mistakes, for instance a moss characteristic of limestone regions is hardly likely to occur in acid bog conditions; in fact mosses are sometimes used as 'indicator plants' to indicate the type of soil on which they grow.

Mosses can be stored in a dry condition in paper packets, and it is as well to decide on the size of these packets and the size of the box to contain the packets - some people use shoe boxes.

HELPING THE EXPERT

It sometimes happens that, without possessing an expert knowledge of a group of animals, one is able to help someone who is an expert. Dr. Reynoldson is an authority or the Flatworms (Platyhelminthes), and I offered to do some collecting for him in our local meres. This not only helped Dr. Reynoldson to sample these habitats more easily, but helped me by having the flatworms identified correctly.

He accepted my offer, and said he would like about 50 specimens collected at random from each of the meres, preferably where there was a shelving beach with stones, each specimen to be sent in a separate tube. This sounded like a lot of work! However, flatworms are tiny creatures, varying in size from half an inch in size; being nocturnal, they hide themselves during daylight under stones, bricks, pieces of wood, etc. A dozen or two may sometimes be found underneath a single stone.

The commonest flatworms belong to the <u>Tricladida</u> (= three branches) so called because the alimentary canal is divided into three main branches. This can be seen quite easily in the fairly large <u>Dendrocoelum lacteum</u> (= gut with tree-like branching; milky) which, as its name describes, is milky white in colour and has its brown gut divided into three main branches which then branch again. The other common genera, <u>Dugesia</u> and <u>Polycelis</u>, are brown or black in colour so that this feature cannot be detected. <u>Dugesia</u> has a white area surrounding each of its two black, dot-like eyes, whilst <u>Polycelis</u> (= many eyes) has many eyes arranged around the front part of its body.

I went down to the Cremorne Gardens by The Mere and did some 'stone-turning* at a place which had a fair amount of old building material, chiefly bricks, mortar and slates. Flatworms were present, although there were far more Freshwater Lice (<u>Asellus aquaticus</u>) and Leeches present. I packed about fifteen specimens and sent these to Dr. Reynoldson. In his reply he identified them as:

<u>Dendrocoelum lacteum</u>
<u>Dugesia lugubris</u>
<u>Polycelis hepta</u>

and gave the exciting news that <u>Polycelis hepta</u> was a new British record, and that a note about it would be appearing in 'Nature'.

On the next occasion I took some boys with me to collect 50 specimens. <u>Dendrocoelum</u> seemed to be more scarce than before and to favour the mortar rubble. Dr. Reynoldson's report stated that two species of <u>Polycelis</u> were present, namely P.tenuis (8) and <u>P.hepta</u> (5). He went on to say "I was most interested to note that there was a relatively heavy infestation of <u>Urceolaria mitra</u> (an epizoic peritrich) on the <u>Dugesia</u> [this means a member of the <u>Protozoa</u> with cilia arranged in a ring, which uses the flatworm as a support, but does not harm it in any way]. This is the first time I have seen this state of affairs, and as I am working on the host specificity of Urceolaria I am much intrigued".

One interesting feature of these flatworms is that, like Hydra, they have the power of regeneration of lost or damaged parts, so that by partially dividing the body into two by a cut through the head, a 'two-headed monster' may be obtained; if the cut is complete two flatworms are obtained in place of one. They glide along by means of the cilia which beset the whole body, helped by the slime from slime-glands. Although they look harmless enough they are carnivorous and can play havoc amongst ova or baby fish in an aquarium.

21. January.'54

GREENFLY AND ANTS

Greenfly have a winged distributive stage, but the gardener is more familiar with the wingless stage when they are found on his roses, beans or other garden plants. As greenfly are 'sap-suckers' they pierce the outer tissues of these plants and remain in the same place for a long time. After a time they reproduce parthenogenetically (='virgin birth', as the eggs develop without fertilization), and become surrounded by a considerable number of their offspring, in fact, their numbers may become so great that they harm the plant.

Nature meets this superfluity by visits of the ladybird beetle, as both in its larval and adult stages it feeds voraciously on greenfly. Other natural enemies of the greenfly are the larvae of the hoverfly, and the larvae of the lacewing fly. Man provides suitable plants for the greenfly to feed upon in such numbers that nature's methods for keeping the greenfly in check are not sufficient, thus he has to resort to spraying affected plants with soapy solutions, which kill the greenfly without harming the plant.

The greenfly does have some friends, however, and the best known are the ants. A continuous stream of plant sap passes through the greenfly, and a sugary solution drips out from the hind end of its body, often making the leaves of the plants sticky.

Ants have a great liking for this sugary solution and ascend the plants in search of it, sometimes encouraging the greenfly to produce a few drops by stroking it. This has led to greenfly being described as 'ant cows', and the ant's activities as 'milking'. There are some ants which take greenfly into their underground nests for the winter season, bringing them out again during the following Spring.

In my own garden I witnessed a procedure which could be compared with the keeping of cows in a field, for, on a large gooseberry, the ants had built a circular earthen rampart to prevent the greenfly present at the base of the fruit stalk from straying. Thus they knew that there would always be a sample of their favourite food in that particular spot. Also, while the ants were present, the greenfly's natural enemies would most likely avoid coming near.

15 July 1958.

P.S. Today my wife pointed out that the leaves at the top of the black currant shoots were all crinkled, due to the attacks of greenfly, and that there was a continuous procession of ants up and down the stems to 'milk' them.

2 August 1972

CROSEMERE AND SWEATMERE

1. CROSEMERE.

The appearance of the countryside around Ellesmere is the result of the happenings at the end of the last Ice Age. The geologists tell us that great glaciers advanced from the north of England, and others from Snowdonia, and met around Ellesmere. There were several advances and retreats of the glacial front as the temperature fluctuated, but in the end there was a general withdrawal of the ice, accompanied by the deposition of massive deposits of sand, and boulder clay, which completely covered up the sand stone bedrock.

As a result of these activities we find there is a very hummocky landscape around Ellesmere, and at one time the coach road leading into the town from the south ran along a morainic ridge, appropriately named - 'Sandy Lane'. Also one of hummocks is being worked commercially for sand and gravel by the ‘Ellesmere Sand and Grave1 Company’.

In these surroundings find eight of the deeper hollows between the hummocks have become filled with water to form 'Meres'. Their water level is maintained by ground drainage, as they have no sizeable inlets or outlets. The hollows which were shallower may have started off as meres but have become filled with bog vegetation to form the many Mosses.

Travelling southwards from Ellesmere towards Shrewsbury the hummocky landscape ceases just before we reach Cockshutt, and it is here that we find the last two of our eight meres, namely Crosemere and Sweatmere. At one time there probably was a large U shaped lake with a high ridge separating the two arms; at the western end of the ridge there was once an Iron Age fort protected to the west by a ditch, which must have joined Crosemere with, what is now, Whattall Moss. During drainage operations in 18?? a well preserved dugout canoe was unearthed on Whattall Moss and was exhibited in the museum at Ellesmere. When the latter closed the canoe was transferred to Rowley's House, Shrewsbury, where it can now be seen. These drainage operations one hundred years ago lowered the surface of the southern arm (Crosemere) and reduced the water level so that only a small mere remained at the eastern end (Sweatmere), while the northern arm gradually became converted into a Moss (Whattall Moss) which was later planted with conifers. The two meres and the moss are connected by drainage ditches.

Crosemere is a lake about 38 acres in extent and is about 30 feet deep in places. It used to be larger, but the drainage mentioned in the previous paragraph has left it surrounded by flat peat land, except where it laps against the gravel ridge. It is fairly isolated. At the western end the approach is by a boggy meadow whose black, peaty soil is pock marked by the hoof prints of cattle. As this mere is the most basic of the Ellesmere meres, the plants we find around it are typical of fens, rather than bogs, such as the Marsh Pennywort (<u>Hydrocotyle vulgaris</u>), Valerian (<u>Valeriana dioica</u>), Water mint (<u>Mentha aquatica</u>), Paniculate Sedge (<u>Carex paniculata</u>) and Marsh Arrowgrass (<u>Triglochin palustre</u>).

The succession from an aquatic flora to a terrestrial one is well shown at the western end. Furthest out from the shore we find both Yellow Waterlily (Nuphar lutea), 'White Waterlily (Nymphaea alba) and Curled Pondweed (Potamogeton crispus). Then a fringe of the Common Reed (<u>Phragmites communis</u>), in places preceded by the true Bulrush (Schoenoplectus lacustris), or mixed with the Lesser Reedmace (<u>Typha angustifolia</u>). The Common Sedge (<u>Cladium mariscus</u>) usually follows, and this introduces a fen community dominated by tussocks of the Paniculate Sedge (<u>Carex paniculata</u>) which may lead directly into an Alder carr or be bordered by fen meadow. The latter is heavily grazed and trampled. The carr has a fine stand of the Great Spearwort (Ranunculus lingua).

If we go eastwards along the north shore we find sapling alder trees on the landward side of the reed fringe, and three or four slatted platforms penetrating the reeds, built for the benefit of the fishermen (and also useful for the biologist for sampling purposes). After a time trees and reeds finish and we get a bare shore line which is both shallow and stony. Stone turning reveals flatworms and leeches, and sometimes caddis worms and leech egg cocoons. On one occasion I found the stones completely covered by algal growth due to the alga, Cladophora; on microscopic examination it was seen that the green alga was covered by the brownish-yellow diatom, Tabellaria. This appears like a succession of matchboxes joined together, but almost separated, being attached by their corners in a zig-zag fashion.

At the eastern end of the mere an ungrazed fragment of fen adjoins the outflow stream. It is here that we find the beautiful Grass of Parnassus (Parnassia palustris). It is not a grass and its attractive white flowers have petals with conspicuous veins; and alternating; with the five fertile stamens we find five staminodes looking like small petals from which 7-15 fine processes extend, tipped with yellowish glands. They remind one of miniature harps when viewed through a lens.

Further round we find the Marsh Helleborine (Epipactis palustris) attractively coloured with light green brown and purple; as well as the Red Rattle (Pedicularis palustris) and the Spotted Orchid (Orchis fuschii). These are relatively few in number and would rapidly become extinct if the ground were ploughed up, or if unthinking visitors pulled them up.

Not many people visit Crosemere, so that it is a haven for birds. Besides the usual gulls, swans, mallard, Canada geese and coots, we get the Black Tern, Tufted Duck, Great Crested Grebe, Pochard and Ruddy Duck. Reed and Sedge Warblers nest in the fringing reeds, while nests of the Coots are easy to find by the bases of the Alder and Willow only just above water level.

2. SWEATMERE

Sweatmere is most unimpressive as a mere, the open water being less than 100 yards across, and being almost silted up: but it holds a place of honour in botanical literature as it is given in Tansley's 'The British

Islands and their Vegetation' as one of the best examples of a hydrosere, i.e. a transition from aquatic to terrestrial vegetation.

Situated in the middle of an alder-dominated fen carr there are two large patches of Yellow Waterlily (Nuphar lutea) a floating raft of Lesser Reed Mace (Typha angustifolia) rhizomes unattached to the bottom - in this respect it is unique in Shropshire. It will support the weight of a moving man almost to the water's edge in summer, but it sinks down below the water's surface during winter.

The next zone is dominated by very large tussocks of the Paniculate Sedge (Carex paniculata), some of which are over a yard in height. The older tussocks bear an epiphytic flora. They finally become so unstable that they topple over. Alders and willows are also found as we proceed through this zone and some of these are also unstable in the miry, semi-liquid 'ground' in which they grow, as I found to my cost before I knew the best route to reach the edge of Sweatmere. I tried to follow the main drainage ditch from Crosemere, but had to admit defeat when I sunk almost to the top of my gum boots in the mire, and found that neither the sedge tussocks nor the alders gave firm support when needed.

As the ground becomes more stable, the wet, shady woodland conditions provide ideal conditions for a great variety of flowering plants; these include:-

Marsh Marigold (Caltha palustris)
Great Hairy Willowherb (Epilobium hirsutum)
Meadow Sweet (Filipendula ulmaria)
Yellow Iris (Iris pseudacorus)
Ragged Robin (Lychnis flos-cuculi)
Gipsywort (Lycopus europaeus)
Yellow Loosestrife (Lysimachia vulgaris)
Purple Loosestrife (Lythrum salicaria)
Skullcap (Scutellaria galericulata)

In fact, this zone is said to be one of the finest undisturbed alder-dominated fen carr known in this country.

Finally, on the landward side, the alders give way to birch with some oak before the wood ceases and we come to meadow land.

27 May 1972

PLANT GALLS

The oak tree provides a habitat for a great variety of insects, and some of the most interesting of these are the gall-making insects. The relationship between the insect and the oak tree is very specific, so that the galls produced are distinctive and usually easy to recognise. The oak tree galls provide a suitable introduction to the subject, and, later on, the field can be extended to include galls on other plants.

How do galls arise? They result when certain insects or mites lay their eggs in the buds of plants (fungi can also produce galls: what happens next I like to express in this way – “a plant cannot scratch itself or remove the irritation caused, so it gives rise to a proliferation of cells to cut off the irritant area from the rest of the plant". The result is known as a gall, and its particular form depends upon the interaction of the fluid injected by the insect and the plant.

The gall wasps on the oak have a most peculiar life history, most of them going through two distinct phases. During the first phase females only occur, and they produce a particular kind of gall; their eggs give rise to males and females in the next phase, and a totally different type of gall is produced by these females. This can be shown in tabular form as follows-

Life history of gall-wasps found on oak trees.

Phase I Unisexual generation of females only, whose eggs develop parthenogenetically in Gall No.l.

Phase II Bisexual generation of males and females; normal fertilised eggs produced in Gall No. 2.

It seems almost miraculous that the reaction of plant and insect produces a result so well adapted to both. Take the Spangle Gall. One may find oak leaves smothered with these flattened discs on the underside, each attached to a tiny stalk. They result from the egg-laying activities of the bisexual generation of Neurotus quercusbaccarum. In the centre there is a cavity just the right size to take a fully grown grub. This cavity at first was surrounded by a starchy layer serving as food for the grub; then by a hard protective wall; and finally by an outer layer studded with rosette-like hairs. The upper surface of the leaf is not affected so that food production can still take place. Towards the autumn the discs fall off in their thousands to remain in the leaf litter until the following Spring. The insects which then emerge are all females of the unisexual generation which attack the oak during the flowering time, giving rise to Currant Galls (so called owing to their shape, size and colour) on the male catkins and leaves; again each gall contains one grub.

On a visit to Glyn Morlas, near Chirk, we found three different kinds of galls on one oak tree in addition to the currant galls. The first was the familiar Oak Apple which results from the insertion of numerous eggs in the base of a bud, by the wingless females of the unisexual generation of Biorhiza pallida in early May. When mature, in June or July, the oak apple is spongy in texture, rose pink in colour, and about an inch in diameter. If cut in half with a razor blade it will be seen to be a multilocular gall with some 30 larval chambers, each containing one grub. Later, during the summer season the galls go brown and begin to shrivel, while the male and female adults of the bisexual generation emerge, leaving numerous exit holes. The two sexes develop in separate oak apples.

Mating occurs in July, after which the females penetrate the soil and insert their eggs inside rootlets. These give rise to root galls which are spherical, brownish and about 1/3 inch in diameter. They may occur in groups but each gall is unilocular. The larvae may take 16 months to mature, so that the adults do not leave until the second winter. They are all wingless females of the unisexual generation, and it may be wintry weather when they crawl up the trunks of the tree and out along the branches to lay their parthenogenetic eggs in the buds of the finer twigs, and so begin the cycle once more.

Oak Apple Day, May 29 commemorates the return of Charles II to this country on May 26 1660. It has nothing to do with his hiding in an oak tree after the Battle of Worcester, which was fought on September 3, 1651 – at this date the oak apples would be withered.

If this gall is kept over dry sand in a jar, the gall insects can easily be bred out. At the same time two other classes of insects may appear (a) parasites which lay their eggs in the gall wasp larvae, and (b) inquilines (=lodgers) which use the vacated cavities in the galls as shelters.

The second gall was the very well known 'Marble, or Bullet Gall'. It is spherical and about ½ inch in diameter and its colour passes from green, through light brown, to a very dark brown, while it becomes hard and woody with age. It is much more plentiful on scrub oak and young plants in hedgerows than on older trees.

It is really an introduced species, having been brought here in 1830 when galls were imported from the Middle East for dyeing and ink making on account of their tannin content. Aleppo galls were generally used in the making of blue-black ink, a blue dye giving an immediate colour, and the gradual oxidation of the tannin giving the permanent black colour.

The gall wasp emerging from the galls are all females <u>Andricus kollari</u>, forming the unisexual generation. It is not certain that a bisexual generation exists, although it is now claimed that it does, and that it arises from the <u>Ant Pupae Galls</u> found in the Turkey Oak.

Once again if we try to breed out the female <u>Andricus kollari</u> from bullet galls, we shall obtain parasites and inquilines, but we may find some galls partly broken open by the lesser spotted woodpecker in search of insects.

The third gall had an appearance of spherical lumps of cotton wool about an inch in diameter, and is known as the <u>Woolly or Cotton Gall</u>. It is multilocular giving rise to male and female gall wasps of the bisexual generation of <u>Andricus ramuli</u>. The galls they produce are known as the Autumn Gall and the unisexual generation emerges from them.

On another occasion I came across the <u>Artichoke or Hop Gall</u> produced by the bisexual generation of <u>Andricus fecundator</u>. Like the Bullet Gall it is more often found in hedgerow oaks than on large trees. It is about ¾ inch in length and has a superficial resemblance to a Hop flower as it consists of overlapping bud scales.

The larva is found in a tiny chamber inside, and may remain there until the following Spring, or even delayed emergence for two or three years, when the female of the unisexual generation appears. Her eggs are laid in the male catkins of the oak, and the resulting gall is known as the <u>Hairy Catkin Gall</u>. It is oval, pointed, uinlocular, and only a few millimetres in length, while its colour changes from pale green to brown as it develops; it is covered by whitish hairs.

Not all galls are formed by gall wasps, and we find the <u>Big Bud or Artichoke Gall</u> on the leaves of the Yew tree is produced by a tiny midge-like, two winged fly called <u>Texomyia taxi</u>. It causes the growing region to become arrested so that 60-80 terminal leaves are clustered to form a single gall. It contains a single larva: which pupates inside the gall and emerges about June. I must relate an anecdote here to show the importance of accuracy in biological drawings. Having bred out the fly from the gall I made a drawing of it using the microscope to get really accurate detail. Its fairly long antenna consisted of bead-like segments, and I drew as many as I could see. Years afterwards I came across a detailed account of the characteristics of this fly, and discovered that the male had twenty segments in each antenna, while the female had nineteen. Reference to my drawing showed that my specimen was a female.

One gall which is an object of beauty is the Bedeguar Gall, also known as the Moss Gall or Robin's Pincushion. When fully developed in August it gives the impression of a ball of moss, its crimson colouring showing up well against the green of the leaves of the Wild Rose on which it grows. It may contain up to 60 chambers each inhabited by one larva, the offspring of Diplolepis rosae, a gall wasp.

The gall turns brown and blackens as winter approaches, and the larvae overwinter as pupae inside them, the adults emerging in May of the next year. If these blackened galls are cut off from the bushes at the end of the winter and kept over sand in jars, the adults can readily be obtained. Not only do we obtain the adult gall wasps, but parasites and inquilines will also be obtained - and hyperparasites which parasitise the parasites!

Mites are responsible for many galls, and it is a common sight to find leaves of both sycamore and maple absolutely peppered with between 500 and 1,000 bright red pimple galls as a result of their activities. The mites responsible are said to be Eriophyes macrorhynchus cephalodes as the maple and Eriophyes macrorhynchus aceribus on the sycamore.

The last gall I will mention is the Witches Broom. It is caused by the ascomycete fungus Taphrina betulina whose presence results in numerous buds proliferating on a growing woody core. As the years pass by the woody core increases in extent, and the number of buds increases, although they do not develop normally, but produce thin short twigs. Leaves appear each Spring but in winter time the whole Witches Broom may be mistaken for a magpies nest or a squirrel’s drey at a casual glance.

CHASED FROM HOUSE AND HOME

Our house has low wide eaves, and when a pair of house martins began to build their mud nest we had a very good view of the proceedings. Day after day we watched the beakfuls of mud being brought and plastered into place and as the nest neared completion our interest grew.

But just before completion some belligerent sparrows arrived and harried the martins to such an extent that they had to leave their new home; this was promptly taken over by the sparrows.

The martins, however, did not give up, but went round to the opposite side of the house, and began to build a second nest. We felt their persistence was rewarded when the nest was finally completed - but no, the sparrows evicted them once more!

To our surprise the martins began to build a third nest, but it was never finished, whether through further harassment by the sparrows, or sheer exhaustion we shall never know. They have never tried nest building with us again.

INGENIOUS DEVICES FOR CONSERVING WATER

Mosses tend to be delicate plants, whose leaves are only one cell thick and not protected from water loss by a cuticle. It is true that many of them live in very shady conditions, forming the ground layer in woodlands, or grow near water or even submerged in the water itself.

But there are mosses which live on bare rock where they get baked by the sun, or grow on bogs and Mosses. We find Sphagnum (Bog Moss), which seems to have plenty of water as we squelch through it on our way across the local Mosses. However, this water is very acid and so is of little use to the plant, which has to rely on the pure rainwater descending from above.

The adaptation shown by Sphagnum have been described in the chapter on the flora of the Fenns - Whixall Moss complex, But it may be as well to repeat that its leaves are still composed of one layer of cells only, although these are of two types, the living cells and the dead empty cells which have pores to allow the entry of rain water. These cells are so small that they tend to retain the water by capillarity, hence, although the upper cells may dry out and look white and dead, it is always possible to squeeze out the water contained in the cells underneath.

Another moss which is very common on the Mosses is Polytrichum commune. There are different species of Polytrichum which all follow the same ingenious pattern for dealing with an inadequate supply of a suitable source of water, whether they live on exposed stony ground or on the Mosses. Their lower parts die and become brown as the upper parts grow up into the air; they are usually crowded together, forming an attractive pattern of myriads of green stars when viewed from above.

The leaf consists of two parts; an almost colourless, sheathing base, and a green portion tapering to a joint which stands out at an angle to the stem under normal conditions. When dry conditions intervene, the leaves close in upon the stem and so the outer ones protect the inner ones from water loss.

To understand the part played by a single leaf it must be viewed under the microscope. The green portion will then be seen consist of 30 or more 'lamellae' of delicate green cells which stand side by side at right angles to the leaf surface, extending for its whole length. Each lamella is only about five cells deep.

Under damp conditions these green lamellae are exposed to the sun and air and manufacture food quite effectively, but we find the top row of cells are empty and thick-walled to afford protection against sudden fluctuations of temperature. Also the spaces between the lamellae are of capillary dimensions and so tend to hold water.

The main mechanism for preventing water loss in dry weather is the rolling of the edges of the leaves to form a temporary tube in which the delicate lamellae are protected; as normal conditions return the leaf unrolls once more.

Some millions of years after the mosses came into existence, the flowering plants came on the scene; and later still one group of flowering plants, the grasses, was evolved and became widespread over the earth's surface, invading many widely different habitats. One of these was the Mosses where Polytrichum was already firmly established. We find one particular grass growing on the drier trackways called Molinia caerulea, the Purple Moor Grass, which also needs to conserve its water. It uses essentially the same method as that used by Polytrichum, but the details differ owing to its higher state of organisation.

One surface of this grass leaf is thick and well protected by a waterproof cuticle. The other surface can be seen to be traversed lengthways by many ridges with intervening grooves. If a thin section is taken across the leaf and examined under the microscope, it can be seen that the ridges contain veins and have thick-walled cells, and some stout hairs at the top. As we look at the grooves we find thinner walled cells containing chlorophyll, and also some stomata, the tiny adjustable spores, which control the water loss.

The most interesting feature is that at the base of each ridge there are thin walled cells on both sides, called ‘motor cells’, which lose water more quickly than the neighbouring cells, so that as soon as evaporation increases, these cells shrink pulling all the ridges closer together and finally rolling the leaf up into a tube. As with Polytrichum the action is reversible, and with an increase in the humidity of the air the motor cells absorb water, causing the leaf to unroll.

Molinia caerulea is very common on the Fenns – Whixall Moss complex, but an even better and more efficient example of this rolling of leaves in dry weather is to be seen at any seaside resort where there are sand dunes; it is Ammophila arenaria (the Marram Grass). Besides this leaf adaptation we find it has another one, namely that it can stand being buried in the sand as fresh roots and shoots develop which soon bring it to the surface once more, and afford further obstacles for holding up the sand, so that they ‘fix’ the dunes. So effective is it that man plants Marram Grass on dunes with the express purpose of stabilising them.

MORE ABOUT THE BREAKING OF THE MERES

For a long time scientists have known that the ‘breaking’ of the meres are caused by colossal numbers of blue-green algae which appear on the surface of the water as a green scum. What was not certain was the events leading up to this break. There were two suggestions, firstly that there was a sudden, almost explosive increase in the numbers of the algae, and secondly that the increase in numbers was more gradual, the break being caused by the rapid rise of the algal population to the surface under suitable weather conditions.

In order to determine which of these two alternatives applied, C. Reynolds carried out a detailed research programme financed by the Nature Conservancy during the three year period, 1966-1968. Much of this work was carried out at Crosemere, although The Mere at Ellesmere, Colemere and Whitemere were also included.

The presence of gas vacuoles in the planktonic blue-green allow them to float to the surface, but only if the conditions there are very still, as the slightest breeze causes sufficient turbulence to disperse them in the water. Experiments in the laboratory on the times taken for the various alga to float to the surface showed that they have different ‘floatation rates’, thus Microcystis rises considerably faster than Aphanizomenon.

Further, if the gas vacuoles are removed by centrifuging the ‘sinking rates’ are in the same order.

For a break to happen the weather must be perfectly calm for several days, and C. Reynolds predicted the appearance of a break at Crosemere, and spent the whole night of 21/22 July, 1966, making observations collecting samples of algae at regular intervals and at different depths. By morning the entire surface was festooned with patches of blue-green algae; 87 per cent of the algae being contained in the top metre of a five-metre column of water, while 56 per cent were found in the top 100 mm. At the same time it was found that during this break there was no increase in the total algal numbers present. This answers the questions posed at the start of the research (which went into a vast amount of detail about temperature, oxygen and carbon dioxide concentration, chemical composition of the water, etc.) and showed that the break resulted from almost the whole of the blue-green algal population rising to the surface.

Now for my part in this research. This was confined to the collection of material twice a week from Whitemere during the Spring and Summer. I was asked to collect samples of the water by lowering a wide glass tube about 10 inches long until its top was level with the surface of the mere. Then I pushed in a rubber bung to close the bottom of the tube, and lifted it out of the water transferring its contents to a capped polythene bottle. As soon as I reached home I shook the bottle to disperse the algae and quickly transferred a sample to quite a small polythene bottle. Iodine solution was added to preserve the contents and the bottle labelled. After ten bottles had been collected they were sent to C. Reynolds.

In order to make the results comparable I rowed out to the centre buoy (used by the Shropshire Sailing Club) and tied up. The boat was not easy to manage as it was leaky, and I finished each trip with more water than when I started out. Further one pair of rowlocks was too damaged to be of any use, so, wearing gum boots, I had to use the other pair and row the boat stern first. As if this was not difficult enough I rarely found two sculls of the same type, and none of them had any 'buttons' on them!

To standardize procedure as far as possible I tried to collect samples at the same time each day, so I got out my boat at 8.30 a.m. during this period. The weather sometimes took a hand, and I remember one morning when the fog was so thick that I only found the buoy by chance. On another occasion I collected specimens during a thunderstorm.

I always collected samples for myself, and for several days early in the season I found the bulk of the organisms collected were those of Volvox aureus, a beautiful, globular green alga. Under the microscope one can see that it consists of a thin, gelatinous globe containing hundreds of green cells in its wall. Each of these cells has two cilia whose co-ordinated vibrations cause the whole globe to rotate. It is a lovely sight to see a number of Volvox rolling around in the water. Some of the globes have lesser globes inside them ('daughter colonies') which are finally set free from their parents by the latter disintegrating.

Towards the end of the season, the samples became browner, due to the large number of Ceratium hirundinella present. This belongs to the algal group known as the Dino-Flagellates. They have three long, projecting spines, and two cilia, one residing in a central groove, and the other free. It contains chlorophyll but also a yellow-brown pigment which masks the green of the chlorophyll. There were always some blue-green algae present, and their numbers increased until a break occurred.

A BEE-KEEPING EPISODE

How is it that some people are able to deal with bees without wearing any protective clothing? I have had one hive for a number of years, but I always use protective clothing. Fortunately bee stings have little effect on me, so no untoward effects have followed the occasions when I have been stung. At the start of my bee keeping activities a local bee keeper asked me if I would like to see an expert examine one of his hives and I went along. The expert was a real old countryman who wore a veil but nothing else by way of protection. He removed the roof and supers thus exposing the brood box. Then he lifted out one frame and examined it carefully, looking for the queen, but he did not find it. Replacing this frame he dealt with the second frame, and then the third frame and the others until he had been through all ten frames, again without finding the queen.

Cells were seen with eggs in them, and worker bee grubs in various stages of development, while pupae were contained in cells capped over with a convex cap of wax and pollen. Other cells were slightly, but distinctly, larger, and contained the grubs destined to develop into drones. Honey, derived from the nectar of flowers, was stored in some of the cells in the brood frames although the bulk of the honey was contained in the supers which had been temporarily removed. When full they were capped over the flattened wax caps. Yet other cells were used for the storage of pollen, need as protein food for the developing grubs.

The expert was sure he would be able to find the queen without any trouble, but when all ten frames had been examined without success, he went through them again, this time more thoroughly, using a goose feather to brush the bees off each frame in succession, but he was still unable to find the queen.

By the time this operation was completed the air was filled with thousands of bees, flying hither and thither, with many of them settling on a nearby hedge. The expert did not like to admit defeat and went to the hedge and scooped up handfuls of bees, and examined each handful with care – why was he not stung?

After this the hive was reassembled and we left the bees to recover from this great upheaval.

THE LEAF CUTTING BEE

My wife noted that many of the leaves of the Enchanter's Nightshade (Circaea lutetiana) in our garden had round and oval pieces cut out of them, the result of the activities of the Leaf Cutting Bee (Megachile centuncularis). This plant is a pernicious weed, but smaller cut outs were noticed on the roses.

The bee itself resembles a rather robust hive bee, but it is solitary in its habits. In July, when the female makes its preparations for egg laying it works ceaselessly and very hard. First it prepares a tunnel in an old beam, a hollow stem or in the earth, using rasping jaws; raking over the loosened material with its legs; and walking backwards to push the debris out of the hole. The tunnel may extend to about a foot in depth. Sometimes much labour is saved if a natural hollow can be found, and, on one occasion, I found one bee making its cells in the overflow pipe from a water closet.

When the tunnel is ready the bee begins its leaf cutting activities, cutting out oval pieces for the sides of the larval cells and four round pieces to close each end. One cell had seven oval and four round pieces used in its construction.

Before closing the cell the bee visits flowers to obtain nectar and pollen. This is made into a paste and added to the cell before the egg is laid.

Further cells are made and stocked in the same manner, and when the tunnel is almost filled the rest is plugged with wood chips.

On hatching, the grub feeds on the sweet paste of which there is sufficient for its needs. Then it spins a silken cocoon, although it does not turn into a pupa before the next spring. One would expect those grubs at the bottom of the tube to mature first, and it is suggested that although they may do so, they wait patiently until those in front have made their escape.

There are two enemies of the leaf cutting bee. Firstly, the 'Cuckoo Bee' which slips into the tunnel while the owner is away foraging and lays its egg in the open cell. The Cuckoo bee grub is more active than that of the leaf cutting bee and the latter dies of starvation. Secondly, a very tiny parasitic wasp somehow manages to pierce the leaf cutting bee's cocoon with its long ovipositor and lay its eggs inside; on hatching the grubs devour the rightful occupants.

VISITORS

Recently we have had frequent visits from a grey squirrel in our garden. It has been on the lawn, coming almost to our front door before climbing over the fence and running rapidly up a nearby tree. When running along the ground its body and tail are held horizontally, but a sinuous movement runs along them.

For the past week Canada Geese have been arriving in the field opposite to our house before breakfast every morning. Just as I was getting up, soon after 7 a.m. I heard their honking and watched them circle around once or twice before landing. One morning two waves landed in succession. I counted two dozen in one wave and there were usually about fifty in the field together. They seemed to be grazing on the stubble or on the undergrowth of weeds left after the corn had been removed, and they remained about three hours - on one morning they left at 10.15 a.m.

In our new biology laboratory I found some of the newly affixed drawer labels torn and suspected blue tits as the culprits, but was very surprised when I caught one of them busily attacking the labels on some microscope slides which had been left on the bench!

HOW DID IT GET THERE ?

Due to a combination of unusual circumstances, the water in the Wharf Arm of the canal at Ellesmere was much hotter than usual. Firstly, there had been a long spell of fine, hot weather - the temperature of the school swimming bath was 70 F. Secondly, there had been a stoppage on the canal owing to repairs to Whitehurst Tunnel, near Chirk, and although water was piped past the stoppage, the amount flowing southwards was greatly reduced with consequent rise in temperature. Thirdly, the Unigate Dairies extract large quantities of water from the Wharf Arm of the canal for condensing purposes, returning it to the canal at a higher temperature.

The temperature of the water in the Wharf Arm was 45 degs. C. (113F.). Note that our body temperature is 37 degs. C, and hen's eggs are incubated at 40 degs. C. The Wharf Arm forms a cul-de-sac leading off from the main canal at the White Bridge, but even in the main canal the temperature was 21 degs C. (70 degs F.)

I could not see any fish or other forms of animal life, and the only rooted water plant present was the Water Milfoil (Myriophyllum sp.) but this was so smothered with muddy scum that it was difficult to see how photosynthesis could possibly take place. Of non-flowering plants there were Spirogyra, a green filamentous alga, and Oscillatoria, a filamentous blue- green alga.

I made several sweeps with a net, and although I found no Cladoceran or Copepod waterfleas, I did find a number of the Ostracod waterflea, Cypridopsis vidua. This has a lightish carapace with brown markings crossing it in two or three bands. Obviously it must be a very hardy species as the amount of oxygen present in stagnant water at 45 degs C must be very small.

I sent specimens to Mr. Galliford, an expert on waterfleas, for identification, and he forwarded them to Dr. Hardy at the British Museum (Natural History). Dr. Hardy identified them and stated that it was a species found most often in old aquaria, and in green house water tanks.

The question remains - how did it get into these two habitats, and into the hot canal arm?

23 June 1959.

AQUATIC SPRINGTAILS

Stagnant farm ponds are a rich source of microscopic life during the summer months, particularly if there is a spell of hot weather. One such pond, near to the school, was often sampled, and an item which could not be missed was the continual jumping of the Aquatic Springtails (Podura aquatica). Looking like animated blue-grey dust, they were constantly springing up from the surface of the water by the sudden flexing; of the biforked tails through l80 degs. They are so tiny and light that they do not break through the surface film of the water during this operation, and are jerked an inch or so into the air.

25 March 1960

ANOTHER RESULT OF HOT WEATHER

The water level of the Top Golf Course pond (one of the ponds in the grounds of Ellesmere College) was quite low owing to the continuous drought, and much semi-dry mud was exposed where previously there had been water. Much of it was covered by a green growth which closer examination showed to consist of little green globules, the largest of which did not exceed 2mm in diameter. These globules were fastened to the mud, and on washing this away carefully, each was seen to have a tuft of branching, colourless rhizoids, responsible for anchoring the green globular portion.

Under higher magnification it was seen that no cell walls were present. Consulting West's 'British Freshwater Algae' it was identified as Botrydium granulatum, although the illustration given there, as well as in 'Strassburger's Botany', differed from our specimen, in being more oval, and having a much less extensive rhizoid system.

According to Strassburger this alga is cosmopolitan, and when the level of the water in the pond rises, its vesicle divides up into a large number of zoospores which escape through an opening at the summit. Each zoospore has a single cilium and two chloroplasts. After swarming the spores surround themselves with a wall and grow into the balloon-shaped plants. Sexual reproduction is unknown.

5 July 1949.

TWO UNUSUAL LIVERWORTS

We had a family outing to Lion Lane Wood, along the Penley Road, and walked along the path which runs through it. At one point the path was very muddy and the hoof-marks of horses were so deep that they formed quite big hollows filled with water. The swampy nature of the ground was indicated by an extensive growth of Starwort (Callitriche sp.) which is, strictly speaking, an aquatic plant, although it is commonly found in muddy situations liable to flooding.

Liverworts and mosses were abundant, the thallose liverworts forming rich, dark green patches. On some of these I noticed short, hair-like processes standing upright from the upper surfaces, and the lobed margin of the thallus was so deeply indented that it appeared intermediate in character between the thallose and the leafy liverworts.

Not being able to identify this liverwort I sent a sample to Mr. Wade (of the National Museum of Wales) who pronounced it to be Blasia pusilla. He was interested because there were no records of it from our locality.

The ‘hair-like processes’ were, in fact, flask shaped gemmae receptacles from which spherical, multicellular gemmae are extruded. Capsules are rarely produced. Another peculiar feature was the presence of dark green ‘dots’ scattered all over the thallus marking the position of colonies of the blue-green alga, Nostoc.

18. September 1949

I was introduced to another, even more unusual liverwort when on a ‘Moss Course’ at Preston Montford Field Centre. This was Cryptothallus mirabilis, a subterranean liverwort having a pale cream colour and no chlorophyll. Its rhizoids and lower cells possess symbiotic (means ‘living together to mutual advantage’) fungal hyphae, which was eventually digested by the liverwort after it had provided nutrients essential to it. It is quite small, only about 1 – 3 cm. long, and 5 mm broad; sometimes the repeated branching give it a coralloid appearance.

Plants which may have been Cryptothallus mirabilis were described in 1914 and 1919, but the first really definite specimens were found in Sweden in 1932. The first British specimens were found in Scotland in December, 1948. The specimens obtained on our course came from Whixall Moss, quite close to the canal. The usual habitat is in the peat under a carpet of mosses, such as <u>Pleurozium schreberi</u> or <u>Sphagnum</u>, but it has also been found in <u>Molinia</u> peat, while our specimens were growing a few inches down under litter in peat adjacent to decaying birch tree stumps.

19 April 1969

<u>LIFE ON A SUN BAKED ROOF</u>

When a moss spore germinates it does not immediately give rise to the familiar moss plant, but to branching, algal-like threads termed <u>PROTONEMA</u> (= 'first' & 'thread'). Usually a great number of spores germinate together, so that their protonema intermingle and cover the ground with a thin, complete green covering.

Then groups of cells ('buds') arise which develop into moss plants, several arising from the spore's protonema. On exposed rocks only a few of these survive, but as the original plants branch and rebranch very compactly a cushion is formed.

I took one of these moss cushions which was growing on the asbestos tiles of the Rifle Range roof of the Armoury at Ellesmere College and attempted to separate and count the individual plants of which it was composed. It was quite small measuring 1¼ in x 1 in x ½ in.

It was impossible to find the exact number of plants. Because they branch as they grow, and then by dying off below these branches become separated, thus forming a number of plants from the original one. Further, the base of the stems and their rhizoids are so intimately entangled with dust and soil that even after soaking in water, it is difficult to separate them without breakage. Thus I decided to count the number of shoots.

A further complication was that the moss cushion contained more than one kind of moss, so that after patiently washing and separating the moss shoots, using a needle-like scalpel, my results read as follows:

Bryum argenteum	820
Grimmia apocarpa	450
Orthotrichum anomalum	142
Tortula ruralis	53

The commonest moss on the roof was Bryum argenteum and it grew along the edges of the large asbestos tiles where few other mosses grew, as well as on the face of the tiles, and as a component of moss cushions. It was also common as fairly homogeneous patches on the gravel paths around the College.

This moss seems well adapted to a xerophytic existence in these bare, exposed situations, as its minute leaves wrap tightly round each other. At least the top third of each leaf has its cells devoid of chlorophyll, and as this was the only part of the leaf exposed, these hyaline cells reflect the light giving a silvery appearance, this makes the plant easily recognisable as well as cutting down transpiration.

Grimmia apocarpa is another moss with xerophytic features. It has small leaf cells with thick walls, and under dry conditions the leaves tend to twist round one another. The hoary appearance of this moss is due to the nerve of each leaf being continued well beyond the leaf tip as a hyaline hair-point.
The tight cushion formation is, in itself, a means of reducing water loss, because the spaces between the tightly packed shoots are of capillary dimensions, so that water is easily soaked up when it rains, and firmly retained during dry weather, particularly in the interior of the cushion. Delicate, microscopic animal life has taken the advantage of this habitat, if a portion of moss cushion is teased apart in as little water as possible, and the water pipetted on to a slide and examined under the microscope, one is sure to find some flagellates, and possibly ciliates; the single-celled protozoan, Arcella, which has a thin, yellow-brown shell shaped like a Chinese coolie’s hat; rotifers, of which I have several times found the pink Philodina roseola; and most fascinating of all, the Water Bear (Macrobiotus macronyx). Although extremely minute and transparent it has eight short, fat legs ending in claws, and its rather clumsy movements give it a superficial appearance to a lumbering bear. In spite of its small size it possesses a muscular system, salivary glands, a 'brain' and nerves, two eyespots and a reproductive system. Water bears feed on the sap of plants by piercing the cells with their stylets and then sucking out the juices. A further common animal found in moss cushions is the nematode worm. It is transparent, pointed at both ends, and moves with a vigorous undulating movement.

8 February1950.

A VISIT TO CLAREPOOL MOSS

Just over two miles from Ellesmere there is a wooded bog complex with a pool close to its eastern edge, known as Clarepool Moss. It can be reached from the Ellesmere-Whitchurch road quite easily as it is only separated from the road by one field; or from the other side along the Lyneal road, although it is somewhat further from the road and not so easy to detect.

It is not often visited so that it is an interesting area to study. On our way to it we saw a pale yellow butterfly which had somewhat bleached orange spots, one on each wing, characteristic of the female Brimstone Butterfly (Gonepteryx rhamni), this male being a rich sulphur yellow in colour with deeper orange spots.

We soon saw the familiar birch trees of the moss habitat, and after crossing the boundary ditch entered a wood. A number of the birch trees were attacked by the bracket fungus (Polyporus betulinus). This forms fruit annually, being brown and scaly above and having a multitude of spores (Polyporus means ‘many spores’). These tubes are lined by spore-producing cells; the spores travel horizontally for a distance which equals the radius of the tube before rising vertically; on reaching the mouth of the tube the spores are carried away by air currents. As the chances of the spores landing in a suitable environment are rather remote, millions of spores are produced by one of these bracket fructifications. Several times I have noticed small, pale brown mites crawling over the spores, but have been unable to find out which mite it is.

After a time the character of the ground changed quite rapidly and we came across ling and cross-leaved heather, pine trees and much Sphagnum, and some patches of the moss, Polytrichum commune. A fallen tree trunk was brilliantly decorated with thousands of capsules of the moss Dicranella heteromalla, while a small tree stump was the habitat Tetraphis pellucida which has stalked gemma cups.

We saw a carter drive out from the Moss with a large load of brushwood as we came to drive through the Moss, with a pinewood on our left where the pines were planted in close array on rising ground. At the end of this wooded portion there was a well-built hut made from pinewood uprights, roofed with corrugated iron, but what interested us most was the sides, which were made of two layers of wire netting, one or either side of the pinewood uprights, stuffed with dead bracken. A wooden seat formed of planking went round three sides of the hut, and there was a well-made table in the centre. The front was completely open. We noticed three young rabbits hanging up, and another on the table; on the floor by the entrance there was a collection of mole traps and wire rabbit snares. Nearby was a ‘gamekeeper’s gibbet’ from which hung a newly killed stoat - this was interesting as we met with partially eaten carcases of rabbit and a wood pigeon on our wandering.

From this point we walked at right angles to our previous direction through more birch trees and bushes with bracken undergrowth until we reached the edge of the Moss in this direction. Making our way slightly inwards once more we came across an area quite different in character from any we had met so far. It consisted of wiry ling bushes with extensive Sphagnum covered pools, often interconnected. The pools were completely covered by Sphagnum, their vivid green colour contrasting strongly with the dull grey-brown of the ling. A rabbit suddenly shot across one of these pools at great speed, its light weight allowing it to do this without any risk of sinking. There was a considerable quantity of a highly branched green-grey lichen, Cladonia impexa, whose appearance resembled a plastic 'pan-scrub'.

Suddenly we caught sight of open water. This was obviously the 'clear pool’ (Clarepool) from which the Moss took its name. For some distance from the pool the ground was so boggy, with a carpet of Sphagnum that it was difficult to get near to the edge of the pool. However we finally did get there and before us stretched a considerable lake. The water was brown, and pH papers gave a reading of pH4, which meant of much fringing vegetation, almost the only plants present being quite large, almost floating, tussocks of the Paniculate Sedge (Carex paniculata) with some Marsh Cinquefoil (Potentilla palustris).

18. April 1951.

On another occasion I took the College Field Club to Clarepool Moss. Soon after entering the Moss we found ourselves walking on dead bracken litter. This dry covering was the home of innumerable spiders which scattered before us as we walked forward. Many of them were females carrying their eggs at the back, wrapped up in white, cobweb-like material. One of the boys brought some of these spiders back to school and tried out various experiments on them. He found he could exchange egg-bags from one spider to another; could take away their eggs and offer them pellets of various materials of about the same size and shape, such as pellets of bread, or pieces of cork, all of which were accepted. These 'wolf spiders' do not spin web snares, but chase their prey and catch them by leaping on them.

One spider we caught looked extremely like an ant, both in shape and size, so that it was probably a case of mimicry, where the spider gained some protection from the resemblance. Later we found a Raft Spider (Dolomedes fimbriatus) moving with great agility on the surface of the water in one of the ditches by means of its long, flattened legs.

After passing open ground with some magnificent hawthorn trees in full bloom; bluebells; comfrey; red campion and forget-me-not; Scots Pines became increasingly more plentiful. Somewhere in the trees a Chiffchaff kept up his repetitive song.

Suddenly we came upon a large area entirely covered by Sphagnum moss. It's colour varied from white to yellowish-green but there was a pink tinge where the tiny lily-like flowers of the Cranberry (Oxycoccus palustris) grew on the Sphagnum; there were also a few tufts of Cotton Grass (Eriophorum vaginatum). The surface was almost level and very soft and yielding to walk on, in fact, it heaved up and down in a most alarming fashion when we tried walking on it near to its edge. When Ridgway tried to pound the bottom by sinking three net-rods screwed together through the Sphagnum cover, there was hardly any resistance beneath. In fact, the whole area was really a, 'kettle hole' containing water, whose surface was completely covered by a tough layer of Sphagnum, the botanist refers to these areas as 'quaking bogs'.

Back on firmer ground we continued our search for the pool. Ridgway sampled one of the boundary ditches and obtained an abundance of waterfleas, with a few gnat larvae, damsel fly nymphs, water boatmen and water beetle larvae. Later examination of the catch showed some large waterfleas, 3-5 mm long, all of which were Daphnia obtuse. They had a surprisingly large number of eggs in their brood pouches - I counted 28 in one individual and 30 in another. Another interesting feature was that most of them were red in colour, due to the possession of haemoglobin. This pigment is similar to the haemoglobin in our own blood but is used to store oxygen and deal it out slowly owing to the poorly aerated conditions. There were multitudes of the tiny waterfleas Chydorus sphaericous.

There was much ling about, although not yet in flower, its wiry stems being completely covered by the grey, crinkled dead-looking lichen Parmelia physodes. A lizard was seen but escaped capture.

At long last we found the Pool and sampled the area for water life and plant life.

25 May 1960

My wife and I paid a visit to the Moss, entering it from the Lyneal road end. We soon found the pool this time but it was with some difficulty that we approached it owing to the spongy, boggy nature of the ground, which had much Round-leaved sundew (<u>Drosera rotundifolia</u>) on it besides Sphagnum, Cranberry and Cotton Grass. I managed to get a photograph but had to keep moving my position as my feet began to sink several inches in a matter of minutes, the vegetation near to the edge of the pool being virtually afloat.

In the meantime my wife had caught a Cardinal Beetle (<u>Pyrochroa coccinea</u>) and had been watching it using its legs to 'preen' itself after getting wet. I was interested to notice that it had a black head, as the Field Club had found a red headed specimen at Crosemere a fortnight before. There are three species of Cardinal Beetle in Britain, all having a brilliant scarlet livery; <u>P.serrattina</u> being completely red; <u>P.coccinea</u> having a black head; while Schizotus pectinicornis has in addition to the black head, a black spot on its thorax.

28.May.l960

I took Ridgway and Turner, two members of the Field Club, to try to find out the depth of the Pool and of the 'Quaking Bog'. To do this we took a set of sweep's canes, each of which was one yard long. Bottom was reached in the Pool, close to its edge, at a depth of 27 feet; while we failed to reach bottom at a depth of 30 feet in the Quaking Bog. Using a B.D.H. Comparator we did a fairly accurate determination of the pH value of the water. Neutrality is indicated by pH=7, but we found a pH of 6 in the Pool, and of 4 in the Quaking Bog. The decreasing numbers indicated increasing acidity.

Amongst the Pine trees on the somewhat drier ground we came across a fine specimen of the moss<u>, Leucobryum glaucum</u>, the name <u>Leucobryum</u> means 'white moss', and in dry weather it is almost white. It forms large, tight cushions, and our specimen was about eight inches across, and hemispherical in shape. If the moss is split open it will be seen that only the peripheral layers are green, the rest of the moss being dirty white in colour. Like <u>Sphagnum</u> it has leaves which can take up water, so that the whole interior of the clump retains water by capillarity, and can survive drought conditions. Sometimes clumps become spherical and as large as footballs, becoming detached and rolling about in the wind.

1 June 1960

On another occasion we found two plants of the Royal Fern (Osmunda regalis) just to the east of the pool. It is quite a rare occurrence to find this fine plant growing in the wild, although it is not uncommon in gardens. It has large leaves, but these do not bear any spores, as there are separate spore-bearing fronds.

PROPERTIES OF WATER WHICH AFFECT THE LIVES OF AQUATIC ORGANISMS

Water has many properties which are admirably suited to the requirements of living organisms - or should we say, living organisms have become adapted to a life in water?

First let us see how water behaves with variations in temperature. The end of a severe winter is the only time at which the temperature is at a uniform, low level. This is due to the fact that as the air temperature at the surface of the water falls during winter it cools the water; the cooler the water the more dense it becomes; and the increase in density causes it to sink.

Strangely enough this behaviour only continues until the density reaches a maximum at 4 degs. C., after which the water becomes less dense and rises, so that at the end of the winter we may find the bulk of the water having a temperature of 4 degs. C. with a thin layer above it at a lower temperature, capped by a floating layer of ice at 0 degs C.

When Spring returns the heat of the sun melts the ice and temperature of the water rises once more. However, it rises very slowly owing to certain properties of water. The first is that water has the highest specific heat of any substance, i.e. the amount of heat required to raise 1 gm. of water 1 deg C. is more than for any other material; in other words it heats up slowly.

As warm water is less dense than cold water, with the progress of summer the warmer water tends to float near to the surface; and a second property of water tends to make this layer quite clear cut. This is that water is a bad conductor of heat. Thus we find in the deeper meres two definite zones, the upper warmer layer, known as the epilimnion, and the lower, cooler layer, or hypolimnion. There is a sudden fall in temperature between these two zones which is known as the thermocline ('heat slope'). This 'stratification' into the two main temperature zones persists all through the summer, but during late autumn and winter it is obliterated by the cooling effect of the falling temperatures, and the mixing effect of winter gales.

Another property of water varies with the temperature, and that is its viscosity. To show the effect of change in viscosity on living organisms a simple experiment can be done in which the results of differing viscosities is greatly exaggerated. Take two long tubes (e.g. burettes) and fill one with water and one with sugar syrup. Then drop into each, at the same moment, a tiny pellet of plasticine. The pellet descends quite rapidly through the water, but much more slowly through the more viscous syrup. A great number of the organisms in the open waters of lakes are microscopic or nearly so; this means that even a minute lessening of the water's viscosity which takes place during the summer becomes important as more effort is needed to keep near to the surface of the water. In order to overcome this difficulty, the blue-green algae possess gas bubbles, and some rotifers and waterfleas produce more spiny forms in order to offer more resistance to sinking.

Before leaving the temperature effects notice the following points:

- at no time does the temperature of the water fall as low as 0 degs. C. the air temperature may descend to many degrees below zero. Although living organisms are not normally active in water during the winter, we do find a few of them swimming around, even under the ice.
- most aquatic organisms get through the winter in the form of eggs or spores, which may sink to the bottom, or be washed to the shore, all of them capable of withstanding the low temperatures without harm.
- microscopic green plants of open water begin to appear in an active state in Spring, are abundant during summer, and tail off during autumn. They are confined to the warmer and lighter waters of the epilimnion.

Another factor is light. Light penetrates water far less easily than in air, the red end of the spectrum being absorbed first, then the orange, yellow and green, and finally the blue and violet at some thirty feet below. However, natural waters are rarely crystal clear, and as the diatoms, blue-green algae, etc., increase in their millions they cut down the distance to which light can penetrate. But green plants must have light in order to manufacture food, and this is another reason why they must live in the epilimnion near to the surface.

A simple way of comparing light penetration in different bodies of water is to lower a white plate and notice the depth at which it can no longer be seen.

Practically all living organisms must have oxygen. We all know that the amount of oxygen in air is about l/5th of the volume involved. To find out how much air is dissolved the following experiment is instructive.

(diagram)

Fill the whole apparatus with pond or tap water, including the 250 ml. flask, delivery tube, trough and test-tube so that not a bubble of air is present. Heat the water in the flask by means of a bunsen burner. As the temperature rises the solubility of the gases dissolved in the water (mainly nitrogen and oxygen) becomes less, and when the water is boiling the solubility will be nil. This means that the dissolved gases will appear in a gaseous form and travel along the test-tube for collection. To find out how much of this gas is oxygen introduce a piece of yellow phosphorus on a wire into the test-tube, and leave it until all the oxygen has combined with the phosphorus. The removal of the oxygen causes the water to rise and if the water levels in the tube are measured before and after the experiment we find that one-third of the gas is oxygen (this is because the solubility of oxygen in water is greater than that of nitrogen). Our results are:

250 ml of air contains 50 cc. oxygen
250 ml of water contains about 5 cc. oxygen

This means that there is far less oxygen present dissolved in water at ordinary temperatures than in air, which makes breathing for aquatic organisms more difficult. What makes matters worse is that as the temperature of the water rises during summer, there will be even less oxygen, for, as we have seen, the solubility of gases becomes less with rise in temperature. If a pond is so small that it is in danger of drying up in hot weather, we have the additional danger of the organisms becoming crowded into a smaller space, and thus using up the small amount of oxygen even more quickly. The same result is obtained if too many organisms are put into a jam jar of pond water or an aquarium during the summer. There is no doubt that his paucity of oxygen is the chief difficulty concerned with the adaptation to life in water.

One advantageous property is the transparency of water, as this allows light to penetrate to the chlorophyll of the multitudinous tiny green plants which appear each summer. Some organisms, such as the 'phantom larva' and a waterflea called Leptodora kindtii have themselves become transparent and this helps them both to capture their prey and avoid detection.

The ancients tried to find a liquid which would be a ‘universal solvent', although their search was unsuccessful. However, water approaches this ideal liquid very closely, even the glass bottles being dissolved to a minute extent. Thus organisms find the chemicals they require dissolved in water, and have an uncanny way of concentrating some of these; such as silica by diatoms living in water in which chemical tests have failed to detect silica; and the concentration of iodine by some seaweeds to such an extent that they were once used commercially as a source of iodine.

The presence of common salt in seawater is easily detected by its taste. To show that pond water contains chemicals we can perform two simple experiments. In the first such water is boiled to dryness in an evaporating dish when a fine crust is left; if the experiment is repeated using distilled water, nothing is left. In the second experiment silver nitrate solution is added to water in a test-tube, when a white precipitate results; another white precipitate results from the addition of barium chloride solution; using distilled water no precipitation occurs.

The last property we shall mention is that of surface tension which makes water behave as if it has an 'elastic skin'. To demonstrate this property a single float should be constructed by taking a flat cork (or ‘shive’) and pushing into its upper surface three fine wires equally spaced. Bend over the top of each wire and fix it to a wire circle which should be parallel to the surface of the cork. Now weight the cork by means of screws, nails, etc., pushed into its underside, so that the cork floats with its upper surface just level with the surface of the water (this is important).

Place the float on water contained in a tall cylinder and push it well down by means of a rod. When the rod is removed the float rises, but not quite to its original position, because the wire circle does-not break surface. What is stopping it? It is the property of surface tension at work, caused by the fact that the particles in the water are shooting about at high speeds, hitting each other and bouncing off in all directions in the bulk of the water. These particles attract each other equally except at the surface where there are far more particles underneath than in the air above, so we get a 'compression' effect, giving a firmer quality to the surface layer of the water; in other words an 'elastic skin' is formed. Water skaters make use of this ‘elastic skin’ as will be explained in the next section.

MORE ABOUT SURFACE TENSION

In the last article it was explained that surface tension results in the surface of the water behaving like an elastic skin. This skin is so delicate that it is not noticed when we, dive or swim in water, but it becomes important to organisms which are very tiny.

There are three ways in which the elastic skin affects their lives.

(a) Organisms which live on its upper surface.
There are two ways by which organisms are prevented from falling through water's elastic skin. The first is to be so small and light that they do not exert enough pressure, and so can run about on the surface of the water quite easily, and, as in the case of the Aquatic Springtail (Podura aquatica) can flex their forked tails so rapidly that they literally give the surface film a hearty smack, projecting themselves into the air.

The second way is to spread out the body's weight over a large area. If someone falls through the ice, it would be of no use walking out to rescue them because your total weight, say twelve stone, would be pressing down on the small area represented by the underside of your feet. It you approached lying down your chances of effecting a rescue would be much better, as the same weight would be spread over a much larger area, so that the pressure at any point would be less. Better still if you could push out a ladder and crawl along it, the pressure would be reduced still further.

Nature has used this method of reducing the pressure on the surface film by evolving insects with long, thin bodies and very long, thin legs which spread out widely, as in the Water Skater (Gerris lacustris). Even so their feet make dimples in the surface film, and if seen on shallow water on a sunny day, six oval shadows can be seen on the bottom as the insect moves along. Gerris is commonly found amongst the emergent vegetation at the edge of a canal or by the shore line of a pond or lake. On September 6.1972 we saw hundreds of them by the edge of the canal near Llangollen - I have never before seen such a concentration; it reminded one of the huge numbers of Whirligig Beetles which are more common. Gerris darts out from the side to capture any insects which may have been trapped by the surface film.

There is one water skater, only ½ " long known as the Water Measurer (Hydrometra stagnorum) which is much more elongated than Gerris; and quite a number of forms are so tiny that they are not often noticed, such as Microvelia which is just over 1.5 mm. in length. Owing to their mode of life wings are not of much use, and absence of wings is common.

One spider, called the Raft spider (Dolomedes fimbriatus), uses the same method, and has eight flattened, hairy legs. We have found it at Clarepool Moss and on Fenns Moss, where it moves rapidly around on the surface of the water to catch its prey.

The Whirligig Beetle (Gyrinus natator) is a common sight on the canals, where scores of them indulge in rapid gyrations on the surface, for all the world like the 'dodgem' cars on our fairgrounds, except that they seem to avoid collisions. There is one interesting feature which must be mentioned, and that is the eyes are divided into two parts, one for seeing in air, and the other for vision under water, because, although they spend much of their time at the surface, they can force their way through the film if danger threatens.

(b) Organisms which hang from the surface film when taking in oxygen from the atmosphere.

Quite a number of insects, while living mainly under water, come to the surface in order to get a fresh supply of oxygen from the atmosphere, and to get rid of spent gases. This process takes time and they often possess means of hanging from the surface film until it is completed.

A good example is the larva of the Gnat (Culex sp.) Less than 4mm long, its density is slightly greater than that of water, so that when it remains still it slowly sinks to the bottom. However, it is a most active organism, flexing its body vigorously, and making its way to the surface of the water upside down. On the last segment but one of its body there is a breathing tube which ends in five tapered flaps meeting at a point. As soon as the pointed tube has penetrated the surface film, the flaps are flung backward to form a shallow saucer-shaped depression; this depresses the surface film, but does not penetrate it. Thus, while being more dense than water, it requires no effort on the part of the larva to remain at the surface, and at any time it can descend by closing up the flaps.

The pupa, which is unusual in being very active, is less dense than water and floats to the surface, while having to make an effort to descend. It has two 'breathing horns' at its head end which is uppermost, and two flaps at its tail end to help in its jerky locomotion.

There are many other examples which could be quoted. There is an insect which visits autumn flowers called Tubifera; this was given as an example of an aquatic larva which possesses a telescopic breathing tube. The top end of this tube is supported at the surface by five radiating, feathered hairs.

(c) Organisms trapped by the surface film

When the gnat is about to emerge from its pupa case, the latter splits and the winged insect gradually extracts itself from the floating case. It has long legs, and thus by the time the legs are freed the rest of the body is quite high up. This means that we have a state of unstable equilibrium as the centre of gravity is so high that the slightest breeze is liable to blow the insect over with its legs still trapped. The delicate insect then adheres so firmly to the surface film that it cannot free itself and sooner or later will fall a victim to a water skater or to a fish.

Normally we do not find gnats in the open water of the meres, but only in still backwaters, marshy ground amidst trees, stagnant ponds, hollowed out tree stumps, etc., where the air is still. We do find a somewhat similar fly, a midge known as Chironomus, in the meres. Its larva lives at the bottom of the meres in the mud, but its pupa makes a rapid ascent to the surface, and the winged midge emerges in the same manner as for the gnat.

How is it that the gnat cannot exist in the meres, whereas Chironomus can? I found out the answer by timing the process of the emergence of the winged insects from their pupae. In the case of the gnat the time taken was 30 minutes, while Chironomus took only 30 seconds. This seems to suggest that in calm weather Chironomus may get the half minute of still conditions needed for emergence; it would be unlikely for the gnat to get half an hour.

In May and June we get what the fishermen term a 'hatch' of mayflies, when hundreds of mayflies appear over the water, having just emerged from their pupal cases. They only live for one day, so immediately engage in a ‘mating dance'. If you watch carefully you will notice that they ascend rapidly holding their bodies in a vertical position. At the top of their flight they alter their position, holding their bodies horizontally, with their wings and three tail processes held motionless as they float downwards. Sometimes they start ascending once more before reaching the water; sometimes they hit the water, but if their wings remain free they are able to take off again; sometimes they not only hit the water but keel over so that their wings adhere to the surface film, and then they are trapped. In a small trout stream at Uttoxeter I watched the mayfly dance just above a small weir, and out of eight mayflies trapped by the surface film only two were not swallowed up by the fish before reaching the weir.

LICE LIVING ON BIRDS

(Original work by T.F.G. Abraham of the VIth. Form, Ellesmere College, 1963 – 64; part only, abbreviated and adapted)

Members of the College Field Club were encouraged to carry out original research on some small aspect of Biology, and the following account gives the result of such work.

The Louse Fly from the swallow

Our dormitory at school is on the top story of the building with eaves above all the windows, and these eaves are the site of swallows', swifts' and house martins' nests. Before long boys began to complain about the 'spiders' appearing on and in their beds, and one began to wonder where they were coming from.

However, when I awoke one morning to find one on my own pillow I realised that they were Stenopteryx hirundinis, the Louse Fly, and not ‘spiders’. They had presumably crawled in through the window after emerging from their pupae. When I announced what they really were many boys were quite worried and lost a lot of sleep!
This revolting creature is the largest of the ectoparasites on birds, sometimes exceeding 1/4" in length - it is a 'fly' and not a louse, but being found with lice is called the 'louse fly'. They live permanently amongst the feathers of the host, and feed entirely on its blood by means of piercing apparatus and a long sucking, sheathed proboscis.

Their bodies are flattened dorso-ventrally and are covered with a very thick, tough cuticle. The whole body is beset with backwardly projecting spines, giving the creature a gruesome look; as do the large, muscular legs, each ending in a large tooth claw. These adaptations help to prevent the parasite from becoming dislodged from its host. They have only vestigial wings but the speed with which these insects move is incredible. When I first examined one I was quite alarmed by the speed with which it moved up my coat sleeve!

The adult fly does not lay an enormous number of eggs; instead it produces one young only which it carried around with it until it is time for it to be deposited as a larva within the nest of its host. It then pupates and passes the winter in this state. The following spring the adult emerges and may survive for several months.

The louse fly relies on the host returning every year to the same nest. However, one specimen that I examined came from a Rook, which seems to indicate that they are not strictly restricted to the swallow.

<u>2. Feather Lice from the rook</u>

These insects belong to the <u>Mallophaga</u> or chewing lice. In order to study them the Corps sergeant took a rook for me and the freshly killed bird was suspended from the cork of an inverted bell jar as shown. As the temperature of the warm-blooded rook began to fall the ectoparasites emerged and crawled around on the surface of the feathers. It was particularly noticeable that they were present in larger numbers on the back of the neck and the top of the head. This position, no doubt, was taken as a safety precaution as the bird would be unable to reach them when using its beak while preening its feathers.

Besides feather lice there were many mites present, and I soon noticed that these mites had an instinct to climb upwards towards the top of the bell jar, and this gave me a chance to make use of this instinct to make the collecting of these creatures simpler. I bored a hole through the cork and inserted an inverted collecting tube, having placed in the mouth of the tube a cone of paper with a small hole in its centre, enabling the mites to get easily into the tube, but reducing their chances of getting out.

There were also feather lice on the large flight feathers of the wings, but these differed in shape from those at the back of the neck, being thinner and more elongated; those on the neck were distinctly more rounded in form.

The eggs look superficially like bits of grit or scurf but closer examination shows they are attached to the underlying feather, near to the skin, by a hardened secretion. The position of the eggs enables the nymph to emerge without losing contact with its host. There is a bulbous projection at the top end of the egg which is pushed off on hatching.

The body form of the Mallophaga is considerably modified to suit them to a parasitic mode of life in that the whole body is flattened dorso-ventrally. A pair of biting mandibles are placed ventrally on the head. They have a pair of eye rudiments which are only slightly sensitive to light, and an antenna which is probably of much more use to the parasite when crawling around within the dark maze of feathers. The legs are extremely modified, each leg ending in a claw, which enables the parasite to clasp the feathers more easily. The whole body is heavily chitinized, especially the head and thorax; the abdomen, also chitinized, is divided into eight segments.

The method of feeding is as follows; a piece of a feather barb is chewed off from one of the downy feathers and guided into pouches on each side of the head. From these the feather is guided down the oesophagus to be forced into the crop by a series of muscular contractions. The actual digestion of the feather is highly complicated involving the breakdown of keratin, a highly resistant protein.

Most feather lice can move forward or backward with equal facility. The short, rounded forms from the head and neck do not move far but can move quickly out of sight into the downy parts of the feathers. The longer, elongated forms are very rapid movers and can run across the breadth of the feathers with great speed, usually moving sideways.

<u>Experiments with Mallophaga</u>.
<u>Experiment 1. The conflict of the two instincts, attraction to warmth and repulsion to light</u>.

The method of obtaining feather lice from a freshly-killed rook by suspending it in a bell jar has already been described. I had not realised that the curved part of the jar would function as a magnifying glass but it did, and all the lice began to congregate around the spot were the glass was focussing the rays of light and heat. The reason seemed to be that the lice have a positive reaction to warmth.

However, they also have a photonegative reaction, so that this accidental experiment seems to indicate that the reaction to warmth is stronger than the reaction to light, as they all tried to get warm, but did not seem to worry much about exposing themselves to light, in fact, they all crowded in a scrum about one spot, even landing up on top of each other.

Experiment 2. A possible explanation of 'anting' in birds.

It is now well known that some birds pick up ants and thrust them under their wings; a process known as 'anting'. It is supposed to rid them of ectoparasites. I decided to check this by experiment, so I obtained some ants and ground them up in order to collect the resulting juice. Two feathers were treated with the juice and placed in a corked tube, while two untreated feathers were placed in a second corked tube. Four feather lice were added to each tube and left for several hours.

The results were quite conclusive, as the lice in the tube containing the treated feathers were dead, while those in the other tube remained healthy.

It is common knowledge that ants contain formic acid thus, in order to substantiate my previous findings, I took a very dilute solution of formic acid in place of the juice, and repeated the former experiments. The results were as I anticipated - the formic acid had killed the lice. Thus it seems that ‘anting’ is a behaviour which helps to free birds which indulge in it from some of its ectoparasites.

Experiment 3. Reaction of feather lice to smell.

I took a feather and boiled it to rid it of any smell, and placed this at one end of a reasonably large tube. An untreated feather was placed at the other end. Then lice were added to the tube. The result was that the lice were soon found to be present only on the untreated feather, and this seems to suggest that they have a positive reaction to the smell of their host.

TWO FUNGI WHOSE SPORES ARE CONTAINED IN FLASK-SHAPED RECEPTACLES

J.P.Parsonage, a member of the Ellesmere College Field Club, noticed an interesting fungus while we were wandering amongst the lush vegetation which covers the marshy extension to the south of The Mere.

Some of the grass stems had bright yellow growths not far from their tops. These growths were cylindrical, about 1/4" long, completely encircling the stem. The grass, with its fungal parasite, resembled a miniature Great Reedmace ('Bulrush'.) a resemblance emphasised by the specific name of the fungus, which is Epichloe typhina, while the name of the Reedmace genus is 'Typha'.

This fungus belongs to the Pyrenomycete section of the Ascomycetes. Almost all ascomycetes have eight spores contained in a slender, spindle-shaped cell - called an Ascus; the spores being squeezed out at one end when ripe. In the Pyrenomycete section the asci are contained in flask-shaped containers (called perithecia) arranged around the periphery of the fructification. If a thin section is cut across the yellow zone with a razor the above details can be seen.

The second Pyrenomycete was Daldinia concentrica. This is a common fungus appearing as hard, black, hemispherical masses on trunks and branches of ash trees, and occasionally on beech or birch, usually about 5 or 6 cms. in diameter. If it is cut vertically into two halves the concentric arrangement of the internal tissues can be seen (once more reflected in the specific name 'concentrica').

In spite of its hard and rigid construction, these fungal 'fruit' are produced afresh each year from the perennial fungal threads ('hypha') feeding inside the trunk.

Numerous perithecia are contained in the outermost concentric layer during the period in which spore dispersal occurs (May to September). The ripe, black spores are discharged when an individual ascus elongates up the neck-canal and bursts to the outside, the cause of the discharge being the increasing turgidity of the cell. The remaining asci elongate in their turn and discharge their spores.

Sometimes the spores tend to stick together, thus forming a heavier projectile which travels much further then the single spores, and it is easy to show this by cutting a slice a few mms. thick and then placing it upon a sheet of glass. After leaving it all night, a thick, black deposit forms a band about one cm. wide - it will be found that towards the outer fringe the spores are mainly in groups of eight, while on the inner side single spores predominate. Another interesting feature which has been tested by experiment is that the spores are shed mainly between 9 pm. and 9 am. The number of spores shed during the several months during which the fungal 'fruit' remains active is truly astonishing, as 100 million spores may be liberated in one night!

RAYED AND RAYLESS FLOWERS AND PLANT INVADERS

Along the Llangollen Canal a common plant is the Bur-Marigold (Bidens cernua). Like the Marigold it is a member of the Compositae, but unlike it has no ray florets, thus making it a relatively unobtrusive flower. What look like flowers in the Compositae are really 'heads' of minute, much reduced flowers or 'florets'; for instance, if the number of individual florets is counted in a dandelion flower head it will be found that over one hundred are present.

In order to make such a flower head more conspicuous many Compositae have developed showy 'ray florets', often white or of a different colour from the central 'disc florets'. As we have seen the Bur-marigold growing by the canal has only disc florets, but it also grows luxuriantly on Brown Moss, and here makes a wonderful show as the flowerheads possess yellow ray florets, so that, indeed, it does resemble a Marigold. This variety is named Bidens cernua var. radiata.

The 'bur' portion of its name refers to the fact that its multitudinous fruit are tiny, flattened affairs with two or four spikes projecting forwards, each spike armed with backwardly projecting spines. Thus the fruit are able to float or to catch in the fur of mammals or feathers of birds as an aid to distribution.

A second example of a flower with both rayed and rayless forms is the Common Groundsel (Senecio vulgaris). The rayed form, having five to eight yellow ray florets, was said to be commonest in the south of England, but it has been increasing in this neighbourhood, and it is quite common to find both rayed and rayless forms growing together.

A third example is the Wild Chamomile (Matricaria recutita) which is so common on waste ground and quite attractive with its yellow disc florets bordered by white ray florets. However, in 1871, the Rayless Mayweed (Matricaria matricarioides), also known as the Pineapple Weed owing to the scent of its crushed leaves (and to the Botanist as 'Mat. mat.'), invaded this country from America.

Its spread after 1900 was most spectacular and it is now found in most British counties. It does not possess parachute fruit, and it spread most rapidly when the motorcar was coming into use, but at a time when the roads were dusty in dry weather and muddy in wet weather. It is suggested that the fruit adhered to the patterned treads of the motor car tyres and were carried some distance before falling from the tyres on to the road where rain wash would carry them to the roadside.

Although not an attractive weed it is certainly a most successful one. A useful book which deals with these new introductions from many countries is 'Weeds and Aliens' by Sir Edward Salisbury.

While not a flowering plant I will add a note here about two moss invaders. The first, <u>Campylopus introflexus</u>, I found on the site of the former Boathouse Wood at Colemere. It is an alien species formerly known only from various parts of the Southern Hemisphere and north as far as the southern States of the U.S.A. First observed here about 25 years ago it is now widely distributed and locally plentiful throughout much of Great Britain and Ireland. Its leaves have long, silvery hair points, which divert at the tips of the shoots to form conspicuous white stars.

The second moss invader was <u>Orthodontium lineare</u>. This was first recognised in England in 1920, although it was a well known species in the Southern Hemisphere, and like <u>Campylopus introflexus</u> it is now widespread throughout Great Britain. My specimen was found in the hollow of a rotted tree stump in the Cremorne Gardens by The Mere.

<u>THE WATER VOLE</u>

On quite a number of occasions we have seen Water Voles (<u>Arvicola amphibus</u>) while walking along the canal towpath at Ellesmere. Sometimes they announce their presence by a sudden plop as they make a hurried dive, but if one is patient and stands still for several minutes they may reappear and continue to eat the stems and leaves of the water plants growing by the canal bank. At other times they may disappear into their burrows.

Their eyesight is not too good although their hearing is keen, so that one can often get within a few feet by moving very slowly and silently. Like other voles they have a rather rounded muzzle, small ears that hardly project from the fur, and a hairy tail - quite different from the Water Rat with which it is sometimes confused.

They do not hibernate, and can be seen early and late in the year. We saw one on 8 April, and another on 15 April in 1964.

BIVALVES

'Shellfish' are plentiful in freshwater which is sufficiently 'hard' to provide calcium compounds needed to make their calcium carbonate shells. We find two groups, the first having one shell we may call freshwater snails, but the second, having two shells, are termed ‘Bivalves'.

The commonest bivalve, both in the meres and the canal, is the Swan Mussel (Anodonta cygnea). On 12 October 1961 a stretch of the canal between Burns Wood Bridge and Miss Each Bridge had been drained in order to replace a broken culvert. This gave us a valuable opportunity to study those organisms which normally live partially buried in mud.

We took a 34 foot length of the canal bed. There was only a small stream of water along the middle, about 2 feet 6 inches wide, and only an inch in depth. On the towpath side of this stream the canal bed was firm and consisted of sandy mud, but on the far side there was thick, deep, black mud. The mussels were practically buried in the mud, but on the sandy side they were unable to bury themselves and could be picked up readily.

The canal had been in this condition for nearly a week and it was surprising to find so many mussels alive. Out of 95 specimens collected only 19 were dead.

One noticeable feature was that there were no really large specimens, the longest being 4¾ inches in length; the most numerous length being 3 inches, with more under 3 inches than over. Few were found under 1 ½ inches long. In the meres they tend to grow much larger and I have found one 7 inches long.

These mussels are slow moving creatures, moving by the protrusion of a fleshy lobe (termed the 'foot') into the mud; this foot is then firmly anchored by fluid pressure enlarging it; then special muscles pull the whole animal forward on to the swollen foot. By a repetition of this process the animal advances, leaving a furrow in the mud behind it.

Under the canal bridge the water was only an inch or two deep over the whole of the flat bottom of the bridge hole. This was covered by sandy mud, barely an inch deep in places, so that it was difficult for the mussel's foot to get a good purchase. Nevertheless they could be seen moving and slight furrows were formed. We timed their rate of progress and found it to be 2 ¼ inches in 5 minutes, i.e. just over 2 miles a year, calculated as a non-stop performance!

No doubt they would move faster when deeper mud was available, but they have no need to move fast owing to their method of feeding. They are 'filter-feeders', and have two very short spouts projecting from their closed shells called 'syphons'. Water enters the animal through the inhalent syphon, goes through fine mesh curtains ('gills') which strain out the microscopic food particles, and then leaves the animal via the exhalent syphon. The movement of the water is caused by multitudes of cilia on the so-called gills, which also produce thin strands of slime to entrap the food particles and move these strands up to the top of the gills and then forwards to the mouth.

As freshwater mussels move so slowly it is surprising that they are so widespread, being found along the whole length of the canal and in all the meres and larger ponds. There is no problem, however, once their method of reproduction is studied. Most of them are hermaphrodite (i.e. are both male and female in turn) and the sperm liberated by a mussel in the male condition leaves it by the exhalent syphon, and enters another mussel in the female condition via its inhalant syphon to fertilise its million or so eggs.

All this happens about July but the eggs and young are incubated for about nine months in the outer gills (these are V-shape in section) which serve as 'brood pouches'. By next March the 'glochidia' larvae are ready for release, each one being a miniature shell-fish with two shells on which growth lines can clearly be seen; the pointed end of the shells have two inwardly direct teeth. They are so tiny that en masse they appear like very fine sand.

They are released in large numbers when a fish passes by, and swim vigorously by snapping their two shells together. They soon die unless they snap on to the fish, preferably the gills which they may enter with the water used for respiratory purposes. The lucky few soon become surrounded by a swelling produced by the fish and live parasitically for several months, after which they break out and fall to the bottom to start their adult life. It is obvious that the slow moving mussel may move many miles while its larva is parasitic on a fish.

When extensive dredging of the canal took place at Whixall Moss a large number of the Painter's Mussel (<u>Unio pictorum</u>) were turned up. This is only about 2 ½ inches long having a very shiny, white inner layer to its shells. It is said to have obtained both its Latin and English names from the fact that in olden times these shells were used by painters ('pictorum' means 'of the painters') for holding their pigments.

We found quite a number of these shells some distance away from the canal on the Moss; these had probably been carried there by birds. While alive two short, stout columns of muscles can hold the two shells tightly closed, but as soon as they begin to die the shells gape and the birds can then eat up the contents.

We have one bivalve, the Zebra Mussel (<u>Dreissena polymorpha</u>), which is restricted to Colemere. It has a number of interesting features which are more typical of marine mussels than those of freshwater bivalves. Firstly, the shape is very much like that of the marine mussel, although it is somewhat smaller, secondly, it is sessile, being fixed to stones, even old swan Mussel shells, by means of a tuft of adhesive threads, termed a <u>byssus</u>; the marine mussels are attached to rocks, pier and dock supports, in the same manner, lastly, there is a motile larva, called a veliger larva, which is not parasitic but swims a short distance and then settles down for the adult stage. It would be swept away by fast flowing water, thus the Zebra Mussel is only found in still or slow-flowing conditions.

The Zebra Mussel gets its name from the alternating bands of dark brown and pale yellowish-brown on its shells which remind one of the Zebra's colour pattern.

How did the Zebra Mussel reach Colemere? and why is it not found in any of the other seven meres? It seems to have started out from the Caspian Sea and spread westwards, becoming adapted to a life in freshwater. It was first recorded in England in 1824, and probably arrived on timber imported from the Baltic countries. Some of this may have arrived at Ellesmere Port and become dislodged into the canal, or become attached to some of the narrow-boats.

John Olegg in his 'The Freshwater Life of the British Isles' states:

'it is usually found in slow rivers, canals, docks and reservoirs, attached in clusters to submerged stones or wooden posts. It has now become a rather troublesome pest of the water engineers by blocking water mains'.

The subsequent fate of these attached Zebra Mussels could have been as follows, after leaving Ellesmere Port the boat may have picked up a cargo of limestone from Llanymynech and then visited the limekilns at Colemere where the top of the kilns is level with the towpath. While unloading its cargo a few Zebra Mussels may have become dislodged, as the hull of the boat rubbed against the wharf side. A few hundred yards further on there is a 'canal overflow' where the bank level has been slightly reduced leading by a tapering brick bed to a channel which connects it up with the mere at a lower level.

It so happens that there is a twenty one mile length of canal in this neighbourhood without a single lock, so that when the occasional 'cloudburst' happens, water will rush down the overflow into the mere, taking with it a few Zebra Mussels.

This sounds involved, but today Zebra Mussels are quite common all over Colemere, but do not occur in any other mere, even in Blakemere which is skirted by the canal running very close to it and only a few feet higher; however, it has no direction connection with it.

In conclusion there is another puzzle, and that is on every occasion when I have examined the canal bed, when the canal has been emptied for repairs, I have never found any Zebra Mussels in it.

THE FEEDING AND CONJUGATION OF PARAMECIUM

Paramecium (the 'Slipper Animalcule') frequently turns up in hay infusions. These are made by taking rain water or pond water and adding hay to it. After standing for a week or so, a gelatinous film forms over the surface of the water consisting of billions of bacteria, some of which come from the hay and some from the water or air.

If a tiny blob of this film is placed on a microscope slide and a coverslip added, the microscope will always reveal flagellates or ciliates. Amongst the ciliates a form, somewhat shorter and more rounded than Paramecium, nearly always appears; it is known as Colpidium; but at certain stages in the development of the hay infusion Paramecium may also appear.

During our own digestive processes food is chewed up in our mouths under almost neutral conditions, to be followed by acid conditions in the stomach, and alkaline conditions in the intestine. It interesting to find that even in such a primitive organism as Paramecium we find the same sequence of operations is followed. This can be shown by feeding it on yeast stained with Congo Red.

This pabulum is prepared by boiling gently for ten minutes a mixture consisting of:

3 gm. yeast
30 mgm. Congo Red
10 cc. distilled water

A slide is then prepared with a small circular enclosure surrounded by vaseline. A drop of the Paramecium suspension taken from the hay infusion is placed in the enclosure, and a minute amount of the stained yeast preparation added by means of a mounted needle. Finally, a coverslip is pressed lightly on to the vaseline ring until the Paramecium is held reasonably still for high power examination.

The yeast, red at first, can be seen being taken into the animal, and then watched as it travels slowly rounds its body in 'food vacuoles'. Before it reaches the end of its travel, the stained yeast turns blue. Now, Congo Red in acid solutions is red, awhile it turns blue in alkaline solutions.

On one occasion we were greatly surprised to see quite a number of Paramecium conjugating. This is a reproductive process in which two individuals come together, mouth to mouth, and exchange nuclear material, after which they separate. The remaining and the exchanged nuclear material then fuses, thus introducing new characters into the organisms.

According to all accounts conjugation is difficult to produce to order and thus its observation is a chancy affair. This was brought out clearly when the G.B. film entitled 'Paramecium' was being made. To quote from 'Cine Biology' (Penguin), page 31:-

When the Paramecium film was made, all phases of the life-story had been duly photographed with the exception of this most important incident, which for some unexplained reason, had failed to appear. Literature and experts were, therefore duly consulted. Works which suggested in a casual way that conjugation of couples could be found in any pond were dismissed as unreliable. To more learned treatises which calmly and seriously stated that conjugation could be brought about by doing this or that, more consideration was given; but we soon arrived at the conclusion that neither this nor that had any effect whatever. Some experts contended that conjugation was caused by weakness due to long inbreeding, and others contradicted this by the assertion that the mixing of two unrelated cultures was essential.

Frantic efforts to try out everything, reasonable and otherwise, produced an agglomeration of pots and jars, smelling horrible, which merely became more numerous and more obnoxious as time went on, while their inhabitants became more obstinate. Month after month passed, and still, no Paramecium would pair up with another, while experts who had started with high hopes and assertive confidence faded away one by one. Finally, when patience was becoming threadbare, in fact, when the hope of filming the conjugation of Paramecium had been reluctantly abandoned, a student at the Imperial College of science spotted conjugation in some material which he had been given for microscopical study in his classwork.

The telephone wires hummed; the precious creatures were rushed by taxi to the Southgate laboratory and filmed at once. In a few hours the performance was completely over. But we were happy....... we had filmed the conjugation, of Paramecium. And now, if the process cannot be discovered, as the textbooks assert, in any pond, it can be observed with unfailing regularity as the film is run through.

A more common form of reproduction which we were able to see was that of 'Binary Fission'. The cells became pinched off at the middle until two cells result. Although nuclear material is shared equally between the two cells, no new characters are introduced as only single cells are involved in the process. The chief advantage is that, starting with a well adapted organism, repeated binary fission leads rapidly to enormous numbers of organisms, all equipped with the same characters.

9 June 1952

BOTANISING ON THE SITE OF AN INLAND SEA

There is no limestone in Ellesmere, but near Llynclys, three miles north of Oswestry, there are extensive limestone hills. These hills contain fossil corals and mollusc shells which prove that they were laid down at the bottom of a shallow, tropical sea millions of years ago, and have since been lifted up until they now form impressive hills.

Going westwards from Llynclys we soon see the site of the old Dolgoch Quarry to the north, and on the same side of the road a complex of old workings at Whitehaven. These include Whitehaven Quarry, Little Rock Quarry and Joey's Hill Quarry. Another disused quarry somewhat further north near Trefonen, is the Treflach Wood Quarry - it is fossiliferous and has been described on page ?.

However, one quarry, the Porthywaen Quarry, which was in operation before 1800, is still worked. It has been modernised and quarrying is carried out on such a large scale that it has begun to affect the landscape. Vertical shafts are bored at several places along the working face, and these are filled with explosives. A colossal explosion removes a considerable amount of rock at a time. The rock is a magnesian limestone, and it is pulverised and sold as a fertiliser.

Two more quarries occur further westward. Nantmawr Quarry to the north of the valley road, was active until recent years, while the Llanyblodwel Quarry, to the south of the road has been much enlarged and modernised.

Returning to Llynclys and continuing south along the Oswestry-Welshpool Road we skirt a limestone hill massif which is first called Llynclys Hill, then Crickheath Hill and finally Llanymynech Hill. This limestone mass becomes higher and more impressive until it finally ends in an escarpment 750 feet in height; it could be described as an inland cliff.

Most of these quarries were worked extensively about 1800, when inclines were made to bring the limestone to the lower ground for distribution by the Ellesmere Canal. Today all is dereliction, for no quarrying takes place here any more.

There is a road leaving the Nantmawr Quarry which follows the 625 foot contour line, and finishes at a house on the slopes of Moelydd, a hill rising to 934 feet. On an outing of the British Naturalists' Association we took this route, and at the end of the road entered a wood which ascended sharply. As it was early in the year there were few plants in flower, but there was an abundance of the evergreen Spurge Laurel (Daphne laureola). This has wiry, little-branched stems, with the leaves grouped together near the top of the plant. These leaves are dark glossy green in colour and evergreen; they rather hide the small yellowish-green flowers, arranged radially underneath. The oval fruit are black.

A close relation is the Mezereon (<u>Daphne mezereum</u>). Although it is a native plant of our limestone region, it is very rare, probably the result of having an abundance of purplish-red flowers which make such a wonderful show in early Spring before its deciduous leaves appear. Because of this it has been frequently transferred to cottage gardens, and we have one in our garden but I have never found it growing wild. Its fruit are scarlet berries.

When we left the wood the ground leading up to the summit of Moelydd was covered by short grass, and divided up into fields by hedges. Along one of the hedges we found a luxuriant growth of the Stinking Hellebore or Bear's-foot (<u>Helleborus foetidus</u>). As its name suggests it has a foetid smell. Its lower leaves are robust and overwinter, so that further leaves develop during early Spring the pale green new growth contrasts with the dark green of the older leaves. The leaf is divided up into segments which are spread out like fingers and have serrated margins.

The numerous flowers are arranged in drooping clusters; they are nearly globular and green in colour, usually bordered with reddish-purple. The Flora states that it is a local plant of woods and scrub on shallow calcareous soils and screes, but in this area it is quite common in fields and is often found in disused quarries.

A close relation, the Green Hellebore (<u>Helleborus viridis</u>) is much more rare, and the only specimen I have seen was in a field alongside the Welshpool-Newtown road; and even that has now gone.

Other forms of Helleborus are cultivated as they occur early in the year when there few other flowers about. <u>H. niger</u> with other species of <u>Helleborus</u> have rather reddish flowers opening somewhat later so that they are known as Lenten Roses. Actually <u>Helleborus</u> belongs to the buttercup family.

Not far from the top of Moelydd one field had a large number of ants nests forming hillocks above the ground to a height of two feet in some cases. They may have been made by the Yellow Hill Ants on the site of molehills.

21. March 1967.

Llynclys Hill

On another occasion we went up a narrow road leading south from the valley, and after a very sharp ascent reached the rather flat area at the top of Llynclys Hill. There were extensive views over the surrounding countryside, a fresh breeze was blowing, and clouds were scudding across the sky. Following a wide, muddy track across an area covered by coarse grass and gorse we stumbled across a number of young pheasants out of their nests. They kept perfectly still and were particularly well camouflaged, so that I am afraid we killed two accidentally by treading on them.

The Greater Butterfly Orchid (Platanthera chlorantha) was not uncommon here, and its almost white flowers made it easy to notice. We visited a pair of cottages which were completely isolated and derelict, although renovation work had been started. A wall at the back of these cottages was thickly covered by the Rusty-back Fern (Ceterach officinarum) which has a tuft of persistent thick leaves that are simply pinnate, dull green above and covered by brown, overlapping scales underneath, which give it its rusty colour.

On this outing we did not go further than 'Jacob's Ladder', local name for the steps leading to the path along the edge of the precipitous Blodwell Rocks - fortunately well protected by a strong wire fence. A grassy hollow here was well supplied with mosses usually associated with limestone, and I identified the following:

Bryum pallens	Climacium dendroides
Ctenidium molluscum	Encalpta streptocarpa
Grimmia pulvinata	Hylocomium splendens
Pseudoscleropodium purum	
Rhytidiadelphus squarrosum	

Climacium dendroides is unusual in being 'dendroid', i.e. 'tree- like'. It has vertical stems arising from a rhizome which are unbranched for some distance and clothed with closely adherent leaves: it then branches in several directions, although mainly here in a horizontal plane, looking very much like a miniature tree.

There is another dendroid moss which occurs on limestone and I found this in a small wood close to Whitehaven Quarry. It is known as Thamnidium alopecurum and formed a close-set covering to some rocky boulders.

<u>The Blodwel Rocks</u>

My knowledge of the botany of the Pant area and of the Blodwel Rocks owes much to the expert knowledge of Miss Doris Pugh. She has lived and taught in this area for much of her life and knows the position of all the interesting plants as well as their date of flowering.

She took me up to Jacob's Ladder from Pant, pointing out where the Spurge Laurel and Stinking Hellebore grew on our way. Then we walked along the edge of the precipice of the Blodwel Rocks looking down the steep slope to the valley below, and across to the hills which are being quarried on the other side at Porthywaen. In one or two places one looked almost vertically down fiercesome clefts in the rocks which would have taken a mountaineer to negotiate, and although it has been reported that Lily of the Valley (<u>Convallaria majalis</u>) grows in one of them I shall not bother to investigate. However, along our path we did find some plants of Columbine (<u>Aquilegia vulgaris</u>) flowering, and at a right-angled bend in the path the Rock Rose (<u>Helianthemum chamaecistus</u>) grew profusely, making a beautiful show.

On the opposite side of the path to the precipice the ground sloped downwards more gradually and was covered by a fairly open coppice, and here I was introduced to a fair-sized patch of Herb Paris (<u>Paris quadrifolia</u>). The English name is misleading as the plant has nothing to do with Paris; this simply being a corruption of the Latin 'pars', meaning parts; 'quadrifolia' refers to its four leaves situated just below the flowers.

At a later date I was shown an even more extensive patch of this plant. The Spurge Laurel was common here, and there were two remarkably large and handsome specimens.

Some orchids are not 'choosy' about their habitat and one of these is the Early purple Orchid (<u>Orchis mascula</u>). In the coppice I found half a dozen and photographed them in colour, using flash - only to find, soon afterwards, a group containing forty seven plants all in flower! There are other orchids which are much more particular about their choice of habitat; one of these, the Frog Orchid (<u>Coeloglossum viride</u>), was not uncommon along the precipice path, and definitely likes calcareous soil. The whole plant, including the flowers, is green and the lower flower petal is very long and hangs vertically.

The Twayblade (Listera ovata) is another orchid we found here which is completely yellow-green; it bears some resemblance to the Frog Orchid, although there is no difficulty in recognising it owing to the fact that it possesses two wide, oval, sessile leaves near to the ground from which the flower stalk arises ('twa' = two: 'blade' = leaf). I would like to mention here that Ian Bonner noticed a small number of Twayblade plants growing by the edge of the Ellesmere Canal at Blakemere. As previously mentioned there no limestone within a dozen miles of Ellesmere, and a careful search did not reveal more than half a dozen plants altogether. How did they get there? The suggestion is that as there was much transport of limestone from Llanymynech, Pant and Porthywaen in the early days of the canal's history, and limestone was also used in making the towpath, some Twayblade seeds may have arrived with a cargo of limestone and the plants become established. For several years I watched these Twayblades, of which the cruising public seemed to be quite unaware, but alas, steel piling was used to repair the bank, and the site was destroyed.

The Green-winged Orchid (Orchis morio) favours calcareous soils, and was found by Miss Pugh by the side of the precipice path. It looks remarkably like a stunted form of Early Purple Orchid to a casual glance, but closer attention reveals the upper petals, which are purple, have conspicuous green veins.

Our path turned eastwards after three-quarters of a mile and led us back to the village of Pant. Quite close to the village, on another occasion - 17 September 1968 - we found the Autumn Lady's Tresses (Spiranthes spiralis), growing on rough hilly pasture. We had to search for quite a time before we located it, as it was only six inches high. Its tiny white flowers are arranged in a single twisted row - hence its Latin name.

Dolgoch Quarry

The main disused Dolgoch Quarry is some distance back from the road, and not easy to reach owing to vigorously growing trees and lush undergrowth; but quite near to the road the spoil heaps of smaller workings are much more approachable. I walked alongside the railway, a single track line running from the Porthywaen Quarry to Llynclys, and here I found yet another orchid which needs a calcareous habitat - it was the Pyramidal Orchid (Anacamptis pyramidalis), so called because its rosy-purple flowers are arranged to form a pyramid. It has a fascinating pollination mechanism which will be described later.

After leaving the railway I entered a field which led me to the spoil heaps which proved to be a veritable limestone garden. There were more Pyramidal Orchids, plenty of Spotted Orchids and about twenty plants of the Bee Orchid (Ophrys apifera). The Bee Orchid can be found at various places in this limestone area, but it is unusual to find more than one or two plants growing near to each other. The resemblance of the flower to a humble bee is very striking, and may be a way of attracting bees to the flower; other orchids have flowers resembling flies and spiders - but what is the purpose of the Man Orchid?

Further plants characteristic of limestone which are growing on the spoil heaps were the Yellow-wort (Blackstonia perfoliata) Centaury (Centaurium minus), Viper's Bugloss (Echium vulgare) and Teasel (Dipsacus fullonum).

14 July 1969

The College Field Club visit the Llanymynech escarpment

Just before reaching Llanymynech we went northwards along a minor road for about half a mile, and then left it by a path until we came upon steep ground leading up to the escarpment. Here we found typical limestone plants such as Thyme (Thymus serpyllum), Rock Rose (Helianthemum chamaecistus), Mouse-ear Hawkweed (Hieracium pilosella), Squinancy wort (Asperula cynanchica) and Quaking Grass (Briza media), all growing amongst a short grassy turf in which much brownish looking moss (Dicranum scoparium) was common. Rocky patches became more frequent as we got higher up and showers of young grasshoppers accompanied our every step.

When we halted for our picnic tea the whole countryside was spread out before us, a great plain with the meandering river Vyrnwy quite near, and Breidden Hill (1202 feet), Moel-y-golfa (1324 feet) and the Long Mountain not many miles distant, emerging sharply from the plain; while in the direction of Shrewsbury and the Wrekin the great Shropshire Plain stretched out until it was lost in the haze.

Some of the party ascended the scarp face by the hard way, namely, climbing straight up - a very risky thing to do. The rest of us took the more gradual route to the top. The wild, craggy nature of the limestone rocks made them most suitable as nesting sites for crows and jackdaws; while many flowers looked their best growing on the numerous ledges, including the Rock Rose and the common Mallow. Just below the scarp Salad Burnet (Poterium sanguisorba) grew well.

10 June 1950

At a later date, on a family outing, we found the Blue Fleabane (Erigeron acris) and the Ploughman's Spikenard (Inula conyza) in flower, and among the rock debris more of the moss Dicranum scoparium and Neckera crispa, whose pale, undulate leaves are flattened almost into two rows. It is typical of limestone regions.

14 August 1952

POLLINATION IN SOME BRITISH ORCHIDS

Pollination consists of the transference of pollen grains to the stigmas of flowers, and is usually a necessary preliminary to the formation of seeds. Cross pollination, in which the pollen comes from another plant, is desirable, as it leads to the introduction of new characteristics into the resulting plants; but self-pollination of flowers by their own pollen does occur, and there are many cases where pollination processes take place, although the ovules in the flower's ovaries develop into seeds without the intervention of the pollen grains as these have no effect.

The pollination in orchids is usually a most elaborate form of cross-pollination, often with the structure of the pollinating insect and the flower bearing an intimate relationship to each other.

There are variations in complexity, however, and in the Twayblade (Listera ovata) any small insects, such as flies, ichneumon flies, and small beetles, may be found visiting its flowers and effecting pollination. The flowers are small and green, the sepals and upper petals forming a small hood. The lower petal, however, has a short horizontal portion before turning downwards to form a long, hanging lip which divides into two lobes. Down the centre of this lip there is a shallow groove which secretes nectar.

The upper hooded portion of the flower contains a short thick column, from the top of which two pollinia (club-shaped masses of pollen grains held together by delicate threads) project forwards. We find the receptive stigma at the bottom of the column, separated from the pollinia by a horizontal, tongue-like process called the rostellum.

Insects alight on the flower, attracted by the nectar, and climb up the groove, finally reaching the tip of the rostellum. Immediately a kind of internal 'explosion' occurs and a drop of sticky liquid is forced out, coming into contact with the insect's head or back, and with the pollinia, fixing the two together in one or two seconds. This may happen several times, but in mature flowers, where the rostellum has been withdrawn upwards, the stigma is the first object touched by the pollinia.

The 'explosive' mechanism serves the double purpose of attaching the pollinia very rapidly to the insect, and of frightening it so that it is likely to fly away to another plant, thus effecting cross-pollination.

A more highly evolved pollination mechanism is found in the common Early purple Orchid (<u>Orchis mascula</u>). The lower lip of the flower is shorter and wider than in the Twayblade and is three-lobed. It forms a landing stage for a bee, from which it can insert its tongue into a long, tubular spur protruding from the back of the flower. Strangely enough this spur does not contain nectar, but the bee obtains water from its fleshy walls.

In pushing its head into the flower, the sticky bases of one or two pollinia become attached to the bee, which flies away with them. What happens next is truly remarkable, as the pollinia pivot forwards in a matter of seconds, moving from an upright to a horizontal position. This can be shown quite easily by pushing a sharpened pencil into the mouth of the flower and then withdrawing it, when the pollinia will be found attached and their movements can be watched. When the bee visits another flower, the pollinia are now in such a position that they make contact with the stigma, so that cross-pollination is once more effected.

We find even more elaboration in the Pyramidal Orchid (<u>Anacamptis pyramidalis</u>). It is adapted for the visits of butterflies and moths, and has very long spurs to its flowers which could not be probed by short-tongued insects - although, once again no nectar is present; only water in its fleshy walls.

A major difference is that the two pollinia are joined to a common, sticky base, taking the form of a short, curved bar. Thus when the long, delicate proboscis of a butterfly is inserted into the flower, this common pollinia base adheres to the proboscis, and at the same time curls round underneath, becoming firmly attached as the cement hardens.

Not only do the pollinia move forward through an angle of 90 degs but the curling around the proboscis splays out the pollinia, so that when another flower is visited they make contact with the two separate stigmata which are placed laterally - what an astonishing mechanism!

The Fragrant Orchid (Gymnadenia conopsea) attains the same result in a slightly different way. Firstly, its long, slender spur does contain nectar, and secondly, although the sticky bases of the pollinia are separate, they lie somewhat laterally, so that each makes contact at a later stage with one or other of the two separate stigmas.

All the examples given above can be found in the limestone area around Llynclys and Llanymynech.

THE ABUNDANT LIFE OF WILLOW ROOTLETS

There are a great many habitats which are virtually unknown to the man in the street, especially when these are inhabited by organisms which are microscopic or near microscopic.

One such habitat is the rootlets of the willow trees which project in bunches under water in our local meres. Early Spring is an especially good time to investigate this habitat, as there is little plant life around elsewhere for the botanist to study. At this period the willow rootlets appear to the naked eye to be smothered with a greyish-green growth.

Pick a bunch of these rootlets and on reaching home place them in a shallow vessel and leave for a while until the shock of removal is over. Examine one of the fuzzy patches surrounding a single rootlet under the microscope. It can be seen that there are scores of a simple protozoan animal called Vorticella or the 'bell-animalcule’, which looks like an inverted bell on a slender stalk. It is practically transparent, and although fixed by its stalk to the willow rootlet, it is constantly on the move, because its stalk suddenly contracts to a tight, coiled spring, and then gradually uncoils once more. It is fascinating to watch the 'dance of the bells' and to watch a single bell with its ring of cilia vibrating rhythmically, giving the impression of a continuous circular movement. When contraction occurs, the cilia are tucked in as the bell becomes globular for a short time.

One is almost sure to find Carchesium, a colonial form of Vorticella, with scores of 'bells' at the end of branched stalks. Although the main stalks do not contract, the branched stalks do. The thousands of bells of these two protozoans give rise to the greyish fuzziness, quite visible to the naked eye.

Some of the rootlets are enveloped by green algae producing a really lovely effect where viewed under the microscope. The alga in question is called Draparnaldia. It has main axes consisting of large rectangular cells, from which secondary, and sometimes tertiary, axes composed of progressively smaller cells are given off. These axes are not very coloured, but the ultimate bunches of the finest cells are markedly green and form branching tufts like a mermaid's hair spread out in gay abandon.

Another alga present is easily recognisable as a close look shows a resemblance to miniature toad’s spawn. The common name for this alga is ‘Frog’s spawn Alga’, while its scientific name is just a translation of this, Batrachospermum (Batracho = frog; spermum = spawn). As so often happens the resemblance is a very superficial one, because frog’s spawn consists of a mass of eggs, each in a gelatinous covering, while toad's spawn consists of a double row of eggs arranged in a gelatinous ribbon and is twisted amongst weeds in the water. Batrachospermum appears to consist of a single row of eggs, certainly contained in a jelly, although very tiny. A more careful examination through a lens or, better still, through a microscope shows that each egg consists of filaments branching out from the same point on the main stem in all directions, thus producing a globular cluster. Darker dots are often present in such a cluster, and these are 'cystocarps' which we may regard as the 'fruit' of the alga.

The colour of Batrachospermum is not green but a purplish-grey, as it is one of the very few Red Algae (Rhodophyceae) which live in freshwater. A great many red algae are most attractive plants growing in rock pools on the seashore.

Dotted over the rootlets are minute green 'blobs' less than ¼” in diameter, and if one is placed on a plain microscope slide and a slice cut by means of a razor blade, and covered with a cover-slip, the microscope reveals a branching green alga, which starts off with few branches at the centre, but finishes towards the outside of the 'blob' with a multitude of branches, becoming ever more green. This is an alga called Chaetophora.

Yet another visible algae can be seen at this time, called Tetraspora (tetra = four; spora = spores or cells), so called because its cells are arranged in close-set groups of fours in the wall of a gelatinous envelope. This envelope is quite small, maybe ¼ inch to ½ inch long, and its form is rather like a flabby sausage skin, and may be attached to the rootlets or float freely in the water.

Coming on to the really microscopic algae there is one, which forms a circular, flattened plate of cells, the outer walls of the peripheral cells projecting as two horns. Its name is Pediastrum boryanum. There are not many cells in the plate and although most of the cells are bright green, colourless, empty cells occur where the contents have divided up and been extruded in a tiny vesicle. After a time the minute contents of the vesicle arrange themselves as a new, but tiny version of Pediastrum and becomes independent.

The desmids are plentiful in freshwater. Closterium being curved like a miniature banana, although it is more pointed at each end. It is quite dark green in colour, but has a colourless cavity at each end containing tiny particles which are in constant motion – at least, as long as the desmid is alive.

Scenedesmus is another simple alga found here, consisting of only four oval cells attached by the gelatinous walls along their long axes, while the outer cells have a projecting horn at each end. Pandorina is exceedingly common, and consists of only sixteen cells forming a ball. The individual cells are slightly pear-shaped which helps them to pack tightly together and possess two cilia each projecting through the common gelatinous wall. This wall and the cilia are hardly visible in the live specimen.

The diatoms have a common ground plan which might be said to consist of a pill box and lid, but within this basic plan there is a very great variety of shapes; some are circular, others oval or rod-shaped; some are single cells, others consist of scores or even hundreds of individual cells adhering together in various patterns. Moreover, the fine markings or 'striae’ shown by the cell walls are so fine that they have been used in the past for testing the accuracy of high power microscope lenses; these striae also show a great diversity of pattern and arrangement.

Although free-floating, the willow rootlets are bound to yield the diatom Asterionella (meaning 'star shaped') in which the long, slender cells, bulge slightly at each end, and are arranged as a star by the cells adhering at their 'inner' end, and radiating rather like the spokes of a bicycle wheel without a rim, their ‘outer’ ends being free.

Fragilaria is another diatom, which has long, slender cells, but these are attached by their long sides to form an extensive ribbon. Further, although they possess chlorophyll they also possess other pigments, which mask the green, the final colour being a brownish-yellow. Both Asterionella and Fragilaria can multiply readily by the breaking up of the 'star' or 'ribbon'. The last diatom found on this occasion was Gomphonema. Although very tiny it is epiphytic on the roots of willow in enormous numbers, and shows up well under the microscope as it is borne up on a transparent gelatinous stalk above -the substratum.

29 March 1973

CAT'S EYES' IN RABBIT BURROWS!

How often one has to say "Nature thought of it first". The invention of 'cat's eyes' which make our roads so much safer was a stroke of genius, but I am sure that the inventor never realised that millions of years ago Nature introduced, them in the life cycle of a particular moss called Schistostega pennata.

Like most mosses it needs a moist, shady situation to flourish, and is most often found just inside the entrance of old rabbit burrows, in caves, and other very shady places. It is quite small, less than a centimetre in height, and the poor light conditions result in its colour being a very pale green, so that it is not easy to see unless you view it at close quarters.

The young stage, or protonema, consists of a fine weft of threads bearing groups of cells designed to collect the minute amounts of light which penetrate the entrance of the burrow. These cells form the 'cat's eyes' as they reflect the light falling on them back to the entrance. Each cell contains four or five chloroplasts which can manufacture food only if light falls on them. The design of the spherical cells and the position of the chloroplasts ensures that every scrap of light is used to maximum effect.

It is quite exciting to look closely into a burrow and view the green luminescence which can be seen in its dim recesses. Kerner in his 'Natural History of Plants', published in 1894, waxes quite lyrical about it - "one can easily see how the legends have arisen of fantastic gnomes, and cave-inhabiting goblins who allow the covetous sons of earth to gaze on the gold and precious stones, but prepare the bitter disappointment for the seeker of the enchanted treasure; that, when he empties out the treasure which he has hastily raked together in the cave, he sees roll out of the sacks, not glittering jewels, but only common earth".

23.August.1973

POSTSCRIPT - DROSOPHILA MELANOGASTER

Although the following piece of work has nothing to do with Shropshire, it was carried out by the boys at Ellesmere College during 1950 and subsequent years, and created considerable interest.

The subject studied was genetics, or the study of heredity. As this subject involves following the inheritance of certain characteristics through several generations it is obvious that the animals or plants used must be quick breeding if the subject is to be studied in the limited time available in school.

There are other points which are equally important. Rabbits, guinea pigs or rats can be used but suffer from the fact that they need considerable space, specially constructed living quarters which need periodic cleaning out, and regular feeding - and there is the question of attention during school holidays.

All these difficulties are overcome if we use the common fruit fly, Drosophila melanogaster, as our genetic material. When magnified it looks somewhat like an ordinary housefly, but it is so small that several generations can be kept in a 1/3 pint milk bottle. They produce a fresh generation about every fortnight, and by keeping them in an incubator at a definite temperature, the stages in their life history will occupy a definite time, so that a strict time schedule can be worked out. A large number of eggs are laid so that there is no shortage of material, and feeding is easy as Drosophila is a yeast feeder in its larval stage, and with a suitable medium added to the bottle no further attention is needed for some time. A visit to school at fortnightly intervals solves the holiday problem.

Making up a maize meal-molasses-agar medium.

1. 350 cc. water, 60 gm. black treacle and 5 gm. Agar powder are boiled together in a saucepan until the contents are almost dissolved. This takes about half an hour, constant stirring being necessary to prevent charring.

2. 70 gm. Maize meal (also called ‘corn meal’ are stirred into 200 cc. Water – preferably in a double saucepan - and boiled until it attains the consistency of porridge.
3. The mixture (1) is then poured into mixture (2), and well stirred until it thickens.

Pouring the food into containers

1/3 pint milk bottles are used for containing stocks of pure bred flies, while glass tubes, 3" x 1", are used for the actual experiments. If the food medium is poured immediately it is made up it can be added by means of a funnel before it sets.

About 1” added to the bottles and rather less than this to the tubes, and they are left to set. In each case the mouth of the container is closed with by a plug of cotton wool.

This medium provides the sugar needed by the adult flies, but one or two drops of a 'cream' of yeast is added to the tubes and bottles to provide food for the larvae. They burrow into the medium and thus spread the yeast away.

With a table knife cut out a wedge of the medium from the tube and insert a rolled piece of tissue paper into the cavity in order to soak up excess liquid which may drain down. Any food medium not needed immediately used can be kept if sterilized by heat in a bottle with a cotton wool plug.

Sexing the flies

One minor disadvantage of Drosphila is that it is so small that a lens (or better still a microscope) is needed to distinguish the sexes with any degree of certainty. The characteristics of both sexes are shown in the drawings, greatly enlarged. However, being very active these flies have to be anaesthetised before they can be observed.

To transfer some from the stock bottle thump the bottom of the bottle down on to the hand - this drives the flies downwards for a few seconds - and quickly remove the cotton wool plug, and place an empty bottle mouth to mouth with the stock bottle, some of the flies will enter the empty bottle. Separate the bottles and quickly insert cotton wool plugs.

To anaesthetise the flies in the bottle, pour a little ether on to the cotton wool of the special cork shown in the drawing and insert this in place of the normal plug. Wait until all movement ceases, but no longer, otherwise death will result. The flies can now be tipped out of the bottle and examined individually to decide on their sex, males being put into one labelled tube and females into another.

Much practice must be carried out until sexing can be determined correctly, as one mistake here will upset a whole experiment.

Picking out virgin females.

In the stock bottle many of the females will already have mated, and this would upset the result of any experiment. There are features by which virgin females can be picked out, such as an almost white body, and wings not yet unfolded, but a safer way is to shake out all the adult flies from the stock bottle into an empty bottle during early morning, and then examine the stock bottle twice daily, sexing the flies which emerge. All the females will be virgins, as they do not mate for several hours. Any of the males can be used Mutant forms.

An enormous amount of work has been carried out using Drosophila, and during this time aberrant forms have arisen which can be separated and interbred, often perpetuating the new characteristics. Such pure breeding forms are called mutants and are used in further experiments.

Although wild Drosophila melanogaster occur in this country, specially selected flies are used experimentally, called 'Oregon R' (+), and a suitable mutant, such as 'vestigial wing' (vg) is mated with it.

Other mutant forms differing in wing characteristics are shown in the drawings. Eye colour mutants include eyes of a purple colour, white, eosin, garnet, etc. Body colour mutants include grey body, yellow body, sable body, while other mutants affect a reduction of the eye area or even the complete absence of eyes. Not only are there books written about Drosophila and its mutants, but there are whole libraries as well!

A simple experiment on the inheritance of the vestigial wing character in Drosophila.

To carry out this experiment we must obtain pure bred stocks of (a) Oregon R (or +) flies, and (b) vestigial wing (or vg) flies from the dealers. By the method previously described we shall need to separate virgin female (+) flies and male (vg) flies, and put three of these females and six males in one glass tube fitted up with food medium. A second experiment should be fitted up in reverse. Label the tubes and keep in a wooden box over a radiator, or in an incubator at 26 C.; at this temperature the life cycle of the fly is completed in a fortnight.

The fly maggots which hatch out from the eggs are almost transparent, apart from the very dark mouth parts which are very mobile and tear at the medium. When fully grown the maggots pupate (drawings of larvae and pupae should be referred to).

Although the adult flies which follow are the result of a cross between a long winged female and a vestigial winged male, all the flies in the first filial generation have long wings. This is because the long wing character is <u>dominant</u> swamping any effect which might have been produced by the <u>recessive</u> vestigial wing character.

When a reasonable number of flies have emerged, three tubes are set up with three virgin females and six males in each tube. Using three tubes ensures a sufficient number of flies are obtained to give more accurate results. The eggs laid by these females produce flies of the second filial generation. The interesting fact is that if the flies are anaesthetised and counted it will be found that the number with long wings compared to the number having vestigial wings is in the ratio of 3 to 1. Being a statistical result this number is more nearly approached the greater the number of flies involved, so seven boys carried out their own experiments and the results were pooled.

Here are the results obtained:

<u>First filial generation</u> - all flies had long wings
<u>Second filial generation</u> -

(a) long wing flies 856
(b) vestigial wing flies 294

this gives a ratio of 2.91 to 1, or approximately a 3 to 1 ratio.

This 3 to 1 ratio in the second filial generation is a normal result on crossing a normal type with a pure bred mutant, and was discovered by Gregor Mendel, although he worked with garden peas, and used such characters as tall plants crossed with short plants.

All his results can be duplicated, using <u>Drosophila</u>, for instance he studied the inheritance of two characters simultaneously, and we can take flies which have red eye colour and normal length wing and cross these with the mutants having purple eye colour and vestigial wings. The results obtained give, in the second filial generation the forms shown in the ratio 9:3:3:1 -

9 long wing, red eye
3 long wing, purple eye
3 vestigial wing, red eye
1 vestigial wing, purple eye.

The whole subject, at first called Mendelism and later Genetics, is a vast and complex subject which we will not follow up any further here.