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FROM ANNUAL REPORT ON EXPERIMENTAL FARMS FOR THE YEAR 1907-8

CANADA

DEPARTMENT OF AGRICULTURE

CENTRAL EXPERIMENTAL FARM

REPORT OF THE ENTOMOLOGIST AND BOTANIST

JAMES FLETCHER, LL.D., F.R.S.C., F.L.S., F.E.S.A.

FOR THE
YEAR ENDING MARCH 31
1908

OTTAWA
GOVERNMENT PRINTING BUREAU
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1909

THE UNIVERSITY OF CHICAGO

PHYSICS DEPARTMENT

PHYSICS 309

LECTURE NOTES

BY

JOHN H. COOPER

1962

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REPORT
OF THE
ENTOMOLOGIST AND BOTANIST.

(JAMES FLETCHER, LL.D., F.L.S., F.R.S.C., F.E.S.A.)

1907-1908

OTTAWA, April 1, 1908.

Dr. WM. SAUNDERS, C.M.G.,
Director of Dominion Experimental Farms,
Ottawa.

SIR,—I have the honour to hand you herewith a report on some of the more important work done in the Division of Entomology and Botany during the year ending March 31, 1908.

The applications for help in fighting insects and weeds from all parts of the country increase in number every year, and many farmers and others visit the Division for advice, or to examine the cabinets to identify plants or insects which are giving them trouble. The demand for help from school teachers and students has increased enormously during the past year or two, since nature study has been recognized as a useful part in a common sense education. Many addresses have been given by the officials of the department on various occasions to help along this movement.

Collections.—The collections in the Division have been much increased during the past year. A large number of specimens have been added to the Herbarium, and the whole has been arranged according to Prof. John Macoun's Catalogue of Canadian Plants, and a card index of the specimens has been completed. In the collections of insects satisfactory progress has been made. The large and valuable collection of noctuid moths has been rearranged, and a large number of specimens which, were lacking, have been procured either by collecting or rearing them, or from correspondents. This class of insects contains the various species of cutworms, some of which every year are the cause of such serious depredations on farm crops. It is always a great surprise to those who find the unsightly cutworms attacking their young plants, when they are shown the moths which come from these caterpillars, many of which are of considerable beauty, notwithstanding the general character of inconspicuous colouring which prevails among the Noctuidæ. Several gaps in our cabinets have been filled in with specimens reared from eggs sent to the Division by correspondents in all parts of the Dominion. Many of these insects are of extreme rarity, and, by getting eggs and then rearing the insect through all its stages, not only are more perfect specimens secured, but, what is far more valuable, a knowledge is acquired of the complete life history of each species, and as it is usually an easy matter to rear insects from the egg, large series showing the range of variation in colour, markings and size are thus secured. The value of the life history of an insect, how it passes the winter, when the eggs hatch and how long a time elapses before the larva becomes full grown and produces the mature form, are facts of enormous importance in devising a remedy

for any species which may have proved destructive to crops. Many insects, particularly moths, lay eggs freely in confinement if enclosed in any small box such as a small cardboard, wooden or tin box, three or four times the size of the specimen. These eggs should be sent off to the Division at once, as most of them hatch in eight or ten days; parcels thus sent have been safely received from the extreme limits of the Dominion, from British Columbia, from Nova Scotia and the far north. The caterpillars, on hatching, are cared for in Ottawa, and the large number of perfect specimens in our collections show to what advantage this method of obtaining specimens and useful information on life-histories may be used. It may be well to mention here to all who are good enough to send in specimens, that full directions as to packing and forwarding such material as plants and insects are given at page 212 in this report.

Among the more important donations which have been made to the entomological collections during the past year, the following may be mentioned:—

Thos. Baird, High River, Alta.—A large number of specimens of rare moths from western Alberta.

J. W. Cockle, Kaslo, B.C.—Several interesting insects from the Kootenays.

The Messrs. Criddle Brothers, Aweme, Man.—Many species of local insects from central Manitoba.

Paul Hahn, Toronto.—Specimens of insects from Niagara Glen and Toronto, including a specimen of *Apantesis virgo* L. var. *citrinaria* N. & D.

Horace Dawson, Hymers, Ont.—Larvæ and moths of the genus *Papaipema*, also supposed larvæ of *Platyssylla castoris* Ritzema.

Edward Denny, Montreal.—A fine pair of the rare moth *Hepialus thule* Strk.

Dr. C. A. Hamilton, Mahone Bay, N.S.—Several interesting species of injurious insects.

A. W. Hanham, Dunsmuir, B.C.—A large collection of British Columbian hymenoptera, diptera and lepidoptera.

W. Metcalfe, Ottawa.—Several boxes of mounted micro-diptera and a few other insects.

Joseph Perrin, Halifax, N.S.—Moths and butterflies from MacNab's Island.

John Russell, Digby, N.S.—Several rare species of Nova Scotian moths and butterflies, including a fine specimen of *Catocala cælebs*, Grt.

N. B. Sanson, Banff, Alta.—Specimens of Rocky Mountain larvæ, including *Neoarctia beanii*, Neum.

J. B. Wallis, Winnipeg, Man.—Several specimens from Peachland, B.C., chiefly lepidoptera and coleoptera.

C. H. Young, Ottawa.—Eggs of rare Ottawa moths and mounted specimens of lepidoptera and coleoptera which were required to complete series in our cabinets, all beautifully mounted.

A large number of additions have also been made to the collections from material sent in for names by entomologists, farmers and others.

The botanical collections have been enriched from the following sources:—

J. R. Anderson, Victoria, B.C.—British Columbian plants.

A. Arsenault, Adamsville, N.B.—A monstrous form of *Leontodon autumnalis*, L.

The Messrs. Norman and Evelyn Criddle, Aweme, Man.—Seeds, living roots and herbarium specimens of Manitoba plants.

Norman Criddle, Aweme, Man.—A collection of paintings of Manitoba violets.

George Fraser, Uchelet, B.C.—Rare plants from Northern British Columbia, including living roots of *Viola langsdorffii*, Fisch.

Rev. L. Gladu, St. Boniface, Man.—Botanical specimen of *Oenothera caespitosa*, Nutt.

Dr. W. Grignon, Ste. Adele, Que.—Living roots and stratified seed of Ginseng, *Aralia quinquefolia*, Dec. & Plan.

Dr. C. A. Hamilton, Mahone Bay, N.S.—A collection of 45 named species and varieties of Nova Scotia sea weeds.

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David P. Kane, Kaslo, B.C.—British Columbian ferns, including a magnificent root of *Adiantum pedatum*, L., var. *rangiferinum*, Burgess and Macoun.

Rev. J. H. Keen, Metlakatla, B.C.—Specimens of *Gentiana Douglasiana*, Bong., and rare insects from northern British Columbia.

Mrs. D. W. Stewart, Renfrew, Ont.—Living roots of violets and specimens of *Medicago falcata*, L.

Mrs. Stoker, Cowichan Lake, B.C.—A large collection of the seeds of 147 species of Vancouver Island plants.

Dr. Douglas G. Storms, Hamilton, Ont.—Roots of *Trillium grandiflorum*, Salisb., abnormal form with green flowers.

E. P. Venables, Vernon, B.C.—Local plants from Vernon, B.C., including *Cynoglossum occidentale*, Gr.

Rev. Frère Marie Victorin, Longueuil, Que.—Specimens of *Butomus umbellatus*, L., and *Sambucus Ebulus*, L., first found growing wild in Canada by the sender.

Correspondence.—The correspondence of the Division has shown a considerable increase over that of previous years, and the number of subjects inquired about has shown that the Division is becoming well known as a source of information with regard to all matters relating to the scientific consideration of insects and plants in connection with agriculture and horticulture. The number of letters exclusive of circulars entered in the Division register, as received from April 1, 1907, to April 1, 1908, was 4,030, and the number despatched 3,640. Articles relating to outbreaks of insects, the treatment of well-known pests and the best methods of dealing with noxious weeds have been prepared for local newspapers and for agricultural journals, whenever required. Many of these have been at the request of correspondents who have intimated that they were of general interest.

Meetings.—Meetings of farmers' institutes and other agricultural associations, teachers' associations, &c., have been attended by the Entomologist and Botanist whenever other official duties would permit.

June 7, 1907: Annapolis Royal, N.S.—A convention of fruit growers to consider the best measures to adopt to control the Brown-tail moth. An address was given on the habits of this insect and its history in America. A full and interesting discussion was carried on, and much information elicited with regard to the localities where it had occurred in Nova Scotia, and the vigorous steps which were being taken by the Provincial Secretary for Agriculture for Nova Scotia.

June 23 and 24: Boston, Mass.—By invitation of the legislative committee of the Commonwealth of Massachusetts, through Mr. A. H. Kirkland, Superintendent for suppressing the Gypsy and Brown-tail moths and with the approval of His Excellency Governor Curtis Guild, Jr., I was invited to be one of fourteen entomologists, from all parts of the world, to inspect and report upon the extensive work which had been done in the New England States in fighting against the Gypsy and Brown-tail moths, and particularly with regard to the importation of parasites of these insects from Europe. On June 24 I visited the laboratories at Saugus, Mass., with Superintendent A. H. Kirkland, and the following day, in company with Prof. John B. Smith, State Entomologist for New Jersey, Dr. E. P. Felt, State Entomologist for New York, Mr. Kirkland and Mr. F. H. Mosher, we covered a great deal of ground in an automobile and examined the work which had been done in clearing street trees, parks and woodlands from these aggressive enemies. The success of this whole movement, both in fighting against these caterpillars by the ordinary means and by the extensive importation of parasites, has been so remarkable that I was much pleased to have this opportunity of examining into the details of the work in the company of the experienced entomologists above named. The whole work forms without doubt the most remarkable experiment which has ever been tried in economic entomology. That in only two seasons 8,000 miles of streets should have been practically freed of devastating caterpillars of two of the worst known pests of shade trees, is a triumph of applied

science which must be of great encouragement to all engaged in such work, and is an indication of what may be hoped for in the near future in Massachusetts, if the same plan of action is persisted in under the same capable and energetic management. The systematic colonizing of parasites of these pests has been carried on under the direction of Dr. L. O. Howard, the United States Entomologist, and the condition of affairs at the present time is very hopeful and demonstrates the wisdom which has been shown by Superintendent Kirkland and Dr. Howard in carrying out this vast experiment. During last year over 100,000 parasites of different forms, chiefly *Pteromalids* and *Tachinids*, were liberated, and there are evidences that many of these are successfully established and that they are working on the insects for the control of which they were introduced. At the present time the field work is going on with a large measure of success, and the people of the State are well satisfied with it as well as with the work of introducing parasites.

July 4: Guelph, Ont.—Summer meeting of the Entomological Society of Ontario. Addresses on 'The Control of the Brown-tail and Gypsy moths in America, with special reference to the Importation of Parasites,' and 'Nature Study as a means of Education.'

July 12 to 31 in Manitoba and the Northwest Provinces:—

July 12 to 15, Aweme, Man., visiting Mr. Percy Criddle at St. Alban's, near Aweme, with Dr. Henry Skinner, of Philadelphia. Collecting insects and plants, at Aweme and in the Douglas sand-hills, where many valuable and interesting specimens were secured.

July 16: Brandon.—Visiting Experimental Farm.

July 17: Regina.—Examining the country around Regina with Mr. Willing. In the evening held a meeting of the Northwest Natural History Society in the Provincial Museum. Address 'The Practical Value of Natural History Studies.' This was the first of a series of meetings held by Mr. T. N. Willing, the Chief Provincial Weed Inspector, Dr. Henry Skinner and myself, at which addresses were given upon weeds and their eradication, the interpretation of the Weed Ordinance and the part played by insects in the transmission of various diseases.

July 18.—Left Regina for Hanley, where a well attended meeting was held in Rollefson's store, Mr. D. McLean in the chair. Questions were asked as to the treatment of Hare's-car Mustard and Skunk-tail grass. The value of summer fallowing was also discussed.

July 19.—Left Hanley and drove to Rudy, where a good meeting of about forty was held at 3 p.m., Mr. William Duncan in the chair. On account of the heat this meeting was held outside the stopping place.

July 20.—Left Rudy at 9 a.m., and drove to Tessier, 27 miles. Stayed with Dr. Tessier, who had gathered together about 50 farmers from this new and exceedingly rich district. The meeting was held out of doors in the evening, and was prolonged on account of the many questions until a late hour. Keen interest was shown in the subjects treated of.

July 21.—Started from Tessier at 8 a.m., and drove 54 miles into Saskatoon. The crops throughout this whole district were excellent, and the country is settling up quickly.

July 22: Saskatoon.—A meeting was held at 1.30 p.m., Mr. John Ashworth in the chair. In the afternoon we took train for Duck Lake, where a meeting was held in the evening.

July 23.—Drove from Duck Lake to Skipton School, 25 miles, which was reached by 3.30 in a heavy and severe hailstorm. After the meeting we drove on to Parkside, another 14 miles, for the night, where we were kindly put up by Mr. George Alamanofski.

July 24.—Drove from Parkside to Shellbrook, 12 miles, where we held a meeting in the afternoon, which was not very well attended, owing to a heavy rainstorm. We left Shellbrook in the evening at 7 a.m., and drove into Prince Albert, 32 miles, through the sand hills, arriving by midnight.

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July 25.—Left Prince Albert at 10 a.m., and drove 48 miles to Kinistino, where a good meeting was held in the evening, in the main street of the town. At this meeting several ladies were present, and many questions were asked about insects injurious to crops.

July 26.—Took train to Star City, where a small meeting was held at 3 o'clock in the afternoon.

July 27.—Took train for Prince Albert, arriving soon after noon. In the afternoon we drove out to hold a meeting at Birson, and afterwards visited the Weed Inspector, Mr. George Connors.

July 29.—Left Prince Albert for Warman, where a good meeting was held in the afternoon in the implement shed of the Saskatchewan Trading Company. Most of those present were Mennonites. We left Warman at 3.20 for Radisson.

July 30.—Collecting on the sand hills at Radisson in the morning, and in the afternoon at 2 o'clock, a large meeting was held with Mr. George Langley, M.L.A., in the chair. We left the same afternoon, and arrived at Lloydminster before midnight.

July 31: Lloydminster.—A large meeting was held in the afternoon, Mr. Jones in the chair. In addition to the other subjects usually spoken of at these meetings, the value of Brome grass was discussed. Seeing the lack of good hay in the district, I urged the settlers very strongly to cultivate this valuable grass, which is not only a source of a very large supply of succulent and highly nutritious fodder and hay, but is very early and also bears late into the autumn. It was explained that this grass had been introduced and was still highly recommended as a source of feed for stock. Many adverse reports which were made against it, were by those who had found trouble in keeping it out of tree plantations, or who did not want to give the proper amount of work to cultivating their land. Awnless Brome grass is a succulent vigorous-growing perennial grass which roots deeply and therefore is rather troublesome to eradicate when the land is required for other crops; but it produces more hay and of higher quality than almost any other grass that can be cultivated. It is specially suited for the soil and climate of the Northwest, where in many places grass is one of the most desirable crops. The seed is easily threshed and handled and has a ready market. Many of the farmers in the Northwest have told me that they owed their prosperity mainly to this grass. The difficulty of eradicating it from the land is, I believe, much exaggerated; and those who have tried it find that they can destroy Brome sod by breaking and back setting in the same way as the native grasses on the prairie. When it is wished to renew a piece of Brome pasture or meadow, this may be ploughed shallow in autumn or early spring, which, as the grass is very deep-rooted, stimulates growth and renews the stand. In districts where the soil is light and apt to blow, there is no better way of putting humus and fibre into the soil than by growing a crop of Brome; and, from a careful consideration of this question, I am convinced that no farmer in the Northwest can afford to condemn Brome grass on the dictum of other people; but should try a small patch of this valuable grass on his farm. Where farmers think more of their ornamental tree plantations than of their farm crops, or if they can make more money out of growing trees, the conditions of course are different, as undoubtedly Brome grass or any other plant growing among trees will rob them of moisture and stunt their growth. This meeting was the last of the series. The meetings were well attended throughout, and a keen interest was shown in the subjects treated of. Mr. Willing's extensive knowledge of farming conditions and farm practice in all parts of the Northwest made him a valuable source of reference to all who wanted information on these matters. Dr. Skinner delighted the audiences with his clear and definite presentation of his subject. He showed the great danger of allowing house flies free access to houses or places where food was kept, and explained the method of transmission of diseases by the various kinds of mosquitoes which carry yellow fever, malaria, &c. He also dealt with other blood-sucking insects, and showed conclusively the value of a knowledge of insect life both to farmers and to dwellers in cities. My own addresses

dealt with the particular farm weeds prevalent in the various districts visited, the agricultural treatments best suited for their control and the answering of questions concerning special pests, both plants and insects.

August 2: Banff, Alta.—Collecting and examining the collections in the Banff National Museum with Mr. N. B. Sanson.

August 3, 4: Laggan, Alta.—Collecting around Lake Agnes and on the mountains around Laggan, where many rare plants and insects were secured.

August 6: Vancouver.—Inspecting the fumigating station. Left for Victoria the same evening.

August 8.—Left for Duncans with Mr. Tom Wilson to inspect work done for the Department of Indian Affairs in clearing the Indian orchards of pests which it was alleged were a danger to the orchards of the white settlers. We were accompanied by Mr. W. M. Robertson, Indian Agent for the Cowichan Agency, who was of much use to us when treating with the Indians.

August 9.—Returned to Victoria. Consulted with Mr. A. W. Vowell, Indian Superintendent for British Columbia, as to carrying on the work in the Indian orchards for the future.

August 10.—Had a conference with the Hon. R. G. Tatlow, Minister of Agriculture, and afterwards with the Premier, the Hon. Richard McBride, with regard to the work which was being done in the Indian orchards.

August 11.—Left for Agassiz, which was reached the same night.

August 12.—Visited Sir Arthur Stepney's hopyards, where a remarkable outbreak of a flea-beetle, *Psylliodes punctulata*, Melsh., has been doing much harm for several years. Left for Kamloops and reached there at 6 o'clock the same evening.

August 13.—Visiting orchards and giving advice on the treatment for Codling Moth, of which there is a rather severe outbreak at Kamloops. There was to have been a meeting of the Fruit Growers' Association at this place, but through some misunderstanding it had not been arranged for. We were, however, able to meet several of the fruit growers. Left for Revelstoke the same evening, and the next day proceeded to Kaslo.

August 15: Kaslo.—Visiting orchards all day with Mr. J. W. Cockle, who had been making investigations into the life-history of the Codling Moth in this locality, and had also treated carefully a few trees which had been found to be infested by the San José Scale the previous year. It was satisfactory to find that, although the Codling Moth was abundant, the San José Scale was entirely destroyed on the treated trees, and not a single specimen could be found in the locality. In the evening a well attended meeting was held in the town hall, and a great many questions were asked concerning the cultivation of fruit trees, and the insect enemies most likely to occur in the Kootenays.

August 19: Nelson.—A large meeting of fruit growers was held in the town hall, at which many matters relating to fruit growing were discussed, and particular attention was paid to the insect pests occurring in the Kootenays and those which it was thought might possibly be introduced. Mr. Anderson detected the Codling Moth at Nelson during this visit; so, special attention was given to it, and the proper steps to control it were explained.

August 23: Indian Head.—Visiting the Experimental Farm and farms in the neighbourhood with Mr. Angus Mackay, the Superintendent of the Experimental Farm.

October 31-November 1: Guelph, Ont.—The annual meeting of the Entomological Society of Ontario. Presidential Address: 'The Entomological Outlook.' 'The Entomological Record, 1907.'

November 15: Toronto.—Annual convention of the Ontario Vegetable Growers' Association. Address: 'Insects that trouble vegetable growers and how to combat them.'

December 19.—Macdonald College, Ste. Anne de Bellevue, Que.—Meeting of the

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Pomological and Fruit Growing Society of the Province of Quebec. Address: 'Insects injurious to fruit and vegetable crops in Quebec province during 1907.'

December 26 to January 3: Chicago, Ill.—Attending the meeting of the American Association for the Advancement of Science; the Association for the Advancement of Agricultural Science; the Entomological Society of America, and the Association of Economic Entomologists.

February 4: Ottawa.—Canadian Seed-Growers' Association. Address: 'The place of the Canadian Seed Growers' Association in the campaign against farm weeds.'

Mr. Gibson also attended the annual meeting of the Entomological Society at Guelph, and took an active part in the proceedings, giving in the various discussions much useful information, which was very acceptable to the meeting. Mr. Gibson also read a paper on 'An unusual outbreak of *Halisidota* Caterpillars.'

Acknowledgments.—It is again my pleasant duty to gratefully acknowledge my obligations to my many correspondents in all parts of the Dominion, to practical farmers who have much aided the work of the Division by promptly reporting outbreaks of injurious insects and noxious weeds, by sending specimens for examination and for our collections, and also by making observations upon points of special interest. My thanks are also specially due to many eminent specialists who have helped by giving us the exact identifications of specimens of plants and insects which were unknown to us. Among these, special mention may be made of the following:—

Prof. John Macoun, of Ottawa; Prof. W. G. Farlow, of Harvard University; Prof. L. R. Jones, of Vermont; Dr. P. A. Rydberg, of New York, and Dr. William Trelease, of St. Louis, for giving me their opinion on some doubtful plants.

Dr. L. O. Howard, Chief of the Bureau of Entomology, Washington, U.S., and the specialists on his staff, for the identification of insects in little known orders.

Dr. J. B. Smith, New Brunswick, N.J., who has examined and reported upon hundreds of noctuids and other moths for this Division and for Canadian collectors.

Mr. W. D. Kearfott, of Montclair, N.J., who has been of great service in naming microlepidoptera.

Mr. W. H. Harrington, Ottawa, for identifying coleoptera and hymenoptera.

Dr. E. M. Walker, Toronto, for examining and reporting upon many specimens of Canadian odonata and orthoptera.

Sir George Hampson, Bart., of the British Museum, has kindly examined several specimens and compared them with the series in the British Museum, not only for this office but for many other Canadian students.

In conclusion, I have again much pleasure in acknowledging publicly the good work which is being done by my assistants, Messrs. J. A. Guignard, Arthur Gibson and J. Létourneau.

I have the honour to be, sir,
Your obedient servant,

JAMES FLETCHER,
Entomologist and Botanist.

DIVISION OF ENTOMOLOGY

CEREALS.

The season of 1907 in all parts of the Dominion will long be remembered for its unusual and irregular character. From the Atlantic to the Pacific the spring was cold, dry and very late. Insects of all kinds were exceptionally scarce and the paucity of insect life in April and May had a direct effect on bird life as well as in many places also upon fruit crops. The amount of fruit set was noticeably smaller where there were no colonies of bees kept in the vicinity. The exceptionally backward nature of the season continued throughout the summer and affected seriously the development and ripening of all crops. This was only partially compensated for by a long open autumn without severe frosts. In the wheat-growing districts the crop was, however, in many places injured by this exceptional season and this was particularly the case in the prairie provinces.

The grain crops in the Northwest provinces were poor and light in quantity owing to the very unusual season, but the much higher price paid for grain than in previous years brought much money into the country and relieved the farmers from much of their loss. In British Columbia very little spring wheat was grown owing to the presence in previous recent years of Wheat Midge. Fall wheat yielded fairly well.

THE HESSIAN FLY, *Mayetiola (Cecidomyia) destructor*, Say, occurred in the Maritime Provinces in several localities, but only in Prince Edward Island was noticeable injury reported. There is evidence that this troublesome insect is again gradually increasing in Ontario, and as it is working westward in the northwestern United States it must at some time be expected to appear in our Alberta fall-wheat districts; it will be well therefore for farmers to be on the alert and apply vigorously the well known remedies which, briefly, are as follows—

Late Sowing of Fall Wheat.—This is the most important preventive remedy and means a change from the ordinary farming practice and for this reason it is sometimes rather difficult to persuade wheat growers to adopt it. By postponing seeding until the end of September the appearance of the young wheat plants above the ground in autumn is delayed until after the egg-laying flies, which emerge in August and September are dead. The chief objection offered to sowing so late as the end of September is that plants have not time to make vigorous roots so as to withstand the cold of winter. This danger, however, experiment has shown is not so great as it appears, and if the land is got into good condition and good heavy seed is sown by the end of September, it will generally give a satisfactory crop.

Burning Refuse.—Many of the flax-seed-like pupae of the summer brood are carried with the straw and at threshing time are loosened and fall beneath the machine with the rubbish, or they may be left in the straw. All dust and screenings therefore from the threshing mill should be carefully destroyed or fed, and all straw and small seeds should be either used during the winter or burnt before spring.

Treatment of Stubble.—Most of the flax-seeds of the summer brood are placed so low on the stems that they are left in the stubble when the wheat is cut. A large proportion of these produce flies in September but some pass the winter in the stubble. Stubble should therefore be ploughed down deeply so as to place the insects so far beneath the surface that the delicate flies when they emerge cannot escape.

Trap Crops.—A method of reducing the numbers of Hessian Flies which is little practised, but which is spoken highly of by some, is sowing narrow strips of wheat in

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August, which will attract the females to lay their eggs; these strips must afterwards be ploughed down before the larvæ are mature when they will be killed, and the wheat which is sown late will escape owing to the egg laying females having all deposited their eggs. This end may also be obtained by running a harrow over the stubble as soon as the crop of fall wheat is cut so as to start a volunteer crop from the grain which had been shelled out in harvesting. This volunteer crop will form an attraction to the females before the main crop appears above the ground and can be ploughed down deeply at any time before the larvæ mature.

Reports of injuries by Hessian Fly from Manitoba proved upon investigation to be unfounded.

WHEAT-STEM SAWFLY, *Cephus occidentalis*, Riley & Marlatt.—This insect which has been referred to occasionally in previous reports of the Division, last autumn appeared in central Manitoba and the eastern part of Saskatchewan, in much more serious numbers than at any previous time. The broken down straws which resulted from its attacks were seen in many fields and caused some alarm. Among correspondents who reported on this insect, Mr. Norman Criddle, an observant farmer and student of insects, living at Aweme, Manitoba, writes at the end of the season as follows:—

‘This native species of sawfly which until the breaking up and cultivation of the prairies was confined to a few native grasses belonging to the genus *Agropyrum*, of which *A. caninum*, R. & S. here is the favourite, has increased considerably during the last year or two. In the absence of parasites this insect seems to have been controlled by the number of flowering stems formed by its food plant, the grass in its turn being restricted by the climatic conditions of the season, so that an unfavourable season for the grass to form flowering stems would also prove unfavourable to the increase of the sawfly; but with the cultivation of the prairie and the planting of cereals the conditions change. For, although native grasses seem still to be preferred, yet if on account of the season, as is sometimes the case, they fail to develop stems abundantly or the insects are too numerous for the stems of the grasses produced, the flies turn their attention to wheat or rye, as well as to the western rye grass, *Agropyrum tenerum*, Vasey, which is now so extensively grown in Manitoba, causing serious damage to that important crop. These conditions occurred in 1907 with the results that in some cases fully 50 per cent of the wheat stems were broken down around the edges of fields, extending in to a distance of 100 feet or more, and damage was apparent to a lesser extent all through the crop. An interesting feature in connection with this attack upon wheat, was that fully 75 per cent of the infested stems were broken down by wind about 2 or 3 inches above the ground, close to where the larvæ were at work; and in many instances an examination showed that the larvæ had been caught by the breaking of the straw, some actually at the broken spot, when they were pinched to death, while in others they were above the break, which proved equally fatal to them. I calculated that on a certain area fully 12 per cent were killed in this manner. It is interesting to note that the native grasses, however, never break in this way, so that in attacking wheat the insect has to contend with conditions which, though favourable to its increase, are not so much so as an abundance of its native food plant would be. The life history, so far as I know it, seems to be about as follows:—The eggs are laid singly upon a stem of grass or wheat, not far from the head, between June 20 and the second week of July. The larvæ soon hatch and begin to eat down inside the stem, usually reaching maturity and the ground towards the end of August. They then eat the stems almost through, slightly below the ground, so that they break off. The stubs are then closed over with a water-tight material and the insides of the stems are also lined by the larvæ to the roots. In these retreats the larvæ pass the winter and remain in an active condition unchanged until May of the following year, when they turn to pupæ and emerge as perfect sawflies towards the end of June, the date varying somewhat with the season.’

In my previous reports from observations I had made on material sent to me I had suggested that an important remedy in controlling this insect would be the burning over of stubbles, but from Mr. Criddle's observations it would appear that the winter location of this insect below the surface of the ground would protect it so thoroughly as to render this practice almost useless. At my request Mr. Criddle made special observations on this point. He writes:—

'Aweme, October 6, 1907.—At your suggestion I have just made experiments with burning stubble to see what its effect would be upon *Cephus occidentalis*. As the stubble was too thin to burn freely, and to make sure of having the experiment complete, I spread an infested piece of ground with four inches of straw and then set fire to it. This burnt decidedly longer than the thickest stubble would do and heated the ground on the top, so that it was unbearable to the hand. After it was cool I examined the inhabited straws, and though in some cases the top of the stubble cut off by the larvæ had been burnt, in no instance was a single larva found injured, but in every case they were found at the extremity of their burrows near the roots of the plants, showing that the heat had merely had the effect of driving them downwards, and as their tunnels in the straw usually extend from one to two inches below the surface, they would practically be uninjured by this treatment.'

The Wheat-stem Sawfly undoubtedly occurs in many places where its presence is overlooked, but correspondents in Manitoba and the Northwest make frequent reference to an injury in wheat fields which can only be referred to this insect. The remedy which suggests itself and which has been practised to some extent is the ploughing down of all stubbles either in autumn or before June 15, at which time the mature insects may be expected to emerge. Mr. Criddle also suggests that all grasses belonging to the genus *Agropyrum* growing around the edges of fields should be mowed down during the last two weeks of July, so as to destroy any contained larvæ.

Wheat Joint Worm, *Isosoma tritici*, Fitch.—There is every year considerable loss in the wheat crop of Prince Edward Island from the Wheat Joint Worm, and some correspondents believe that the insect is spreading quickly throughout the province. Father Burke, of Alberton, who has many opportunities of examining the crops, believes it to be a serious matter, and regrets that more of the farmers do not consider it specially with a view to adopting concerted measures for its control. The adoption of a regular short rotation of crops and the mowing down of all grasses along the borders of fields in June, as well as the keeping up of the fertility of the soil, so as to produce a healthy vigorous growth, will not only discourage egg-laying by the Joint Worm but will have many other beneficial effects on the land where these wise measures are practised.

'Lower Montague, P.E.I., July 30.—I send you a few stalks of Laurel wheat. This crop was sown on May 19, and appeared to be all right and looked splendid until lately. On examining it I find a great many crooked straws similar to those which I send. I have never seen this before. I have a field of White Fife wheat which was sown on the same day as the Laurel, and this is very little affected.—MONTAGUE ANNEAR.'

'Stanley Bridge, P.E.I., August 3.—The Joint Worm has totally destroyed all the wheat in this vicinity and is spreading rapidly. As yet farmers have made no effort to fight the pest. Will it take oats and barley if we give up growing wheat?—A. J. McNEILL.'

'Bay View, P.E.I., March, 1908.—In reply to your question, the Joint Worm of wheat was first observed in our district in northwest Queen's county, at Long River, about five years ago. The next season it had spread five miles along the shore. The remedies recommended were not applied, as the farmers on the Island seed down all their wheat land with clover and grasses, and firing the stubble would destroy their hay crop. In 1907 the pest had spread from Kensington along the shore to beyond Rustico, a distance of over thirty miles, and some nine miles inland. All wheat

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seeded before June 3 was attacked, and practically all was ruined, and later seedings although free from the pest gave light crops of soft wheat. Parasites have not been observed as yet, and there seems to be a steady increase in the numbers of this very serious pest of our wheat crop. I may mention that I saw Joint Worm flies on the wing on May 23.—J. A. CLARK.

Specimens of the galls were sent from Prince Edward Island and such of the flies as were reared proved to be the Wheat Joint Worm, *Isosoma tritici*, Fitch, but from the difference in the appearance of the galls it would seem likely that another species was also at work on wheat in Prince Edward Island. No specimens of *Isosoma hordei*, Harris, were received, nor were there any complaints of injury by joint worms to barley. It is not likely that the Wheat Joint Worm will attack either barley or oats. There is apparently only one brood of the Wheat Joint Worm in Canada, the larvæ of which winter in the straw, for the most part so near to the ground that when the crop is cut the greater portion of them are left in the stubble. It has been recommended as a remedy for Joint Worms to burn over the stubble or to plough it down deeply for the destruction of the contained larvæ, and the disposal by burning or feeding of the galls or hardened portions of the straw which become separated in threshing. There is great variation in the extent of the swelling which results from the attacks of these larvæ. Frequently the galls are hardly noticeable, but the tissues of the stem are thickened and become brittle so that they break from the rest of the straw when threshed. These and all straw from an infested crop should be either fed or burnt before the ensuing spring. As is pointed out above by Mr. Clark, the farmers of Prince Edward Island are getting into the way of seeding down their wheat lands with clover and grasses, so that either burning of stubble or ploughing down cannot be adopted where the land is to be left in hay. A more extensive cultivation of clover than has been the practice in the past in Prince Edward Island is highly desirable, but while the Wheat Joint Worm is abundant and increasing in destructiveness, some modification of the ordinary practice is decidedly advisable and the benefit of sowing clover as a nitrogen-gatherer, might still be preserved to a large extent by sowing a few pounds of clover seed with all grain crops and then ploughing this down with the stubble either in the first autumn or the following year. In fighting against insects it frequently becomes advisable to modify accepted agricultural practices so as to control a pest which has become unusually abundant at a special locality. By examining the stubble of an infested crop of wheat it could soon be seen whether or not the galls were located near the base of the stem or so high up that they would be carried with the straw. The location of the gall will vary with the season in the same way that the point of attack by the Hessian Fly varies. In late cold springs the attacks of both of these insects are lower down, in the case of the Hessian Fly being sometimes entirely confined to the root shoots, while in other years the larvæ may be found one or two joints up the stem from the base.

It is important that the farmers of Prince Edward Island should now come together and discuss methods of prevention for this insect, so that some wholesale, vigorous and concerted action may be taken to prevent the further increase of this insect which is now becoming of importance to the whole Island.

The perfect insect of the Wheat Joint Worm is a minute, shining, black, four-winged fly, only one-tenth of an inch in length with clear wings and pale legs. The larvæ are slender, footless grubs, one-eighth of an inch long with perceptible brown jaws. These occur only inside the galls on the stem and vary in number from 4 or 5 to as many as a dozen in a single gall. The galls as a rule occur just above the first or second joint above the root. Nearly all of the larvæ winter unchanged inside the galls, but occasionally a small proportion change to flies and emerge late in autumn.

The Grain Aphis, *Macrosiphum granaria*, Kirby.—There was an unusual amount of interest and considerable alarm in the Northwestern provinces last summer concerning grain plant lice and several letters were received asking if specimens sent were the so-called 'Green Bug' which was causing such a great sensation in the

States to the south of our border. Actual specimens of this insect, *Toxoptera graminum*, Rond., were received from Emerson, Manitoba, but these had merely spread over the border from an infestation a few miles to the south in Minnesota and did no harm in our wheat fields. There were, however, serious complaints of injury in Manitoba and the eastern part of Saskatchewan from the ordinary Grain Aphis, *Macrosiphum granaria*, Kirby, a somewhat similar insect but one which is easily distinguished from it by the venation of the wings when examined under a magnifying glass. There are four plant lice which injure wheat in the west. (1) The Spring Grain Aphis, or so-called 'Green Bug' which for the most part attacks the leaves of the young plants, and which has the second vein from the tip of the upper wings only once forked or divided, and the small honey tubes at the end of the body above, of a pale colour with only the tips darkened. (2) The Grain Aphis, which has the second vein twice divided and the tubes black. (3) The Oat Grain Aphis, *Siphocoryne avenæ*, Fab., also called the European Grain Aphis, which in the winged form has the second vein forked, but instead of being divided at the tip so that the first fork from the tip leaves the main vein one-quarter of the way from the end, it is only about one-eighth of the distance, thus leaving the cell at the tip of this vein very small. The tubes at the end of the body are distinctly broader at the base than toward the apex. The eyes are reddish as in the Grain Aphis and the front of the head is not pointed in which it agrees also with the last named species. The two last named plant lice although they occur upon the leaves of the small grains during part of their life-history are much more apt to cluster together on the heads as soon as these are formed, while it is stated that the Spring Grain Aphis only attacks the leaves. Prof. Washburn states distinctly, 'Toxoptera was never found according to the reports of our field workers on the heads of any of its food plants, differing in this respect from *Macrosiphum granaria* which attacks the heads as soon as they appear.' (4) The Apple Aphis, *Aphis mali*, Fab. This species does not feed the whole season on the plants of the various small grains but migrates to them during the summer time from apple trees, the winter being passed in the egg condition on the branches of apple trees in a similar way to that in which the Hop Aphis winters on plum trees. After four or five generations on apple trees in the spring, winged migrants are produced all of which fly to the grain fields and at once produce large numbers of wingless young, all of which are females. These towards the end of the season produce perfect males and females, which, after mating, deposit the winter eggs on apple trees.

The injuries by the Spring Grain Aphis have been more pronounced in the southern districts of the United States; but the species has spread northward in injurious numbers almost to our borders. The chief check on the excessive increase of this pest in the United States has been the sudden appearance in large numbers of a minute parasitic wasp, named *Lysiphlebus tritici*, Ashm., which not only destroys this grain aphis but also all other species found in grain crops. It is fortunately present in large numbers in all the districts from which grain plant lice were sent last summer. The injuries by the ordinary Grain Aphis, *M. granaria*, were in some places severe, being reported in July, August and September. These injuries were chiefly in the west.

'Welwyn, Sask., August 26.—I send specimens of a green aphis and some heads of wheat showing the way in which they feed. Seemingly they suck the sap out of the base of the grain where it is attached to the stem. Is this the same as the green bug they have in the Western States? They are doing the grain fearful damage, as they are in millions. So far I have only seen it on breaking. I have not heard of any other fields in this neighbourhood, and I only discovered them on my own three days ago.—RALPH STEWART.'

'Welwyn, September 10.—I send you some more wheat and bugs. I have found no parasites. The bugs are not as plentiful as they were three weeks ago and summer fallows seem to be free. I have just heard to-day that there are hundreds of acres about 30 miles northeast of here which are not worth cutting. Two farmers there

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have 200 acres of wheat, and out of that they are only going to cut 35. I think the damage is more widespread than people have any idea of. I have put my own loss at 15 per cent of the crop and probably more, but we have had two heavy rains since these bugs appeared, and this seems to have washed many of them off.—RALPH STEWART.

These specimens sent by Mr. Stewart were at first thought to be the dreaded 'Green Bug,' but winged specimens were afterwards received and they were found to be the Grain Aphis. Specimens of the same species were also sent from localities in Manitoba, mostly from the west of the province. Parasites were reared in numbers from all the material sent, including that from Welwyn.

Unfortunately for the Grain Aphis there is no practical remedy which can be applied in a wholesale manner, but Prof. F. M. Webster, who has devoted much attention to the insects which attack grain crops, has constantly drawn attention to the great advantage of practising good agricultural methods in working land, such as the adoption of a regular rotation of crops, so as to keep up the fertility of the soil, and advises that care should be taken to sow grain at the best time to secure a vigorous growth, which will enable the plants to withstand the attacks of the aphis sufficiently long to allow the natural parasites which always sooner or later appear, to increase, so that the numbers of the plant lice may be reduced before serious injury is done to the grain plants. In the case of the Oat Grain Aphis and the Apple Aphis, the two commonest species in Ontario and the east, as these pass the winter in the egg condition upon apple trees the regular spraying of apple orchards with kerosene emulsion or the lime and sulphur wash would not only clear those trees of enemies which sometimes do much harm but, also, to a large measure protect the wheat fields the following season. Fortunately for the wheat grower a severe outbreak of grain plant lice is almost invariably accompanied by a rapid increase in the numbers of various parasitic and predaceous enemies, which as a rule prevent serious losses.

GRASSHOPPERS, *Melanoplus* spp.—Locusts, or as they are more generally spoken of as grasshoppers, were injuriously abundant in some places in eastern Ontario and along the Quebec shore of the Ottawa river. A great amount of injury was done to pastures and all growing crops. Large swarms of the ordinary species which are common in Ontario also occurred in many places in western Ontario, where injury was done not only in field crops but in vineyards and orchards. The species sent in were *Melanoplus femur-rubrum*, DeG., *Melanoplus atlantis*, Riley, and *M. bivittatus*, Say. In Manitoba the same species were all present and destructive as well as *M. packardii*, Scudd., and *Camnula pellucida*, Scudd., was destructive in British Columbia. The following letters chosen from many received show the extent of injury by some of these swarms and the time they appeared:—

'Kamloops, B.C., May 31.—Please send the latest information on fighting grasshoppers. They took my crop last year and are now hatching in great numbers. I have just put out Paris green and salt mixed with horse manure and a little water. My neighbours have tried this also, but they tell me the grasshoppers will not eat it.—J. P. SHANNON.'

'Treesbank, Man., August 16.—Grasshoppers are decidedly on the increase again, and with favourable conditions I fear that they might be as bad as ever in a year or two. We shall, however, watch them and try and put out the poisoned horse manure if they attack the crop.—N. CRIDDLE.'

'Neepawa, Man., September 7.—I send specimens of grasshoppers which are most unusually numerous this fall in this vicinity. They were never seen so thick before. I am wondering if they are the forerunners of a grasshopper plague next summer. Is there any danger from their laying eggs which will hatch next spring? If so what is the best thing to do?—E. T. MOODY.'

The species sent by Mr. Moody was the Two-striped Grasshopper, a large heavy species, which as a rule is found in rather low ground near bushes, and is not so often injurious to crops as some of the smaller and more active species.

'Pointe du Lac, Que.—I send specimens of grasshoppers which are actually destroying the crops in our district. We have tried the Criddle mixture, but it has not had an appreciable effect on their numbers.—Rev. J. CARON.'

'Galletta, Ont., July 17.—Please give a remedy for grasshoppers. A very large army of them has attacked a field of oats having come from a large adjoining pasture. I have tried Paris green on a ridge without effect.—MATTHEW RIDDELL.'

'Ballantrae, Ont., Aug. 22.—Seeing that various reports are going in with regard to the grasshopper plague I thought I would tell you how we were faring in this part of the province. I live on the ridges of the township of Whitechurch, county of York, and our soil here for the most part is a sandy loam. The grasshoppers struck this locality early in the season and we are suffering greatly from their ravages. Other localities escaped until later in the season, but they are becoming general and widespread now. They have taken all second crop and spring-seeded clovers. Pasture land is as bare and brown as a barn floor. Some farmers left their oats standing until completely stripped, others cut them in the milk, and they were half stripped even at that stage. The turnip crop is practically gone. In some cases the carrot crop is eaten level with the ground and their latest freak is eating out the mangel roots. Peas have escaped fairly well but some fields are nearly stripped of their foliage. Fodder corn is eaten in holes and they are boring through the husks and eating out the grain of the ear. They started about a week ago upon the potatoes and some patches are now bare. They cut the leaves off and drop them and the stalk is sometimes eaten through at the bottom and just falls over and dries up. Vegetables are entirely destroyed and raspberry, gooseberry and currant bushes are stripped bare.—W. A. QUANTZ.'

Last summer was extremely dry in many localities and where this was the case growth was slow and meagre and here the grasshoppers did most harm. In some places where copious rains came late in the season and vegetation of all kinds picked up the injuries by grasshoppers were much less apparent. Rev. Father Caron when writing in the middle of August from Point du Lac, Que., refers to this and speaks of his previously reported poor effects of the Criddle mixture of Paris green and horse manure in his parish, which he says the farmers did not use sufficiently to give it a fair trial because it did not show immediate results. This was the case also in many other places where the mixture was tried. There is evidence to show, however, that this mixture which undoubtedly gave most satisfactory results in Manitoba wherever it was tried has not proved so successful in some other places. Whether this is due to the climatic conditions I am unable to say, but in Manitoba the grasshoppers were destroyed in myriads and the mixture was remarkably attractive to them, so that they would flock to those parts of the field where it had been scattered and were poisoned by eating it. In Ontario on the other hand it would seem to be much less attractive to the species which occur commonly here. For these districts it may be remembered that the now well known poisoned bran remedy for cutworms (one pound of Paris green, one pound of salt and one gallon of water, in 100 pounds of bran) may be used and is extremely effective against grasshoppers of all kinds. In fact this mixture of Paris green and bran was originally devised in California as a remedy against grasshoppers in vineyards. The spraying of the edges of fields with arsenical mixtures when grasshoppers first begin to move towards crops has also been found very useful. Later when the insects have their wings and are occurring in large numbers a modification of the tin pans or light frame works known in the west as 'hopper-dozers,' may be used to great advantage. These are light frames with wings and a back covered with canvas and having a tin pan at the bottom which will hold tar or coal oil and water. These are drawn over pastures or in such places as grasshoppers are abundant and the insects are caught in large numbers. If a grasshopper has only a small drop of coal oil on its body it will soon spread all over it and be fatal.

PEA WEEVIL, *Bruchus pisorum*, L.—The Pea Weevil which for three years has hardly been mentioned in correspondence, is evidently again increasing in numbers

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and it is of the greatest importance that pea growers and seed merchants should use vigorously the well-known remedy of fumigating all seed peas before sowing them, or, what is far preferable, as soon as they are harvested and threshed. One or two samples have been recently sent in which were as badly infested by the Pea Weevil as in the worst years four or five years ago. One of the important centres of the pea-seed trade is the county of Prince Edward in Ontario. A few years ago peas in that county were infested by the Pea Weevil to an extreme degree. Mr. J. D. Evans, of Trenton, who has kindly kept me informed regularly with regard to this infestation, reports on the season of 1907, as follows: 'I discussed the matter of Pea Weevil injury with Mr. W. P. Niles, of Wellington, one of our best authorities, and he tells me that the Weevil is almost extinct in Prince Edward county at the present time, but owing to the carelessness of farmers in attending to their seed peas, he will not be at all surprised to see it again troublesome in the near future.' Mr. Niles said that he had received some peas from Oshawa which were somewhat infested but not very seriously; but he had, however, a sample from Exeter, in Lambton county, which was about as bad as it could be. The remedy above all others by which the Pea Weevil has been kept in check in the past is the scrupulous fumigation of all seed peas. There is still some confusion on the part of farmers as to what the Pea Weevil really is. This is to a measure due to the senseless persistence of merchants and farmers in speaking of it as the 'Pea Bug' and consequently as almost every insect is called a bug on this continent, as many specimens of peas injured by the Pea Moth are sent in as having been attacked by the Pea Weevil, as those injured by the insect properly so called. The injuries of these two insects are entirely different. The work of the Pea Weevil is inside the seed and after the small brownish gray beetles, one-fifth of an inch long and bearing two conspicuous black spots on the end of the body, have emerged, there is on the side of the pea a small perfectly round hole. The work of the caterpillar of the Pea Moth is an irregular ragged-edged cavity eaten in the side of the seed while it is green. The life-history of both of these insects is perfectly well known: The egg of the Pea Weevil is laid on the outside of the young green pod and the grub on hatching eats its way in and penetrates the nearest pea. Here it remains until full grown which is late in the summer time after the peas are ripe. When peas are threshed as soon as they are ripe and the seed is fumigated at once the grub of the Pea Weevil can be destroyed before it has eaten very much of the seed; but if left untreated until later in the winter or until just before sowing, the benefit is merely that the beetles inside the peas are killed. This is of much importance but if the work is done as soon after harvesting as possible the injury to the seed is reduced very much indeed. The larval life of a Pea Weevil is passed entirely inside the pea it first entered. The egg is laid during June and the small grub has to penetrate the pod and locate itself inside a seed before this becomes too hard. The development from a white fleshy grub to the pupal condition and the change to the perfect beetle, all take place during the late summer and some of the beetles are fully developed by about the middle of August, a few, in certain seasons, leave the peas in the autumn or even as early as harvest time; but the regular habit of the insect is for the beetles to remain in the seed until the following spring. Those weevils which emerge in the autumn pass the winter hidden away under rubbish or in barns, out-houses, &c. Occasionally there is a wholesale emergence in the autumn, and when this takes place the numbers of Pea Weevil are enormously reduced. They are exposed to many dangers which they would have escaped had they remained inside the peas. Insect eating birds and mammals destroy many, and I have been shown, near Picton, in Prince Edward county, Ont., thousands of the beetles which had crawled beneath the shingles of an old barn and had died there, presumably killed by the cold of winter. Those weevils which pass the winter safely outside, or those which have been sown in the spring with the seed peas, fly to the fields, and for some time feed on the foliage of the pea plants. As soon as the young green pods are formed the eggs are laid and the grubs hatch soon afterwards. There is only one brood of this insect in

the year, and the important fact in its life-history is that every pea containing a weevil, and this is by far the largest proportion of all the insects produced every year, is for a considerable time entirely at the mercy of the farmer or seed merchant, for there is no other known food plant for this insect than the cultivated pea. It is not a native of this country any more than its food plant is, and the pea is not one of those cultivated crops of which the seeds lie over and produce a volunteer crop the following year.

Remedies.—(1) Holding over seed. Of many remedies suggested that of easiest application and requiring no expenditure is the holding over of seed. Where only a few seed peas are used it is very easy to store these away until the second year after harvesting. Peas should always be bagged and the sacks tied up tightly at once after threshing. It has been found that the Pea Weevil cannot eat its way through bags even when these are made of paper. Therefore all the weevils which emerge either in autumn or the following summer will die inside the bags, and the seed can be sown the following year without danger. Sound seed will not be injured in the least by being held over for this time. Seeds which have been injured by the weevils will grow unless the germ has been destroyed, but such seeds produce only weak plants, which unless all conditions are extremely favourable, do not produce nearly as heavy a crop and should not be used for seed unless no others are obtainable. Of 400 seeds picked at random from a sample sent in last winter, all of which had been attacked by the weevil, only 34 grew:

- a. 10 seeds germinated, 3 weak plants, 7 strong.
- b. 9 seeds germinated, 2 weak plants, 7 strong.
- c. 10 seeds germinated, 4 weak plants, 6 strong.
- d. 5 seeds germinated, 3 weak plants, 2 strong.

This experiment merely confirms previous experiments which have been tried here on several occasions.

(2) Fumigation.—The standard remedy upon which chief reliance must be placed to control the Pea Weevil is the fumigation of all seed peas with bisulphide of carbon. For treating large quantities, specially prepared houses are maintained by the large seed merchants. These 'bug houses' are tightly constructed, and are made to treat from 1,000 to 3,000 bushels at a time. The treatment of smaller quantities, such as are required by farmers, is an easy matter, and an ordinary coal oil barrel is a convenient receptacle for the seed. A 40-gallon coal oil barrel will hold about five bushels, or 300 pounds of seed, which can be treated with 3 ounces of bisulphide of carbon poured right on to the peas and the barrel quickly closed up tightly. The bisulphide of carbon should be of the best quality which will vaporize entirely without leaving any residue. The time to keep the barrel closed is 48 hours. As stated above, the seed should be fumigated as soon as possible after harvest, but the work may be done at any time when the temperature is above freezing. It is well to mention that bisulphide of carbon is very inflammable; fumigating therefore should be done out of doors in a shed or at a distance from buildings, and no light of any kind must be brought near.

FRUIT CROPS.

The spring of 1907 was cold throughout the Dominion and very dry in the eastern provinces. This had a direct effect upon all fruit crops. The remarkable scarcity of insects of all kinds prevented the fertilization of much fruit, except in such orchards as were near to apiaries. The crop in Ontario, Quebec and the Maritime Provinces was not of very high quality, but good prices were obtained, particularly when grown under the best horticultural methods. At the Central Experimental Farm there was a full set of fruit owing to the number of bees which had access to the bloom. Prof. Hutt, of the Ontario Agricultural College at Guelph, drew particular

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attention to this matter also at the last annual meeting of the Entomological Society of Ontario. Bees wintered poorly and many colonies were weak in spring. Prof. Hutt attributes the small set of fruit in some localities in Ontario in 1907, chiefly to the lack of domestic and wild bees, and noticed many instances where men who kept bees had better crops of fruit. In British Columbia the fruit crop was excellent and as good in quality as in quantity. In western Ontario the crop of grapes was large except in those districts where the Rose Chafer destroyed the blossoms. wing to the late cold season many kinds of grapes were not ripe when the frosts came. Small fruits produced poor crops owing largely to the drought. The crops of vegetables of all kinds were also much affected by the drought, and in the eastern portions of the province of Ontario and in parts of Quebec the potato crop was exceptionally poor. In some places the seed tuber remained in the ground without decaying until the end of the season.

CODLING MOTH, *Carpocapsa pomonella*, L.—Of the insect enemies of fruit crops some of the old enemies and well known pests were more than usually destructive. The Codling Moth in western Ontario was so destructive in some places that several fruit growers discussed seriously the advisability of cutting down their apple trees and planting grapes or peaches. This part of the province is within the area where there are two regular broods of the Codling Moth in the season, the latter of which is by far the more destructive. It therefore becomes necessary for fruit growers not only to spray their trees in spring but also to apply bands regularly as shelters for the larvæ to spin up in. This causes a great deal of work, and in this district grapes and peaches are considered the best paying crops. This fact I believe accounts to a large measure for the increase of the Codling Moth in the Niagara peninsula. The apple orchards are not given the same care as in other parts of the province and consequently some of the regular pests increase unduly. In this district three sprayings with poisoned Bordeaux mixture in spring and the banding of all trees in July and August are the means by which the apple, pear and quince crops should be protected from injury by the Codling Moth. Some care is necessary in attending to the bandages, or putting them on may do more harm than good. These bandages may be made of any soft material such as burlap, hessian, old sacking, &c., and can be quickly and easily attached to the trees by placing a piece of string or wire around the middle and then turning down the upper half. These bands should be put on the trees by the beginning of July and should be examined at least once a week for the rest of the season. During August a great many cocoons and larvæ will be found and these must be destroyed, for which purpose it will be necessary to remove the bandages. Later in the season the caterpillars will be fewer and the easiest way of killing them is with the point of a knife without removing the bandages. The caterpillars have the habit of boring some distance into the bark of the tree and spinning in the dust on the outside of their cocoons. This renders them extremely difficult to detect and I have found a convenient implement for cleaning the bark beneath the bandages is a wire brush such as is used for cleaning out furnaces. This tears the cocoons from the bark and destroys the contained larvæ.

A fact which is always apparent in orchards which are regularly sprayed year after year with poisoned Bordeaux mixture is that the effects are cumulative. Regularly sprayed orchards gradually become year by year freer from insects and fungous enemies, notwithstanding the fact that many insects are able to fly long distances and the spores of parasitic fungi may be borne easily almost to any distance.

THE OYSTER-SHELL SCALE, *Lepidosaphes ulmi*, L.—Owing possibly to the inclement season the increase of the Oyster-shell Scale in the summer of 1907 was particularly noticeable and undoubtedly much injury resulted from its attacks upon fruit and other trees. The young of this insect hatch beneath the parent scale about the end of May or the beginning of June and are active for a few days only. They are then

very minute, six-legged mite-like insects which swarm over the trees giving them the appearance of having been dusted with some coarse white powder. By the second day most of the young scale insects have chosen a suitable place and have attached themselves to the young tender bark by means of their slender sucking tubes. There they remain for the rest of their lives, growing rapidly during June and July. Early in August the females have become little more than a bag of eggs beneath the waxy scale. The insect itself is crowded up into the narrow end of the scale where it dies, leaving the eggs to carry the species over the winter. The scales of the male are seldom noticed; they are most frequently found upon the leaves and are of an entirely different shape from those of the female, being elongated, square at the end and somewhat tapering to the front. They are very small not more than one-twentieth of an inch in length and pale in colour. Unlike the female which lives all its life inside the scale and has no power of motion after it once settles, the male is a minute two-winged fly which when mature emerges from beneath its scale and has the power of flying very rapidly.

Remedies.—The remedies for the Oyster-shell Scale are the invigoration of the tree by high culture and good orchard management and the direct treatment of the scale insects with contact insecticides. The young hatch about the beginning of June and as soon as these are noticed on the trees, whale oil soap solution, or kerosene emulsion, should be promptly applied as a spray. The sooner this is done after hatching has taken place the more effective it will be. Trees badly infested should be helped by having some quick-acting fertilizer spudded in around their roots in spring and in autumn should be sprayed with a lime wash made of one pound of quick lime in each gallon of water. Two applications of this weak whitewash should be made and the second one may be put on immediately the first one is dry. This spraying should be done as soon as the leaves fall or at any other convenient time afterwards before the intense weather of winter sets in. During the winter the lime flakes off and carries with it a large proportion of the egg-containing scales which have been loosened by the lime.

THE SAN JOSÉ SCALE, *Aspidiotus perniciosus*, Cmstk.—The condition of affairs with regard to the San José Scale in the orchards of Ontario is practically the same this year as it has been for the last year or two. This insect although it has spread to new orchards has not invaded new territory in the province. Owing to the late season of 1907 the appearance of the young was also later than usual and there is no doubt that the fruit growers of that part of Ontario where the scale occurs, now understand its habits and the importance of using the lime and sulphur wash which is the standard remedy. Mr. J. Fred. Smith, the San José Scale inspector for the province of Ontario, reports that never before has there been so much done for the destruction of the scale by fruit growers as during the past season. The lime and sulphur wash was the remedy mostly used. Mr. W. H. Bunting, a large fruit grower and a leading member of the Fruit Growers' Association of Ontario, stated in a lecture given at Ottawa last winter that he considered the advent of the San José Scale into the orchards of Ontario, although it had done an enormous amount of injury, had really been a blessing to fruit growers, because with the lime and sulphur wash if properly applied, they now knew they could control this insect and the work which had been necessary owing to its presence had placed their orchards in a far better condition than they would have been had the scale never invaded the province. Systematic spraying had become a necessity and with its practice many of the regular enemies of the orchard had disappeared. The general condition of these orchards, he believed, was now greatly improved. Many different materials have been experimented with as remedies but up to the present time nothing better than the lime-sulphur wash has been discovered and fruit growers will be wise to recognize this as the standard remedy for the treatment of their orchards and leave experimenting with new materials

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to the professional entomologists who always try these newly suggested remedies, and, it may be added, have in the past found most of them of little value.

There is much inquiry every year for the regulations under which the government permits nursery stock to be imported into Canada and also with regard to the formula used for destroying the scale on trees which are imported. In the first place it may be stated that the sole purpose of the government federal fumigation houses is for the cleansing of the stock from the San José Scale, and there is no legislation whatever of the same nature against any other insects. This statement is called for by persistent misrepresentations which are made in British Columbia. In that province the government officials condemn and frequently destroy nursery stock upon which they find several other insects besides the San José Scale; but the only one against which at the present time any federal legislation has been enacted is the San José Scale.

The formula used.—The formula used at the federal fumigating stations is one ounce of cyanide of potassium (98 per cent), one ounce of commercial sulphuric acid (60° Baumé), and three ounces of water, for every 100 cubic feet of space, and all nursery stock is exposed to the gas generated by this mixture for 45 minutes. This formula generates sufficient hydrocyanic acid gas of a strength requisite to kill every scale insect upon the trees in the 45 minutes during which stock is exposed to it.

Fumigating Stations.—There are six points only along the border at which nursery stock can be imported into Canada. At those points the federal government maintains houses for the fumigation of all nursery stock coming into the country from other countries known to be infested by the San José Scale. These are as follows: Vancouver, B.C.; Winnipeg, Man.; Windsor, Ont.; Niagara Falls, Ont.; St. John's, Que.; St. John, N.B.

The federal fumigation houses are kept open, with a superintendent constantly in attendance, throughout the spring and autumn shipments of stock. The superintendents are all trained men, expert in examining stock, and in unpacking and repacking all packages which come into their hands. Up till the present time the superintendents at all of the stations have done their work carefully and well, and no well founded complaints as to carelessness or injury to stock have been received from importers, either with regard to the reasonable delay which must occur while stock is being treated or as to injury to trees during the necessary unpacking, handling and repacking. In every instance when complaints have been made a thorough investigation has been promptly instituted, and in every instance it has been satisfactory to report to the Honourable the Minister of Agriculture that any injury that trees suffered in transit could not be attributed to carelessness on the part of the superintendents.

The Customs regulations as now consolidated under the San José Scale Act read as follows:—

1. Under 'The San José Scale Act' the importation into Canada of any trees, shrubs, plants, vines, grafts, cuttings or buds, commonly called nursery stock, from any place to which the Act applies is prohibited, and 'any nursery stock so imported shall be forfeited to the Crown and may be destroyed, and any person importing nursery stock from any such country or place, or causing or permitting it to be so imported, shall be deemed to be guilty of an offence under section 6 of the Customs Tariff, 1897, and shall be liable to a penalty prescribed by that section.'

2. By an order in council approved March 18, 1898, the said Act prohibiting the importation of nursery stock is declared to apply to nursery stock from the following countries, viz.: United States of America, Australia, Japan, Hawaiian Islands.

3. By an order in council approved March 18, 1898, plants exempted from the operations of the above mentioned Act are as follows:—

(a) Greenhouse plants with the exception of roses (such as palms, ferns, orchids, cacti, chrysanthemums, azaleas, begonias and carnations, but not roses or any other woody plants).

(b) Herbaceous perennials (the tops of which die down in winter, such as perennial phlox, dielytra, peonies, perennial sunflowers, &c., and also strawberries).

(c) Herbaceous bedding plants (such as geraniums, coleuses, verbenas, pansies, &c.).

(d) All conifers.

(e) Bulbs and tubers (such as lilies, hyacinths, narcissi, and all other true bulbs, gladioli, caladium, irises, cannas, dahlias, &c.).

4. By an order in council approved April 25, 1900, permission is given for the importation of roses in leaf and in a growing condition which have been propagated under glass.

5. By an order in council approved January 5, 1901, nursery stock may be imported if fumigated at the following customs ports during the periods undermentioned, viz.:—

Winnipeg, Man., and St. John, N.B.—From March 15 to May 15 in spring, and October 7 to December 7 in autumn.

St. John's, Que., Niagara Falls, Ont., and Windsor, Ont.—From March 15 to May 15 in spring, and from September 26 to December 7 in autumn.

Vancouver, B.C.—From October 1 to May 1 of the following year.

Note specially, that,—(k) 'All shipments made in accordance with the above will be entirely at the risk of the shippers or consignees, the government assuming no risk whatever.

(l) Packages must be addressed so as to enter Canada at one of the above named ports of entry, and the route by which they will be shipped must be clearly stated on each package. The nursery stock will, however, be fumigated when transported via other ports to a fumigating station.

(m) Nursery stock imported by railway or vessel may be fumigated in bond while in transit, and after fumigation may be forwarded under customs manifests to a customs port of destination—the customs officer in such case to mark plainly on the manifests the word 'fumigated.'

(n) Collectors of customs at ports of fumigation are requested to co-operate with the railways and officials of the Agricultural Department in securing speedy fumigation of nursery stock in transit, and also to use their best endeavours to expedite the transit of such nursery stock.

6. By orders in council of March 23, 1901, and May 31, 1901, Dakota cottonwood, or 'Necklace poplar' (*Populus monilifera*, Ait.), may be admitted at the custom ports of Brandon and Winnipeg, Man., without fumigation.

IMPORTATIONS BY MAIL.

7. Nursery stock imported through the mails (by postal package or otherwise) is subject to the provisions of the San José Scale Act, and during the period allowed for fumigation customs officers are to send such nursery stock, after customs duty has been paid thereon, to the collector of customs at the nearest fumigation station, marked 'In bond for fumigation,' with post card advising that the parcel be fumigated and then returned by mail direct to the importer (giving his address) marked 'Duty paid.'

8. *Seizures.*—Customs officers are requested to strictly enforce the provisions of the law prohibiting the importation of nursery stock, and to seize all trees, shrubs, plants, vines, grafts, cuttings or buds, commonly called nursery stock, when imported from the countries above mentioned, in contravention of the aforesaid Act.

(Sgd.) JOHN McDUGALD,

Commissioner.

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Dipping of Nursery Stock.—The only safe remedy yet discovered, for the treatment of nursery stock for the destruction of San José Scale when nursery stock is being shipped from place to place, is fumigation with hydrocyanic acid gas. Many experiments have been tried with various washes for dipping nursery stock to obviate the expense and inconvenience of this operation but none of these have proved satisfactory, nor as good, all things considered, as the method of fumigation which has been adopted by this department. Experiments, however, are being constantly tried and if anything better is discovered it will be at once adopted. Nurserymen and fruit growers now know that no injury whatever is caused by the fumigation and it is now seldom advanced by shippers as was the case a few years ago as an excuse for bad packing and poor stock.

The San José Scale Act has now been in force for ten years having been passed on the 18th March, 1898. Since the fumigating houses were established in 1900 constant examination has been made of nursery stock which passed through the fumigating houses and on no occasion has a living scale been detected upon trees which have been treated by our superintendents. Many thousands of fruit trees and ornamental shrubs worth large sums of money have been imported by nurserymen and others in all parts of Canada, and although the scale can be killed with certainty, by fumigation in the way it is done in the federal fumigating houses, no injury whatever has been done to the stock by the treatment which it has received to free it from any possible presence of living scales.

In view of the above it may be justly claimed that the Honourable the Minister of Agriculture has taken every wise step to protect the fruit growers of Canada against a further introduction of this most serious enemy, and at the same time has done everything which was reasonably possible to protect the interests of nurserymen and others who wished to import stock from outside the Dominion. The methods adopted for the fumigation of stock are those which are most highly approved by experts and have been found perfectly effective in destroying any scales which occurred on nursery stock which was treated. The governments of Ontario and British Columbia have also adopted drastic measures to prevent the spread of the San José Scale from known points of infestation to new localities. At the present time after eleven years from its first appearance it may be said that the only place in Ontario where the scale now exists is the comparatively small area running from Essex county along the north of Lake Erie and extending to the county of Wentworth, west of Lake Ontario. In British Columbia the scale has been detected at two places, Kaslo and Spence's Bridge, but at the former of these the trees were carefully sprayed and since that time no further infestation has been detected. At Spence's Bridge the whole orchard was cut down. The San José Scale has never been found in the maritime provinces, the prairie provinces, the province of Quebec, nor in any other part of Ontario than that mentioned. As this insect seems to be able to thrive in all districts where the peach can be grown commercially it is most advisable that fruit growers in such districts should be on the alert to detect any strange scale insects upon their trees and have them examined by experts as soon as possible. Prompt attention at the beginning of an outbreak will frequently save great destruction of trees and crops and the expenditure of much money.

THE ROSE CHAFER, *Macrodactylus subspinosus*, Fab.—Injuries to grapes, peaches and apples by the Rose Chafer are of yearly occurrence in the Niagara districts of Ontario, but during 1907 their depredations were so serious that in many vineyards the whole crop was destroyed and the large wine-making firm of Bright & Shirriff, who buy between two and three hundred tons of grapes in the immediate neighbourhood of their establishment at Niagara Falls South, could not last year buy locally nearly all the grapes they required and had to import them from other districts. Mr T. R. Stokes, secretary of the Board of Trade of Stamford township, and of Niagara Falls South, in writing on this subject, says:—

'Last year the Rose Bug destroyed grapes to the extent of \$60,000 in Stamford alone, immense graperies of ten and fifteen acres not producing more than a ton or a ton and a half. More than this they ruined shrubs and flowers in the historic cemetery at Lundy's Lane and the flowers in the beautiful Fairview cemetery have been much injured. They destroy the petals, pistils and stamens of the flowers of the grape. They make their appearance at the same time as the first grape blossoms. They also riddle the leaves of strawberries, raspberries and many other plants. The beetles only last for about a month, but they do an immense amount of harm. They appear suddenly simply in billions, destroying all flowering plants. In 1907 they appeared a week before grapes bloomed. They ate off the cap of the bloom and tore open the blossom and ate out the centre. They also ate the leaves to a certain extent, but the great injury is to the flowers. These Rose Bugs also tear up and destroy entirely the flowers of any scented roses they can get at. They do not touch the unscented varieties such as the Prairie King and the Crimson Rambler. They destroy a large percentage of the raspberry crop by destroying the blooms. This is a very serious matter and I trust that you will be able to come and map out some line of action for fighting this pest.'

There is no doubt that the Rose Chafer is a very serious enemy of the fruit grower wherever it occurs, and sometimes, as last year in the Niagara Falls district, it does an enormous amount of harm by attacking the flowers and young fruits of grapes, peaches and apples. Unfortunately very little can be done to control it. It is known that it breeds in sandy land, and where this can be ploughed up either just before the insects emerge early in June or late in autumn, a certain amount of good can be done, but all efforts with a view to poisoning the beetles on the flowers have failed. Prof. F. M. Webster in 1899 reported to the Association of Economic Entomologists (Proc. 11th Annual Meeting, Bull. No. 20, U.S. Div. of Ent.), the first successful experiment in killing the beetles in a wholesale manner. He says, page 20: 'At last we have found out how to kill the Rose Chafer. In view of the fact that the digestive apparatus of this pest seems to be proof against the poisonous or caustic effects of most drugs, this seems an achievement. One-half pound of fish oil soap dissolved in a gallon of water and sprayed upon them will kill 95 per cent of the adults, the females being especially susceptible, if the suds is sprayed directly upon them. Drenching their food plant does not seem to affect them in the least, even if one pound of soap is used to each gallon of water, so the question of protecting vineyards is yet unsolved. Rhubarb has been found to be a valuable bait plant, the bloom which appears about the time of that of the grape being especially attractive to the beetles, and while clustered on the blossoms they can be collected or sprayed with the fish oil soap mixture and killed. The stronger mixture mentioned above did not appear to affect the peach, while the weaker injures the leaves and young fruit of the grape to some extent.'

The old fashioned remedy of hand picking is of course of service, but is slow and expensive even when as at Niagara Falls South there is an abundant supply of cheap labour. The children and women of the village are utilized in picking the beetles from the blossoms of grapes, but it is very easy for them to do much harm at that time by rough handling. The beetles may also be jarred on to sheets or frames saturated with kerosene, but these methods are tedious and must be practiced daily in the early morning or in the evening. Useful mechanical appliances on the plan of a funnel or inverted umbrella with a bag or can containing kerosene at the bottom for collecting the beetles when jarred from the plants are referred to by Dr. F. H. Chittenden in a circular on this insect (No. 11, 2nd series, U.S. Div. of Ent.).

In view of the success obtained by Prof. Webster in spraying with whale oil soap, experiments should be tried as to the strength which may be used without injury to the grape blossoms. The numbers of the beetles which have appeared for the last two or three years in the vicinity of Niagara Falls South are simply incredible. The occurrences were fortunately very local, some vineyards having every blossom stripped,

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while in others hardly any bunches of fruit had been injured. Mr. Stokes attributes this freedom from injury to the time at which the blossoms opened. If the fruit is set before the beetles appear they do not seem to be specially attracted. It is while the flowers are open and the perfume is given forth that they are attracted and do so much harm. Clover when in bloom is also a favourite food plant for the Rose Chafer. Mr. Geo. Green, of Niagara Falls South, showed me a field of clover close to his vineyard which was simply a seething mass of beetles, which were swarming over the blossoms in hundreds of thousands. Mr. Green attributed a fairly good crop of fruit in his vineyard to the greater attraction which the clover had been for the beetles at the time the grapes were in bloom.

The Rose Chafer is a dull, yellowish grey beetle about one-third of an inch long, tapering a little towards each end. Its long sprawling legs are reddish with the feet black and tipped with strong claws with which it hangs tightly to the flowers it is destroying. The eggs are laid beneath the surface of the ground by the females, which burrow down about two inches at the time they lay their eggs. Each female lays about thirty eggs which hatch in three weeks, and the young grubs feed on the roots of grasses and other plants within their reach. They become full grown in autumn and pass the winter in a cell deep beneath the surface. At the opening of spring the larvæ come up near the surface in the month of May and change to pupæ in small oval cells. In shape the larvæ and pupæ resemble those of the well known White Grub.

Dr. Chittenden points out the advantage of prompt action in the collecting of the beetles or destroying them with contact sprays, immediately on their first appearance, and advises that all land which might serve as a breeding place should be ploughed and harrowed in May for the destruction of the pupæ. The least amount possible of light sandy land should be left in sod.

There are many brands of whale oil soap in the market. Those which are made with potash are considered the best and most convenient to use for the destruction of insects. That used by Prof. Webster was made by W. H. Owen, of Port Clinton, Ohio, and costs about $4\frac{1}{2}$ cents a pound by the 100-pound keg.

THE BROWN-TAIL MOTH, *Euproctis chrysorrhæa*, L.—There has been considerable correspondence again during the past season with regard to the infestation of the Nova Scotian orchards by the Brown-tail Moth. The matter has been taken up energetically by Prof. Cumming, Secretary of Agriculture for Nova Scotia, who made use of the school children in the public schools in an effort to destroy all of the winter colonies of the caterpillars. A bounty of ten cents per nest was paid and these were sent in and identified by stated qualified officials and about 3,500 nests were passed as being those of the caterpillars of the Brown-tail Moth. Most of these were collected in a small isolated area near Bear River, N.S., where little work had been done the previous year. In those districts where operations were carried on last year, although a very much larger area was covered, not more than 200 nests were found. Prof. Cumming and Profs. Smith and Shaw, of the Agricultural College staff at Truro, N.S., have also been studying the matter carefully during the summer and arrangements were made for qualified men to go through the infested areas right up to the end of the season. Prof. Shaw thinks that the orchards of King's county, one of the infested districts, are absolutely clear of the pest and he does not know of any having been found in the forests adjacent. In Digby county also only four Brown-tail Moth nests had been found up till December 6 last, by five inspectors who the previous spring had found the nests exceedingly numerous in the same county. At the end of the winter season Prof. Shaw writes:—

'There have been about 15,000 specimens of insects sent in to Principal Cumming by the school children who have been collecting the Brown-tail Moth winter nests. Of these, 3,500 were of the Brown-tail Moth and these were found chiefly at Bear River and Smith's Cove, Digby county.'

The above reports are very satisfactory and the fruit growers of Nova Scotia are to be congratulated on the energy which has been shown by the above officials who have recognized the importance of this infestation and have acted promptly and energetically. It must be remembered, however, that the insect had become widely spread through the orchards of the province, that many of these are thickly planted and closely surrounded by forests or strips of wild native trees, and that this is a very difficult insect to control. It is almost too much to hope that the Brown-tail Moth can have been exterminated even by the energetic efforts which have been directed against it and every fruit grower in the provinces of Nova Scotia and New Brunswick should promptly send either to Prof. Cumming at Truro, or to this Division, specimens of any strange caterpillars they may find on their trees and particularly when these are occurring in large numbers during the summer, or gathered together in nests composed of leaves spun together with silk during the winter months. The only kind of caterpillar which is likely to be found in colonies inside such nests, is that of the Brown-tail Moth. These pass the winter as small caterpillars, only one-quarter of an inch in length and there are from 200 to 300 inside each nest. The caterpillars themselves are black, but are covered with rusty hairs but they can be at once recognized by two conspicuous orange cushion-like tubercles on the top of the 10th and 11th segments towards the end of the body.

Remedies.—The remedies for this dangerous enemy are the collection of the winter nests of the caterpillars and the systematic spraying of all orchards during the summer. For this purpose the poisoned Bordeaux mixture is the best remedy and will control at the same time the Brown-tail Moth and all other leaf eating caterpillars, and will reduce better than any other known remedy, the fungous disease known as the Black Spot of the Apple and Pear, which frequently does great injury to the important apple crop of the Maritime Provinces. As the Cankerworm is a frequent and destructive pest in Nova Scotian orchards, one spraying should always be done within two or three days after the apple blossoms fall. At that time the Cankerworm can be more easily destroyed than at any other time, but if it is left unmolested until half grown it is extremely resistant to the effects of arsenical poisoning. As poisons for the above purpose, arsenate of lead and Paris green are probably the best. Of the arsenate of lead there are several brands in the market and the material can also be made at home, but for convenience and effectiveness probably the manufactured article is the most satisfactory, because it is not only put up in very convenient packages but the chemicals with which arsenate of lead is made, are sometimes variable in quality, whereas in the large factories these materials are tested carefully to see if they are up to standard. When using Paris green in Bordeaux mixture, one pound may be used in 100 gallons of the Bordeaux mixture. This is stronger than is actually required, but the lime in Bordeaux mixture will neutralize the caustic effects of the arsenate and the Brown-tail Moth is a very serious pest which must be dealt with, with drastic measures, and the same may be said of the Cankerworm. Arsenate of lead should be used at the rate of three pounds of the paste to a 40-gallon cask of Bordeaux mixture. It may be well to warn fruit growers against using arsenites in what is known as the soda-Bordeaux mixture, more properly called Burgundy mixture. The true Bordeaux mixture is made with lime and for all ordinary purposes on fruit trees the amount recommended is 4 lbs. of bluestone, 4 lbs. of unslacked lime, 4 ounces of Paris green and 40 gallons of water, but for certain pests more Paris green is advisable and by increasing the amount of lime a little it becomes a safe application for orchard trees while the leaves are young and vigorous, but the arsenites should always be applied in the real Bordeaux mixture made with lime and not with the soda-Bordeaux.

In the report of the Chemist of the Experimental Farms for 1905, at page 149, will be found an article on the Chemistry of Insecticides and Fungicides. In the conclusions of Mr. Shutt's experiments the matter is summed up as follows: 'Burgundy mixture pure and simple has shown itself as far as our experiments have gone, to be

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non-injurious to foliage. The addition of Paris green or other arsenite, however, renders the spray corrosive and therefore dangerous for orchard use. When it is desired to use Paris green as an insecticide in the spray, only Bordeaux mixture made with lime should be employed.

Cankerworms.—Reports of rather serious nature came to hand with regard to the injuries of cankerworms in the apple orchards of the Annapolis Valley of Nova Scotia. These caterpillars are very slender and inconspicuous at first and are frequently overlooked until they have attained considerable growth. They are then much more difficult to kill with the ordinary insecticides used in orchards and it becomes necessary to use more poison to the barrel than for most other insects. It is recommended to use as much as one pound of Paris green in 100 gallons of Bordeaux mixture and this latter should be made with five pounds of lime to the four pounds of copper sulphate in the 40 gallons of water. If applied while the caterpillars are young the cankerworm can be controlled the same as every other leaf-eating insect. The other remedy for cankerworms is the destruction of the wingless female moths when they leave their chrysalids in the autumn and climb up the trees to lay their eggs. There are two materials which are largely used for this purpose. These are printers' ink thinned with fish oil, one gallon of the latter to five of the former, which quantity will treat about an acre of orchard, and the other is a mixture of castor oil and resin. Mr. O. T. Springer, of Burlington, Ontario, gives the following receipt:—

For cold weather; castor oil 2 pounds, common resin 3 pounds; for warm weather add another pound of resin. This mixture must be heated slowly until all the resin is melted, and then should be painted directly on to the bark of the trees while still warm.

Mr. Geo. E. Fisher, of Freeman, Ont., after many experiments uses the same materials but prepares them rather differently. He writes: 'For use against cankerworms, I use for warm weather, 3 pounds of castor oil and 5 pounds of resin, and in cold weather equal parts of both by weight. A little experience is necessary to decide just what proportions of the materials will suit the prevailing weather conditions, but they will vary between the weights I have given. The rough bark of the tree should be scraped off at a convenient height before applying the mixture. The first application will not remain sticky very long, being apparently absorbed by the bark, and a second may be necessary in about a week. This will keep fresh for a good while, and certainly is an excellent trap for cankerworms either in the moth or caterpillar stage.' When applying these mixtures they are painted directly on to the bark of the tree with a large paint brush so as to form a band right around the trunk about three inches wide. The castor oil used is a commercial article, unpurified, which will cost in most places about 8 or 10 cents a pound. Mr. Springer says that the work of banding in the above mentioned way is not so great as might be supposed. One man can go over 250 trees in ten hours if the mixture is ready for use. Should the mixture get too cold to spread readily it may be easily and quickly brought to the proper temperature by using a portable oil stove. It is best to put on the first coat plentifully so as to leave a good body of material on the tree. In the Burlington district, which is near Hamilton, Ont., the female moth seldom leaves the ground before the last week in October and never before the first frosts of autumn. If watched for and the bands are painted on to the trees when the females first appear, thousands are caught by the band, including many of the males, which also are destroyed, their delicate wings adhering to the sticky material on the slightest touch. The females, unable to cross the sticky bands, lay their eggs in large numbers on the trunks of the trees between the ground and the band. These must be scraped off and destroyed during the winter or the caterpillars will climb up into the foliage when they hatch in the following spring, for by that time the bands will have dried on the surface or will have become rough by rubbish or dust adhering to them.

The Rusty Tussock Moth, *Notolophus antiqua*, L.—The work which has been done in Nova Scotia in collecting the larvæ of the Brown-tail Moth has shown that

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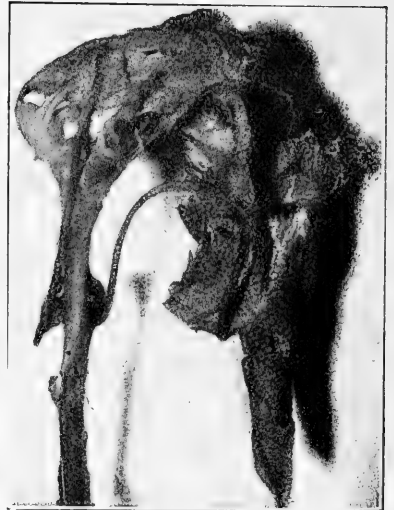
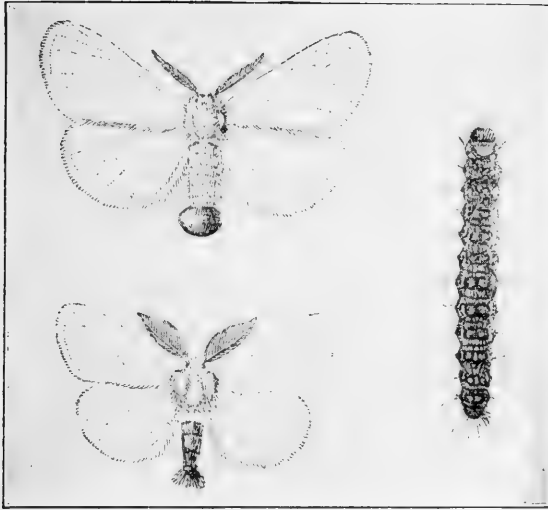
considerable injury is done every year to apple and other fruit trees by the Rusty Tussock Moth, not only in eating the leaves of the trees but by gnawing cavities in the sides of the growing apples. Both the Rusty Tussock Moth and the White-marked Tussock Moth occur in Nova Scotia, and the work of both is very similar, but the latter is the more serious pest of the two because it generally occurs in large colonies and not in the scattered way that the former does. The two insects are quite different and easily recognized in all their stages. The caterpillar of the Rusty Tussock Moth is a much less showy insect than its near relative. The general appearance of the body is gray with four short thick tufts of whitish hairs on segments 5, 6, 7 and 8 with red spots along the sides and a yellow line beneath the spiracles. The most conspicuous difference is that the head is black instead of coral red as in the caterpillar of the White-marked Tussock Moth and there is an extra pair of long tufts of barbed bristles on each side of the 6th segment (counting the head as the 1st), which are entirely lacking in the allied species. The yellow stripes down the back so conspicuous in the White-marked Tussock Moth caterpillar are almost obliterated in that of the Rusty Tussock Moth. The food habits of the Rusty Tussock Moth are very much less restricted than those of the White-marked species, which is almost confined to the foliage of trees, while the caterpillars of the Rusty Tussock Moth may be found upon almost any kind of tree, shrub or herbaceous plant. They seem to be particularly partial to the foliage of geraniums and some other garden flowers. The moths are also different. In the Rusty Tussock Moth the male is of a rust-brown colour, the front wings crossed by two wavy streaks and there is a conspicuous white crescent near the hind angle of each. The wings expand a little over an inch. The female is gray and practically wingless, in this respect resembling the female of the White-marked Tussock Moth. The male of the White-marked Tussock Moth is gray and the wings are crossed by wavy bands. The base of the front wings bears a dark patch and there is another of smaller size towards the tip. There is also a small white spot near the outer hind angle of the front wings. In both species the wingless females emerging from their cocoons remain there at rest for their whole moth existence. The males seek them out and after pairing, the eggs are laid on or close to the cocoon. Those of the Rusty Tussock Moth are bare and easily distinguishable but in the White-marked Tussock Moth they are covered with a frothy white deposit so that their shape cannot be seen without breaking up the egg mass.

Both of these insects are sometimes the cause of considerable injury and neither should be allowed to increase with impunity. In many of our Canadian cities the beautiful shade trees are year after year rendered unsightly by these caterpillars and little is done to check them except an occasional spasmodic effort when they have become so bad that the municipal authorities are compelled to do something.

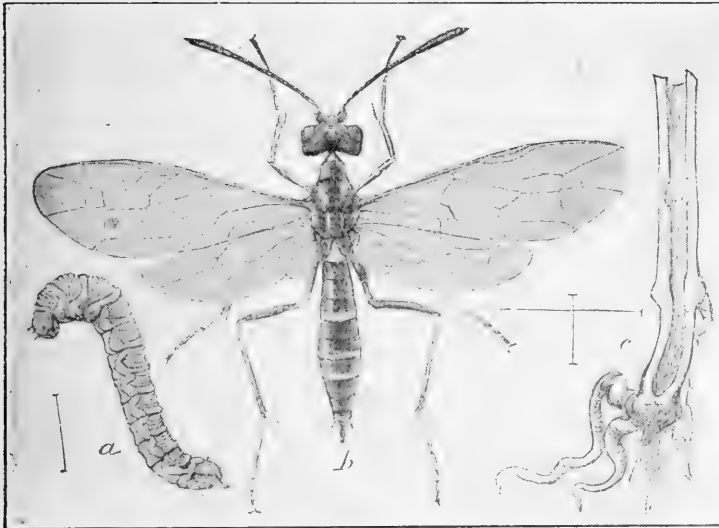
The remedies are the spraying of the trees as soon as possible after the young caterpillars have made their appearance, and the collection of the egg-masses during the winter.

THE HICKORY TUSSOCK MOTH, *Halisdota caryæ*, Harr.—Throughout the whole of eastern Canada considerable damage was done to forest trees of several kinds, such as hickory, elm, birch, ash and basswood by the black and white hairy caterpillars of the Hickory Tussock Moth. These caterpillars occurred in unusual abundance in 1907. When young the caterpillars are very gregarious and frequently strip whole branches of a tree. They have a habit of collecting together in dense clusters beneath the leaves at night, but when feeding spreading out all over the tree making silken paths as they travel along the branches. This caterpillar is particularly objectionable as an orchard and shade tree pest because when falling on the bare skin the barbed hairs produce a painful and persistent irritation.

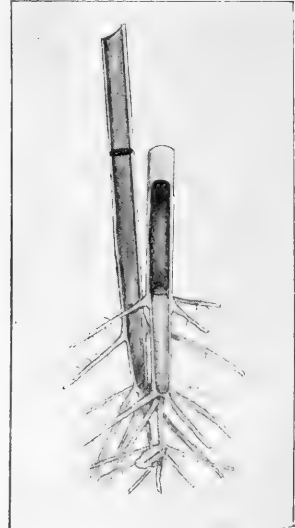
The caterpillar of the Hickory Tussock Moth when full grown is described as follows by Mr. Arthur Gibson in an article written for the report of the Entomological Society of Ontario for 1907, at page 84. 'The body is clothed with dense tufts of white hairs with a ridge of black hairs down the centre of the back, and two pairs of



Female and male moths ; full-grown caterpillar. Winter nest. (After Kirkland.)
 (Figures from Howard, U. S. Dept. of Agr. Farmers Bull. 204).
 THE BROWN-TAIL MOTH ; *Euproctis chrysorrhæa*, L.



Western Wheat-stem Sawfly. (*Cephus occidentalis*, Riley & Marlatt.)
 (Riley & Marlatt, *Insect Life*, IV, Div. Ent. U. S. Dept. Agr.)
 6127—p. 208.



Larva and work of the Western
 Wheat stem Saw-fly.
 (Drawn by Norman Criddle.)



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long black pencils on the 1st and 7th abdominal segments. When full-grown this caterpillar is one inch and a half in length.

Occurring with the above and almost as abundant was the rather handsomer caterpillar of the Spotted *Halisidota*, *Halisidota maculata*, Harr., which is covered with tufts of bright yellow and black hairs, the black tufts being on the four anterior and the three posterior segments, the yellow tufts on the central segments of the body. These latter are centered down the middle of the back with a row of black tufts. This larva is rather shorter than that of the Hickory Tussock Moth and although a general feeder like the other seems to prefer willows and poplars to other food.

Large numbers of these caterpillars were sent in by correspondents who had been attracted by their appearance or who had suffered from the irritation of their bristles. In the autumn and early spring large numbers of the close oval cocoons beset with the bristles of the caterpillars were found beneath stones in woods and in other shelters near where the caterpillars had fed. Many of these were found to be parasitized by *Pimpla pedalis*, Cress.

As a rule neither of these insects develop into pests of importance, but upon occasion, as during 1907, their attacks upon shade trees are serious.

A sufficient remedy is spraying the trees when the caterpillars are noticed with Paris green or any other of the arsenical poisons. Both of these species are late summer and autumn insects and neither of them has so far proved a serious orchard pest.

THE APIARY.

The Apiary is under the management of Mr. D. D. Gray, the farm foreman, whose report I append herewith. The practical work of handling and caring for the bees has been done by Mr. C. A. Burnside. There was a considerable amount of disease in the colonies in the beginning of the year, but by the end of the season this had disappeared and such colonies as we had were in good condition. The inclement weather of early spring rendered the services of bees in fertilizing fruit conspicuously apparent. In orchards situated near apiaries there was a considerable increase in the fruit over those not so advantageously located. It having been decided to reduce the number of colonies in the apiary, some of those which were strong and healthy were sold and the number on our own stands was reduced to 32.

REPORT OF MR. D. D. GRAY.

SEASON OF 1907.

The spring of 1907 was very cold and backward.

The bees were placed on their summer stands on April 20, nearly all very badly affected with dysentery and very weak, in fact a number dwindled and died, although they had had plenty of stores through the winter.

The weather continued cold and windy well on into May and the first notice of pollen being gathered to any extent was on May 10. Some feeding was done to encourage brood-rearing and by June 15 quite a number were strong enough to have supers put on and by the first week in July all were ready for work. The first swarm came off on July 10 and we had six of an increase from the 32 colonies put out on the stands. There were a few colonies, however, which escaped with very little of the disease and these did well, one colony making 215 lbs. of honey.

The bees were put into their winter quarters on November 13 weighing an average of about 50 lbs. each.

All the colonies were raised from the bottom boards and blocked up 1 inch all around between brood chamber and bottom board to allow for better ventilation. The wooden covers were also removed and replaced by bran sacks, 2 or 3 being put on each colony.

The bees were examined from time to time and kept as nearly as possible at a temperature of 45° to 50°, and at time of writing, April 1, are seemingly in good condition and quiet, keeping well clustered up in the combs.

D. D. GRAY.

INSTRUCTIONS FOR SENDING INSECTS THROUGH THE MAIL.

A constant source of inconvenience and loss of time to the officials of the Division is the manner in which insects and plants are sent in for identification. It is most advisable that inquiries should always be accompanied by specimens and that these should be packed in such a way that they may come safely by mail without the parcels being crushed and destroyed, or in the case of living insects so that these should not escape. Experience has proved that it is a very difficult thing for those who do not make a study of natural history to write descriptions of either insects or plants so that they can be recognized without specimens. There is also a tendency everywhere to give new and local names to any enemy which has forced itself upon the notice of farmers, fruit growers and others, by its sudden appearance in unusual numbers or by its injuries to crops. These local names are as a rule not in the least descriptive of the pest and only in the very rarest instances are they in any way applicable to any striking characteristic of the insect or plant to which they are given. They are generally quite unintelligible to others and are a source of dire distress, annoyance and waste of time to the specialist who is referred to for information, unless specimens accompany the inquiry. It may certainly be accepted as a general principle that any insect or weed which occurs in sufficient numbers to be troublesome is not of a new kind which requires re-naming. There are now several sources of reference in Canada, where every one who wishes to do so can find out with very little trouble the nature and habits of any unwelcome visitor which may appear in farm or garden. All that is necessary is to send a specimen to one of the many government institutions or agricultural papers with a few lines descriptive of the occurrence and a statement of what information is desired. When such inquiries are made the following rules may be followed and are merely mentioned here, surprising as it may seem, because they are so frequently neglected by correspondents of this Division.

1. Sign the letter of inquiry and give post office address in full, stating province and post office to which a reply should be sent.

2. Send specimens representative of the species. In the case of plants, if possible, send flower, leaf and root. As everything comes free by mail to the Experimental Farm, Ottawa, and the postmasters in all parts of Canada have printed instructions to this effect (Canada official Postal Guide, 1908, p. xxiv), there is no advantage to any one, and a great disadvantage when accurate information is desired, in sending small chips instead of proper specimens.

3. In all cases write the name of sender with his address on the packet.

4. Do not inclose letters inside packets of specimens but send them separately.

5. Do not send specimens without a letter or note saying what information is desired.

6. Do not send fragile specimens in paper boxes. The post office officials have sometimes to handle several tons' weight of mail, and fragile packets are easily broken under such circumstances.

7. Do not send specimens in glass bottles or in liquid unless carefully protected.

8. When sending specimens or writing for information let the letter and the specimens if possible go by the same mail.

9. Living specimens of insects or plants should always if possible be sent in tin boxes. Insects should always be accompanied by some of the food plant for them to feed upon during the journey. Tin boxes prevent the evaporation of moisture and

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keep the food plants fresh. For this reason as well as for the greatest safety of the specimens they are very much preferable to cardboard boxes.

10. When sending specimens do not punch holes through the box for the insects to breathe through. These are quite unnecessary and as a general thing cause the death of the specimens.

It will be easily understood how very inconvenient it is in an office with a limited staff, but with a very large daily correspondence, when, as frequently happens, four or five packets of insects or plants arrive by the same mail without any name on them of the sender and without any letter stating what information is desired. Parcels when sent through the post offices are very seldom postmarked and all that can be done is to hold them over for some days and then compare the writing of the address with letters which have been received during the past week. This means, frequently, in the case of specimens of important pests which we want to know about or concerning which an immediate reply should be given, looking through about one hundred letters. The inconvenience of caring for these parcels is also considerable. Living specimens have to be unpacked and fed and provisional numbers and labels put on each, so that they may be recognized in case letters turn up afterwards. Notwithstanding every care to keep these parcels straightened out there are every year many which come to hand which can never be acknowledged, either because the parcels have nothing on them by which we can associate them with letters or because the letters are not signed.

In addition to specimens which are sent in by farmers, fruit-growers and gardeners, many insects and plants are sent in for identification by those who are studying natural history in a more or less scientific manner. An excellent sign for getting better results in farming, is that, many of the younger farmers and fruit-growers in the country are now making reference collections of injurious insects and weeds, so that they may become more familiar with these enemies from which they every year suffer so much. These collections are continually being received for identification and classification by the officers of the Division of Entomology and Botany. Similar collections are sent in by teachers and other students.

The study of entomology in Canada is now receiving a good deal more attention than heretofore. Each season sees new collectors in the field and much of the material collected is sent to Ottawa for identification. Unfortunately, however, many of these specimens received here are more or less injured from lack of knowledge as to the proper way to pack, or of care in doing up the parcels. It is a constant matter of surprise to see how few of even experienced entomologists, know how to pack specimens for sending by mail. A frequent disappointment experienced at the Division is to find on opening a box, valuable specimens which have been entirely ruined through the neglect of some small or commonsense precaution in sending the specimens. Mail matter received at large centres must of necessity be handled quickly and a moment's thought will convince any one that a box containing specimens of fragile pinned insects, wrapped only in the paper on which the address is written, has very little chance of reaching its destination with the contents intact. Many such consignments come to us with nearly every specimen broken.

There are several good ways of packing boxes of pinned specimens. The box containing the insects firmly pinned, the pins being forced into the cork at the bottom with a pair of forceps, can be wrapped lightly with cotton batting, or some other light elastic material, and the whole placed inside a larger box of wood or strong cardboard. The inside box should be wrapped neatly in thin paper and tied up to keep out dust. The elastic packing between the two boxes will protect the specimens from being broken by the jarring in the mails. Another excellent way which may be used when it is not convenient to obtain an outside box of the right size, and indeed is the method most in use by entomologists, is to simply surround the box of specimens after wrapping it in paper, with a good supply of cotton batting, hay, straw, excelsior or

other light material of an elastic nature, and then wrap this in good strong paper. The address of the person to whom the specimens are sent should always be written on a separate label which should be tied to the parcel so that this may receive the postmark instead of the parcel, should the postmaster stamp it while passing through the mail. It may be remembered that it is always better to put too much packing than too little and when the box containing the specimens is protected by an outside box there should be plenty of space between the two. An ordinary shallow cigar box corked at the bottom answers very well to pin insects in. Cork is by far the best material to use for this purpose but corrugated paper, pith, sheets of peat, or any other soft penetrable material may be used if of sufficient depth to support the pin securely.

Packages packed as above will come safely through the mails and may, as in the case of letters, be sent to the Division of Entomology at the Central Experimental Farm, free of all postage. If for any reason it is desirable to send specimens by express, this can be done by placing the box of insects in an ordinary fruit basket, surrounding it well with light packing, such as is mentioned above, and covering the top with ordinary wrapping paper. When sent by express, charges on the parcel must be prepaid by the sender.

A convenient way of sending specimens for identification, particularly when these are winged insects, such as butterflies and moths, is to put each specimen in a small envelope as soon as it is killed, with the wings folded backwards over the back. This should be done before they become too dry and brittle, or the legs and antennæ will be broken, which very much reduces their value as scientific specimens.

The killing bottle used for insects is easily made. Having procured a wide-mouthed bottle, place in the bottom of it two or three small pieces of cyanide of potassium, each of about the size of a hazel nut, and then mix some fresh plaster of Paris into a thick paste and pour enough of it into the bottle to entirely cover up the poison. The plaster will set in about half an hour and the bottle is then ready for use. This bottle will last for a year or two if kept closely corked. The fumes given off will pass through the plaster and will kill any insect put in the bottle in a few minutes. When insects are packed in the envelopes these should at once have written on them the date and exact locality of capture, as well as the name or initials of the collector. They should then be packed away in a firm box and should not be moved again until such time as they are to be relaxed for examination or mounting for the cabinet. To relax specimens all that is necessary is to soak a cloth in water and then after wringing out the superfluous water by twisting it tightly, place the envelopes between the folds without opening them and leave them there for 12 to 24 hours according to the size of the insect. They will then be soft enough to be set on the setting boards. When set they should be left on the boards for at least a week, so as to become thoroughly dry or the wings will not remain even, after they are put in the cabinet. This 'springing back' of the wings spoils the appearance of the specimens in the collection. The envelopes used by entomologists are not gummed but are made as required. A convenient size can be made by taking oblongs of any moderately stiff paper, 4 inches long by 3 wide, and folding them diagonally down the middle so that the portion folded down reaches to within half an inch of the end of the opposite side, the half-inch flap is then folded down over the central triangular double folded portion and the envelope is turned over and the flap on the other side is treated in a similar way. This gives a triangular envelope which can be opened by taking the flaps on each side with the finger and thumb of each hand, and the specimen can be examined without danger of breaking it. This cannot be done easily with an envelope made in the usual way. The envelopes can of course be made of any size to fit the specimens to be saved.

When plants are sent as botanical specimens to be named, they should first be dried in the usual manner between sheets of absorbent paper and each specimen should be placed on a separate piece of newspaper, cut to a convenient size for mailing. With each specimen or written on the sheet of packing paper, should be a note of the date

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and locality where it was collected. Unmounted specimens are preferable for examination to those mounted or fastened down to sheets of mounting paper. Botanical specimens should never be fastened down in bound books and there should never be more than one kind of plant on each sheet. A bundle of dried plants can be sent safely by mail if protected on the outside with sheets of cardboard.

When plants are sent in as weeds or merely to get the names of a few specimens, all that is necessary is to roll up each one separately in a piece of paper and number the specimens in accordance with notes on each given in the accompanying letter of inquiry. If it is desired to have the specimens returned this should always be stated and as with specimens of insects every packet of plants should have the name of the sender written plainly on the outside and be accompanied by a letter enclosed in a separate envelope.

Under the above conditions it is always a great pleasure to examine and report upon any specimens which may be sent in, and all will be attended to and the report sent back as promptly as other work in the Division will allow of, but when several plants are tied up in a bundle or crowded into an envelope, as is sometimes done by our correspondents, frequently in a moist condition, much time is wasted in doing here what the enquirers ought to have done before sending in the specimens. Moreover when they get their plants back again they are of far less value to them for purposes of identification than if they had dried them and packed them with a little care at first.

When correspondents wish it, we are always pleased to return the specimens sent in for naming; but when they have duplicates in good condition we are glad to get them either for our own collections in the Division or for other correspondents who frequently ask for specimens of special plants or insects. Very many species of natural history objects although very common in certain localities, do not occur at all or are quite rare at other places.

THE UNIVERSITY OF CHICAGO

PHYSICS DEPARTMENT

PHYS 441

LECTURE 10

STATISTICAL MECHANICS

The first law of thermodynamics states that the change in internal energy of a system is equal to the heat added to the system minus the work done by the system. This is a statement of energy conservation. In statistical mechanics, the internal energy is related to the average energy of the particles in the system. The heat added to the system is related to the change in entropy, and the work done by the system is related to the change in volume.

The second law of thermodynamics states that the entropy of an isolated system never decreases. This is a statement of the irreversibility of natural processes. In statistical mechanics, entropy is related to the number of microstates of the system. The second law can be derived from the fact that the number of microstates of a system increases as the system evolves over time.

The third law of thermodynamics states that the entropy of a perfect crystal is zero at absolute zero. This is a statement of the fact that a perfect crystal has only one microstate at absolute zero. In statistical mechanics, the third law can be derived from the fact that the number of microstates of a perfect crystal goes to one as the temperature goes to zero.

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PHYSICS DEPARTMENT

PHYS 441

LECTURE 10

STATISTICAL MECHANICS





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