Elementary Science, Nature Study, & Practical Work

in Preparatory Schools and the Lower Forms of Secondary Schools

Being a Report of the

SUB-COMMITTEE *appointed by*

THE SCIENCE MASTERS' ASSOCIATION

1922

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NOTE

This Report is a detailed schedule of main principles agreed upon by the Head Masters' Conference, the Association of Preparatory Schools, and the Science Masters' Association.

It should not be taken as being a statement of the views of the Science Masters' Association as far as introductory science is concerned, but it is hoped that it may form the basis of work in Preparatory Schools and the lower Forms of Secondary Schools so that some correlation may be possible.

Elementary Science, Nature Study, and Practical Work in Preparatory Schools and the Lower Forms of Secondary Schools.

In June 1921 the Joint Standing Committee invited the Science Masters' Association to send representatives to meet them to discuss the teaching of Science in Preparatory Schools and its correlation with that given in the lower forms of Public Schools. Mr. C. Godfrey was also present as representing the Mathematical Association.

The Joint Standing Committee arrived at the following recommendations, which were forwarded to the Headmasters' Conference and to the Council of the Association of Preparatory Schools for adoption:

(a) That the scope of the Geography Paper in the Common Entrance Examination be widened.

(b) That all candidates for the scholarships for Public Schools should have an opportunity of answering questions on Natural Science in a viva-voce examination.

(c) That some of the questions set in the Common Entrance Mathematical papers should be so framed as to test a boy's proficiency in Practical Mathematics.

(d) That an opportunity should be given both in the General Paper for scholarships, and in the English Composition and Literature Paper of the Common Entrance Examination, for a candidate to show his knowledge of Natural Science.

(e) That where possible two periods weekly should be given to Science in the curriculum, or, at any rate, one period.

The first four of these five recommendations have now been accepted by both bodies, and they have been sent forward to the Common Entrance Examination Board.

The Science Masters' Association was then invited to prepare a statement of work, in accordance with the above recommendations, which might with advantage be carried out by young boys. The sub-committee, consisting of Messrs. O. H. Latter of Charterhouse, J. R. Eccles and S. Wilkinson of Gresham's School, Holt, V. Seymour

Bryant of St. Piran's, Maidenhead, with the assistance of Mr. C. Godfrey of the Mathematical Association, recommend as follows:

1. The object aimed at should be to arouse an intelligent interest in the natural phenomena in the world at large, but more particularly those around the school and the home. With this end in view, it is most important that *the work should be done by the boys themselves* with as little help as possible from the Master in charge.

The function of the Master should be to propound questions, to suggest inquiries by experiment and observation, and to set boys on the right path to find out for themselves the answers to intelligent questions that they address to him.

Set lectures giving mere information in a didactic manner should be avoided.

2. That as far as Nature Study is concerned the recommendations of a previous sub-committee of the Public School Science Masters' Association be adopted.

3. That the principle of dovetailing subjects should be carried out wherever possible. In practical Geography for example, much of the work can conveniently be interwoven with the ordinary topography teaching on the one hand, and with woodwork in the Carpenter's shop on the other. Much of the Practical Mathematics may also conveniently be carried out in the workshop, and most of the remainder covered in the classroom by the Mathematical Master.

The Nature Study Course affords great opportunities for instruction in drawing, writing, and particularly in English. This should be mutual, however, and friendly co-operation between the English and the Science Master is eminently desirable.

The sub-committee have drawn up the subjoined syllabus of work which may reasonably be undertaken by boys up to 14 or 15 years of age at both Preparatory and Secondary Schools.

The syllabus in Practical Geography and Practical Mathematics should be completely covered during the Preparatory School stage, but it is not suggested that the Nature Study syllabus be attempted in its entirety. It is strongly urged that the Master in charge of the Nature Study should make his own selection from the list and calendar hereto appended.

A few model lessons have been sketched out as examples of the method to be employed in this subject. It will be observed that there is a certain amount of overlapping in the Nature Study and Practical Geography schedules. This is intentional, as some portions of the complete scheme may be more conveniently dealt with by the Nature Study master than by the Geographer or Scientist in some schools and *vice versa* in others.

V. SEYMOUR BRYANT,
Hon. Sec. S.M.A.

SYLLABUS OF NATURE-STUDY WORK SUITABLE TO PREPARATORY SCHOOLS

(The syllabus is here arranged according to subjects, in order the more readily to enable Masters to perceive the scope of the work. The same syllabus is also presented below in the form of an annual calendar.)

BOTANY.—(This is to be understood merely as a list of suitable subjects, from which the Master will make his own selection.)

1. Seeds: their structure and germination as exemplified by the seeds of mustard, French bean, runner bean, and ash. The behaviour of the root and stem of the seedling with regard to the force of gravitation.

2. The effect of light and of darkness upon the growth of seedlings.

3. The attitude and position of leaves on various plants with regard to incidence of light.

4. Climbing plants; the manner in which such plants grasp their supports.

5. Experiments on the nutrition of plants; the chemical substances necessary to plant life as shown by water-cultures.

6. The presence of starch in leaves exposed to the light; how to recognize starch by the iodine test.

7. Starch in bread, rice, potatoes, and seeds employed as food by man.

8. The structure of buds, bulbs and corms; the relation of the bud to the leaf.

9. The structure of a flower. The colour and scent of flowers in relation with insects. The absence of fruit from plants, e. g. strawberry, screened by muslin from insect visitors.

10. Trees that flower before they develop their leaves in Spring, and vice versa; the differences between the flowers in the two groups, and the significance of the differences.

11. The fall of the leaf in Autumn a 'vital' process, i. e., does not occur on a branch broken off in Summer, but is accomplished by living trees and shrubs only.

12. Evergreens and their characters.

13. The differences between species of trees in Spring, Summer, Autumn, and Winter.

14. Fruits: the structure and chief modifications of edible fruits.

15. The dispersal of succulent and of dry fruits; winged seeds, burrs, &c.

16. Ferns, their habits, mode of growth and life-history.

17. The defences of plants; the nature of thorns, prickles, stinging hairs, &c. (Microscopic examination should be made if possible.)

ZOOLOGY.—(It is not intended that the whole of this Section should be attempted, but only such parts as each individual Master may prefer.)

1. The life-history of moths, butterflies, dragonflies, and other insects; to be ascertained by keeping living specimens and recording and sketching the successive phases.

2. The influence of the colour of surrounding objects upon certain caterpillars and chrysalids, frogs, and some fishes (sticklebacks.) Experiments on these points to be conducted by the boys themselves.

3. The life-history of the frog, toad, and newt.

4. The nests of 'social' insects—ants, bees, and wasps. (Ants may be kept in captivity for years confined in cheap glass cases; 'observatory' bee-hives can be purchased or made on the premises at very moderate cost.)

5. Comparison of the external form of earthworm, insect, spider, centipede, woodlouse, and snail.

6. The growth of the shell of a snail.

7. Sea-shore animals: the occupants of rock-pools, and the fauna between tide-marks. The manner of life, spawning habits, &c., &c., of such animals. The fresh-water hydra and sea-anemones.

8. The hibernation of animals, e.g., mammals, reptiles, amphibians, insects, snails, earthworms; the modes by which they contrive to pass through the winter.

9. Comparison of the feet, legs, and tails of horses, donkeys, cows, sheep, and pigs.

10. A diary relating to birds: the arrival and departure of migrants; lists of resident birds, nesting habits, notices of songs heard and identified; changes in the character of the song at different seasons. The varieties of feathers of an ostrich, or other flightless bird, and those of birds that fly. The forms of the claws and beaks, and the relation between these and the habits of the birds.

GENERAL.—(As with the preceding sections, so here it is intended that a selection should be made from the subjects enumerated, and the whole not attempted.)

1. Meteorological Observations:—Records of the altitude of the Sun throughout the year; how to determine the points of the compass by the Sun and by the Pole Star; the names of the chief stellar constellations; the planets Venus, Mars, Jupiter, and Saturn; the phases of the Moon; tides; the daily record of the wind, of the height of the barometer, of the maximum and minimum temperatures, of the amount of rain as shown by the rain-gauge (these records should be entered numerically and also indicated upon scaled charts); the state of the sky from day to day, the occurrence of fog, dew, snow, clouds, and the various forms of clouds.

2. The principle of the Thermometer; the principle of the Barometer. (These are suitable only for upper divisions. The

instruments themselves should be used and observed by all boys. It is not necessary that the principles involved should be understood before the daily observations are undertaken.)

3. The effect of frost upon the soil, garden paths, freshly tilled earth, &c., and upon rocks. The freezing of water in a closed vessel.

4. The effect of rain upon the surface of the earth; the formation of rills and small streams upon the surface of roads, bare banks, &c., during rainfall; roadside deltas; denudation by atmospheric and by marine agencies; the denudation of rocks of different physical character, e. g., clay, sandstone, and chalk. The outbreak of streams upon a hillside.

5. The examination and description of quarries, sand-pits, brick-yards, cuttings, limekilns, gravel-pits, &c., in the neighbourhood; stratification; fossils from the above localities; pebbles and running water; shingle of sea-beaches; sand and its formation.

6. Lecture on Coal. (An exception may be made here, as it is not possible for boys to find out much of the nature and history of Coal by their own observations.)

7. The evaporation of rain-water, spring-water, and sea-water; the comparison of the residues and the steam condensed from each. Application of the facts ascertained to the 'water-cycle' in nature; rain (or snow), rivers, springs, sea, vapour, cloud, rain (or snow).

8. Map-drawing. A plan of the school grounds drawn to scale, with compass points marked and the positions of various buildings, trees, and other plants indicated; also the haunts of particular animals, birds' nests, &c., &c.

SYLLABUS ARRANGED AS A CALENDAR OF WORK

(It is not expected nor advised that the whole of this syllabus be attempted in any one school. A selection should be made in accordance with individual tastes and circumstances.)

January.—Meteorological observations: sun, moon, stars, and planets; temperature, rainfall, &c., &c. The effect of frost upon the soil and upon rocks. The freezing of water in a closed vessel. [The principle of the thermometer and of the barometer.] The differences between various species of trees in wintertime. The state of various hibernating animals. Observations on the species of birds and their habits; their songs.

February.—Meteorological observations as in January. Trees that flower before they develop leaves in spring; the character of the flowers. Comparison of the feet, legs, and tails of horses, donkeys, cows, sheep, and pigs. Observations on birds; species preparing to nest, arrival and departure of migrants, list of those heard to sing during month.

The effect of rain upon the surface of the earth; the formation of rills and small streams upon the surface of roads, bare banks, &c., during rainfall; roadside deltas; denudation of rocks of different physical characters, e. g. clay, sandstone, and chalk. The outbreak of streams upon a hillside.

The evaporation of rain-water; comparison of the residues and of the steam condensed from each. Application of the facts ascertained to the 'water cycle' in nature; rain (or snow), rivers, springs, sea, vapour, rain (or snow).

March.—Meteorological observations as in January. The altitude of the sun should be observed at the equinox, or as near that date as possible.

Seeds, their germination and structure. Mustard seed: behaviour of root and stem with regard to the earth.

Trees that flower before they develop leaves; the character of the flowers.

Moths and butterflies that appear during the month.

Frogs' spawn and tadpoles.

Bees, wasps, and ants—their nests and renewed activity.

Arrival and departure of migratory birds. Nests, songs, &c., &c.

April.—Meteorological observations as in January.

Seeds, their germination and structure; French-bean seed, runner-bean seed.

Structure of a flower—buttercup, blue-bell, primrose. The colours of flowers and their relation to insect visitors.

Trees that flower before they develop leaves; the character of the flowers.

Moths, butterflies, dragonflies, &c.; the early stages of their life-histories.

Frogs' spawn, toads' spawn, tadpoles, newts.

Nests of ants, wasps, bees.

Arrival of migratory birds; nests, songs, &c., &c.

May.—Meteorological observations.

Seeds, their germination and the growth of seedlings. Structure of Ash-seed.

Effect of light and darkness upon the growth of seedlings.

Experiments on nutrition of plants, water-cultures (to be continued up to the end of summer).

Structure of a flower. Absence of fruit from strawberry plants screened by muslin from insect visitors.

Trees that flower after their leaves are developed. The character of the flower as contrasted with those of trees which flower before their leaves open.

Plan of school grounds drawn to scale, with compass points marked and positions of various buildings, trees, &c., indicated.

Continuation of life-histories of insects.

Influence of the colour of surrounding objects upon certain caterpillars, chrysalids, sticklebacks, &c., to be treated experimentally.

Further stages of tadpoles.

Nests of insects.

Migratory birds—nests, songs, &c.

June.—Meteorological observations. Altitude of the sun should be observed at the solstice.

The attitude and position of leaves on various plants, and the connexion with incidence of light. Ferns, their habits and life-history.

Water-cultures (continued).

The relative positions of leaves and buds upon the stems.

Strawberry plant (continued).

Trees that flower after their leaves are developed (continued). The general appearance of the commoner trees at midsummer.

The defences of plants: thorns, prickles, stinging hairs, &c.

Life-histories of insects (continued).

Influence of colour of surroundings upon caterpillars, &c. (continued).

Life-history of frogs, toads, and newts (continued).

Nests of ants, &c. (continued).

Sea-shore animals; the occupants of rock-pools, their habits, manner of life, &c., &c.

July.—Meteorological observations. Climbing plants—tendrils, &c.: ivy, scarlet runner, clematis, convolvulus, hop, honeysuckle, pea, briony, vine, &c., &c.

Water-cultures (continued).

Ferns, their habits and structure: their spores.

Presence of starch in leaves exposed to light. The iodine test.

Strawberry plant (continued).

Trees that flower after their leaves are developed (continued).

Structure of cherry and strawberry fruits; significance and value of each part.

Life-histories of insects (continued). Influence of colour of surroundings (continued).

Life-histories of frogs, toads, newts (continued).

Growth of shell of snail. Sea-shore animals, their habits, &c.

Birds; their nests, songs, &c.; moulting; departure of some migrants.

Effect of rain upon the surface of the earth; denudation; the denudation of rocks of different physical characters, e.g. clay, sand-stone, chalk. The formation of small streams on a hill-side during rainfall; roadside deltas.

Examination of quarries, sand-pits, brick-yards, cuttings, lime-kilns, gravel-pits, &c. Fossils in such exposures. Pebbles and running water; sea-beaches, outbreak of streams on hill-sides, &c.

August (holiday work).—Arrangements should, if possible, be made for continuance of the meteorological observations during the summer and other holidays. This especially applies to the readings of the maximum and minimum thermometer and of the rain-gauge.

Life-histories of insects (continued). Influence of colour upon chrysalids, fish, &c.

Sea-shore animals: the occupants of rock-pools, their manner of life, habits, &c.

Wasps' nests; ants' nests.

Departure of migratory birds.

Examination of cliffs, quarries, sand-pits, cuttings, &c.; pebbles and running water; the arrangement of boulders, shingle, sand, &c., on a sea-beach. Fossils.

September.—Meteorological observations. Altitude of sun should be taken at the equinox.

The presence of starch in bread, rice, potatoes, seeds, and other storage organs of plants used as human food.

The dispersal of succulent and of dry fruits by animal and other agencies; winged seeds, burrs, &c.

Life-histories of insects (continued).

Life-histories of frogs, toads, newts (continued).

Comparison of the external form of earthworm, insect, spider, centipede, woodlouse, snail.

Sea-shore animals, &c. (continued).

Wasps' nests.

Departure of migratory birds. Songs heard during the month.

October.—Meteorological observations.

The presence of starch in bread, rice, &c. (continued).

The structure of bulbs, corms, and buds; relation of bud to leaf.

The fall of the leaf: it is a 'vital' process, i. e., does not occur on a dead branch broken off while in full leaf during the summer.

Evergreens and their characters.

The structure and modifications of edible fruits—plums, apples, &c.

The dispersal of succulent and of dry fruits (continued).

Life-histories of insects (continued).

Life-histories of frogs, toads, newts (continued).

Nests of ants, wasps, &c.

Spiders' webs.

Migratory birds.

Effect of rain upon the surface of the earth, &c. (*vide sub July*).

November.—Meteorological observations.

The structure of bulbs, corms, buds, &c.

Evergreens and their characters (continued).

The fall of the leaf (continued).

The hibernation of animals—mammals, frogs, toads, lizards, snakes, insects, molluscs, worms.

Arrival of winter migratory birds. Resident birds. Examination of varieties of feathers; feather of ostrich contrasted with feather of a bird that can fly.

December.—Meteorological observations. Altitude of sun to be taken at solstice.

Evergreens and their characters. Winter berries.

Structure of fruits—oranges, apples, medlars, dates, almonds, &c.

General appearance of different species of trees in mid-winter.

Resident birds—winter visitors.

Effect of frost upon the soil and upon rocks. Freezing of water in a closed vessel.

NOTE:—In this syllabus no mention has been made of the metric system, weighing, the determination of densities, &c., as the sub-committee are of opinion that these subjects are best taken in connexion with the mathematical teaching.

(Signed) OSWALD H. LATTER.
W. E. CROSS.
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SPECIMEN LESSON.—I.

COMPARISON OF THE EXTERNAL FORM OF EARTHWORM, INSECT, SPIDER, AND CENTIPEDE.

Every boy should have a living specimen to examine, and should answer the following questions and make drawings of the animals.

1. Compare the nature of the outer covering: is it hard or soft in each case? Is it equally so all over?

2. Does the animal move by changing the shape of its body or by changing the shape and position of outgrowths from the body (legs and wings)?

3. Can you suggest a reason for the outer coverings of the insect, spider, and centipede differing from that of the earthworm?

4. Which of these animals are divided up into rings (segments) by grooves running round the body?

5. How many regions are clearly marked off from one another by deeper grooves in the insect? How many in the spider? How many in the centipede?

6. How many legs has the insect? How many has the spider? How many has the centipede? On which parts of the body are they placed in each case?

7. Has the worm anything that at all corresponds to legs? If so, state all that you can find out about them.

8. Which of these animals have antennae? What use are the antennae?

9. Which of these animals have eyes? Where are they placed? Examine them with a microscope.

10. Which of these animals are slimy? What is the use of the slime?

11. Which of these animals is able to spin silk? From what part of the body does the silk come? What uses do they make of the silk?

SPECIMEN LESSON.—II.

Development of Tadpole and Frog.

This lesson, as in the case of several others, will occupy several months, and should run concurrently with observations upon other types.

Newly deposited frogs' spawn can be found in March. Some should be placed in a tank or aquarium, containing living water weed and left undisturbed until the tadpoles emerge. A separate stock of spawn should be kept in water and specimens given to the pupils for observation up to the time of hatching.

The first signs of change in the egg occur within a few hours of the time they were deposited. The egg is hatched and the tadpole liberated in ten to twelve days, the frog being fully developed in about three months.

These times vary greatly with the temperatures at which the eggs and larvae are kept. Development is considerably retarded by cold. An even temperature of 15° to 17° C. is suitable. It would be well to look up from some hand-book details upon the management of fresh water aquaria.

In the following lesson the left-hand column contains directions for observation by the pupils, but for the sake of clearness and to show the bearing of one question upon a previous one, the *results* of observations are often stated also. It is of course assumed that in an actual lesson, these results will be supplied by the pupils themselves.

The specimens should be examined daily, and any change that has occurred noted down. The notes would then form the subjects of discussion in class at suitable intervals.

Directions and suggestions for observation and inference.	*Notes for Teachers.*
Place your egg in a watch glass, cover with water, and examine with a magnifying glass.	
Sketch the egg and its surrounding layer of jelly.	
Compare the use of this jelly, with that of the outer covering of any other egg you may have studied or that of the seeds of plants.	The function is chiefly protective.
Why should the outer covering of the frog's egg be different from that of a bird's egg?	In the latter case a hard envelope is needed to resist the pressure of the sitting bird.
Examine the egg daily and keep it in a warm spot. Note that one side of the egg becomes dark first, the other side remaining unchanged for a longer time. Remember which side of your egg became dark first. Can you find any mark dividing the light from the dark portion?	The dark side will give rise to the chief organs of the animal. The light portion is yolk or food for the embryo.

Watch daily to see if other lines or marks have appeared. In a very short time the egg will be divided up into a number of small patches by these lines or grooves. The patches are called cells. Each cell may divide again and again by grooves forming across it, each part becoming as large as the original cell. All living matter whether animal or plant grows by this division of cells.

A microscope with a low power will easily show these grooves, which are the beginnings of cell division. The subsequent process could be explained by blackboard demonstration or omitted altogether if thought advisable.

In a day or so you find the egg altering in shape. Sketch it again, note the difference between the two ends. The blunt end is the future head, the pointed end the tail.

The egg is elongating. The head and tail ends can be distinguished.

Examine daily the head, and with your magnifying glass look for any markings upon it. Directly you find any show them in your sketches. Watch these daily to see what they will turn into.

A small central pit will appear on the under surface of the head. This is the future mouth. A strong glass will show two more pairs of pits, above and behind the central one. These will form the optic and auditory organs respectively.

At each side of the 'head' of your egg, you will find four bar-like swellings. Watch for changes in these.

The last two will bear external gills. The development of the others cannot be traced by external observation.

Look at the under side of your egg (i.e. the original light side). Do you notice any peculiarity in its shape? Remember its shape and note what happens to it after the tadpole is hatched. You may then be able to say what the swelling means.

It is swollen with yolk cells.

In about twelve days from the first changes in the egg appearing, the tadpoles will be hatched and will break through the surrounding jelly.

Continue observations from this point upon tadpoles taken day by day from the tank or aquarium.

Examine the bars on the sides of the head. Two of these now bear gills. Tadpoles, like fishes, breathe by means of the air dissolved in water.

Note how the tadpole passes its time for the first day or so after hatching. Look for any organs by which it attaches itself to plants.

It seems attached to weeds until its jaws are developed.

Special organs called 'suckers' are developed for this purpose.

Watch the changes in its mouth during this period.

Note also what is happening to the swelling on its under surface.

The swelling has practically disappeared, for much of the food yolk has been used up.

Note how it changes its manner of living in about three days from hatching.

As soon as the jaws are developed it swims freely in search of food.

Can you suggest any connexion between the changes in its mouth and in its manner of living?

Why did it not feed directly it was hatched?

You have probably learned how plants live before they germinate, and that their roots can suck up food from the soil.

Try to say how the tadpole kept itself alive before it could feed itself.

In all cases nature provides food until such time as the organism can obtain a supply for itself.

Now that the tadpole can swim and eat the water weed, what is happening to the 'suckers' by which it attached itself to plants?

They are disappearing.

Why did the tadpole need them at first?

Why are they no longer needed?

They were needed to keep the tadpole in a place of safety until it was able to swim.

As the tadpole has no fins, how can it move through the water?

What is happening now to the gills?

How does the animal breathe now?

External gills have atrophied and internal gills have taken their place. Careful examination will show an exit hole on the left side.

The water is taken in at the mouth. Find how it gets out again.

Here examine a fish and show the water passages from the mouth through the gill slits.

When the legs appear, note what happens to the tail and account for the change.

About the same time you must carefully watch the mouth and eyes. What happens to them?

Jaws are now developed and eyes opened.

Has the frog again changed its general manner of living?

What have the changes in legs, mouth, tail and eyes to do with its changed habits?

Should you think its changed habits are accompanied by any further change in its breathing apparatus?

As the breathing is now performed entirely above water, lungs have been developed.

Why should it not have had lungs for breathing from the first?

Examine the frog's tongue. Of what use is its peculiar shape and position? To answer this question you must find out what the frog now feeds upon, and how it seizes its food.

All animals go through many changes before they are fully developed, in much the same manner as a frog; but many (birds for instance) are practically fully developed when hatched. You know also that the tadpole had a food supply that it lived upon before it was ready to seek food for itself; in the same way the yolk of birds' eggs form food for the young bird before hatching.

Should you think that the bird's large and frog's small food supply have anything to do with their different states of development when hatched?

The large food supply of the bird enables it to complete all its changes before it need seek food for itself.

Summary.

Besides some knowledge of the life-history and development of the frog, the pupils will have been collecting information leading up to the following generalization:

1st.—The growth of organism by cell-division.

2nd.—Change in manner of living is accompanied by change in structure.

3rd.—Food is provided by Nature until the organism is sufficiently developed to seek it for itself.

4th.—An organ no longer needed disappears, e.g., the tail goes when the legs are developed.

5th.—Temporary needs are often met by the development of temporary organs, e.g. the development of gills for use during aquatic state only.

6th.—An organ is not usually developed until it is needed, e.g. a frog, as an insect feeder, has greater need of sight than a tadpole, a plant feeder.

SPECIMEN LESSON.—III.

Climbing Plants.

It is advisable to warn the pupils, perhaps a week before, that they will have to consider these plants at some particular lesson.

Furthermore, the teacher should provide himself with specimens of climbing plants, or still better be able to take the pupils into a garden or greenhouse where they can see them growing.

To begin it may be well to ask a series of questions or tell the pupils to write in their books as many climbing plants as they know. If the class is small each may read out his list. Next, particulars should be stated as to the part used in climbing, and if, as is probable, little knowledge is shown, the pupils can be instructed to draw up some such table as is here appended, and told to fill it in during the coming week from their own observations.

Next, attention may be drawn to the places where climbing plants are found; to the slender stems they usually possess; and the pupils be got to see why slender-stemmed water plants do not require to climb, while those on land must.

The teacher should also have a hop and a runner-bean growing in the same pot, or as near together as possible, and the pupils left to notice the different way each climbs. Each plant should be sketched in a note-book.

As will be readily recognized, such a lesson as is sketched here can be of little value unless efforts are made to make the pupil think for himself; and it is also highly desirable that he should amplify what he does in school by personal observation out of it.

Anything like dictated notes should be strictly avoided.

It is even more necessary that the teacher himself should be an original observer.

Part of Plant which helps in climbing.	*Examples.*
1. Stem	
2. Roots	
3. Leaf stalks	
4. Tendrils formed from leaves	
5. Tendrils formed from stipules	
6. Tendrils formed from shoots.	

PRACTICAL GEOGRAPHY.

The Practical Geography course has been arranged to cover a period of either two or three years. If the scheme be adhered to all boys will be doing the same type of work in the same term.

Two advantages follow from this:

1. At any one period of the year the master in charge will only require one set of apparatus or collection of photographs.

2. An arrangement becomes possible for the junior boys to question the seniors. Not only will this give rise to revision, but the senior boys will make efforts to be in possession of sufficient knowledge to give a clear exposition.

1st Stage.

Maps.

Local 1" and conventional signs. Appreciate—map represents country.
Description of routes from map.
Make plans:—pacing—cross-staff, &c.

Story of Drake or Columbus.

How to find directions—compass—sun—dead reckoning, &c.
As stories develop explain meaning of geographical terms.
Learn names and positions of continents—seas, &c.
Layer system—compare with models.
Appreciate layers in Atlas Maps.

Earth.

Rotation.
Day and night.
Altitude of Sun.
Principal constellations.

Atmosphere.

Simple experiments on composition.
Relation of living organisms to atmosphere.
Properties of air—expansion on heating—presence of water vapour, &c. [Experimental treatment only.]

Temperature.

Seasonal and daily variation.
Thermometer as an indicator.

Rain and Clouds.

Evaporation and condensation.
Cooling of Air on expansion. [Experimental treatment only.]
Story of rain—measurement of rainfall—typical clouds.

Weather.

Observation of local weather.

Denudation.

Experiments.

Snow and Ice.
Life on the Sea.
Solids, Liquids, and Gases.
Local distribution of plants.
Stories of Life in Zones.
Lives of Typical British animals.
Stories of Early Britons.

Mode of Life, &c.
Life of Farmer.
" Fisherman.
" Herder.
" Hunter, &c.

2ND STAGE.

Maps.

1″ maps.
Contours.
Simple problems on contours.
Simple map-making—traverse—model theodolite.
Story of Livingstone—Land routes.
Story of Cook—latitude and longitude. Read *Coral Island* (abridged edition).
Make map and model of Coral Island.

Earth.

Shape (Latitude from above).
Experiments on rotation.
Sun and seasons.
Sun and planets.
Phases of Moon.

Atmosphere.

Experiments on pressure.
Productions of winds.

Temperature.

Scales of temperature.
Distribution over British Isles.
Winds.
Nearness to Sun.
Mountains, &c.

Rain and Clouds.

Mode of formation of rain.
Methods of cooling air.
Experiments—direct chilling—warm to cool latitudes, &c.

British Climate.

Work of Rivers.

Erosion.
Transport, &c.

Glaciers and Cold Regions.

Shore deposits and formation of fossils.

Volcano.

How plants live.

Types of vegetation.

Lives of Typical foreign animals.

Beginning of Manufacture in Great Britain.

Types of Living Races of Men.

3rd Stage.

Maps.

Contours.
Spot heights—hachures, &c.
Problems on gradient, &c.
Map-making—compass (prismatic). (Read *Three Englishmen and Three Russians.*—Verne.)

Earth.

Seasons—eclipses—altitude of Pole Star—size of earth—longitude and time.

Atmosphere.

Isobars—land and sea breezes—monsoons.

Temperature.

Isotherms.

Rain.

Cyclones, &c.
Clouds and weather associated with above.
Construct a rain gauge.

World Climates.

Work of Rivers.
Carving valleys—building up alluvial plains—deltas, &c.
Communication.

Work of Ice.

Formation of Sedimentary Rocks.

Formation of Igneous Rocks.

Distribution of Food Plants.

Vegetation and Climate Zones

World Distribution of Animals.

Typical Modern Industries.
Distribution in British Isles.

Distribution of Main Races.

SPECIMEN LESSON.—IV.

Evaporation of Rain, Spring, and Sea Water.

Comparison of Residue and Steam condensed from each.

Preparatory Work.

(1) Facts teachers should know.

All water is constantly evaporating—though heat increases the rate of evaporation it is not the same as boiling, since it only goes on at the surface and not all through the liquid. The 'vapour' given off is absolutely invisible—the cloud the cook calls 'steam' is really made up of minute drops of water condensed from the true steam on meeting colder air. Therefore where this true steam exists, e.g. between tip of spout of boiling kettle and visible water-drop, *nothing* is visible. Contact with any colder body causes water-vapour to condense to water-drops.

Since evaporation only goes on at surface, the greater the surface exposed the quicker the rate of evaporation, e.g. a flat wide dish—or heating (which constantly brings more water to the top)—will increase the rate. The rate also depends on the amount of water-vapour already in the air. Therefore anything removing the water-vapour-logged air just over the water supply will increase the rate, e.g. wind or draught. Sea-water contains especially salt, spring-water contains chalk and other minerals: if the water is boiled away these will be left as solid residues, e.g. 'fur' in kettles and boilers. Rain-water contains no dissolved solid and leaves no residue. All fresh-water contains air—on heating water the air bubbles escape first—later larger bubbles containing steam.

(2) Class.

Previous week. Tell each pupil to put a little water in a saucer and leave it until the morning of the lesson and to examine it then.

Questions, &c.—Any difference to quantity of water in saucer? Where has it gone? Can it be seen? Examples of renewing liquid lost by evaporation, e.g. unused ink pot left open,—aquarium tank, unused dog's water-trough, &c. Would water disappear more quickly from deep or shallow dish? Make pupils suggest and direct experiment to find out; but see that all conditions are equal, e.g. same volume of water must be taken. Measure the volumes accurately before and after the experiment.

Wet a handkerchief or window-pane and watch the 'drying'. Why does the water evaporate more quickly in a flat than deep dish?

What is a good day for drying clothes? Do they dry more quickly in winter or in summer? When there is wind or still air?

How can we find whether heat and wind increase evaporation?

Boil some water in a kettle (if there are no Bunsen burners, spirit lamps do equally well), and make pupils discover the invisible true steam in the gap between spout and cloud. What will happen to the visible cloud if we heat it with another flame? Do so and let them see that it disappears. Boil some water in a glass vessel, e.g. beaker, flask or thin tumbler, and make them distinguish air-bubbles from steam-bubbles. Make them breathe on a knife-blade or a watch-glass and describe the effect. Where does the water come from? Make them describe their breath or that of a horse pulling up hill, on a cold day. Thus there is invisible water in the *air*, and we have given some of the ways it gets there.

(3) Can we get this invisible water-vapour out of the air? What principally sends it there? Ought not the opposite to make it visible again?

Fill a metal pot or glass jug with ice, and note the deposit on the *outside* of the pot. Where has this wet come from? Touch watch-glass, spectacles, knife-blade with warm damp body; what happens? Hold a cold inverted tumbler (or beaker) over boiling water; what happens? Which of these various things is hotter and which colder? What then is the way to get invisible water-vapour out of the air as visible water-drops (cf. Dew and Rain Nature-Study Lessons).

(4) Catch pure rain-water high up—evaporate to dryness—no residue—pure water and air. Condense the vapour in an inverted tumbler and taste it. What is happening to every free surface of water—especially on dry windy summer days—whether sea, lake, river, pond, or rain-puddle? What happens to all this evaporated water? But rain-water is pure water and nothing else. What about sea- and spring-water? Evaporate sea-water. What shall we expect? Condense and taste before—examine residue, and cf. salt, &c. For rain-water then does it matter whether sea or lake evaporates? But perhaps spring-water is not as pure as rain. Try as before and examine residue, and compare 'furred' kettles

and pieces of burst boiler, &c. Stereographs of Geyser incrustations, &c., should be shown. Iron deposits in local water—if occurring—examined, &c. An inverted bell-jar over a dish of dirty water in the sunshine, if possible, will illustrate the whole subject.

(5) What are clouds?—observe different types on different days—cause of mist in river valleys and over lakes—fogs in big towns and at sea.—Where do Atlantic liners run into them usually? Why? Why is the west coast of England wetter than the east?—When is dew heaviest? Why? Local weather observations.

SYLLABUS FOR PRACTICAL MATHEMATICS

1. Measurement of straight lines by means of scale, including the estimation of tenths of the smallest scale division.

2. Measurement of the diameter of cylinder and sphere by placing between two rectangular blocks of wood and measuring the distance of these apart; also by means of calipers (without vernier).

3. Measurement of curved lines, and determination of the value of π.

4. Measurement of the areas of rectangles and triangles by means of squared paper, and determination of the formulae to express these areas.

5. Measurement of areas of plane surfaces of irregular outline by means of squared paper.

6. Area of circles by means of squared paper and confirmation of formula.

7. Determination of the formula for volumes of rectangular solids, special stress being laid upon the fact that this is the product of the area of cross section and the length.

8. Measurement of the volumes of dense insoluble solids by displacement of water in graduated cylinders or burettes.

9. Determination of the formulae for the volumes of geometrical non-rectangular solids by methods 7 and 8.

10. Measurement of inaccessible heights and distances, and finding areas by triangulation, &c., the results being determined by drawing to scale.

11. Examination and use of balance and weights.

12. Determination of areas by cutting out in card-board and weighing.

13. Determination of the weight of unit volume of various substances.

14. Determination of the weight of 1 c.c. of water, and elementary ideas of the meaning of specific gravity.

15. The specific gravity bottle, and its use in finding the specific gravity of liquids.

16. The specific gravity of solids by means of the specific gravity bottle.

NOTE ON METHODS FOR THE EXPERIMENTAL DETERMINATION OF THE VALUE OF π

Any of the following methods for finding the value of π are recommended; in the majority of cases it is wise for the pupils to find it by at least two separate methods.

A. The diameter of a cylinder is found either by means of calipers or by placing it between two rectangular blocks of wood and measuring the distance of these apart; a piece of thin paper is then wrapped round the cylinder, pricked with a pin, and the circumference found by measuring the distance between the two resulting holes after the paper has been unfolded. Several cylinders of different diameters should be used, in order that the pupil may become convinced of the constancy of the ratio.

B. A series of circles is drawn, the diameter of each measured directly, and the circumference approximately found by stepping round the circle by dividers.

C. Circles are drawn and their diameters measured as in B, but the circumference measured by means of an opisometer or by placing the end of a piece of thread upon one point and carefully tracing round the circle by its means.

D. A penny or other large coin is placed upon a sheet of paper against a straight edge; a pencil mark is made upon the coin at its lowest point, and also upon the paper at this point; the coin is now rolled along until the pencil mark is once more in contact with the paper, when another mark is made; the distance between the marks is measured directly, and the diameter of the coin found by means of calipers.

E. A cylinder is placed on its end, a mark made at any point on its circumference, and this placed against a scale; by means of another rule the cylinder is rolled along the scale until the mark is once more in contact with the latter: having obtained the circumference by this means, the diameter is directly measured.

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