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DIRECTIONS FOR COLLECTING AND PRESERVING SPECIMENS

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DIRECTIONS FOR COLLECTING BIRDS.

BY

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Curator of the Department of Birds.

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DIRECTIONS FOR COLLECTING BIRDS.

By Robert Ridgway,
Curator of the Department of Birds, U. S. National Museum.

§ 1. GENERAL REMARKS.

The general principle to be observed in making collections of natural history, especially in a country but little explored, is to gather all the species which may present themselves, subject to the convenience of the collector or practicability of transportation. The number of specimens of each species to be secured should, of course, include all the varieties of form or condition caused by the different features of age, sex, or season, and also show, within reasonable limits the range of individual variation.

As the object of the Institution in making its collections is not merely to possess the different species, but to determine their geographical distribution and variation, their migrations, and other matters of scientific interest, it becomes important to have as full series as practicable from each locality. In commencing such collections, the commonest species should be secured first, as being most characteristic, and least likely to be found elsewhere, and even the commonest should be taken while they are to be had, since they may totally disappear when least expected. It is a fact well known in the history of museums, that the species which from their abundance would be first expected are the last to be received.

In every little known region the species which are the commonest are rarest elsewhere, and many an unscientific collector in Texas, Mexico, the Rocky Mountains, Alaska, etc., has been surprised to find what he considered the least valuable species in his collection (owing to the ease with which they had been obtained in numbers) more prized by the naturalist than the rarities, which were in fact only well-known stragglers from more accessible localities.

The first specimen procured, however imperfect, should be preserved, at least until a better can be obtained.

Where a small proportion only of the specimens collected can be transported, such species should be selected as are least likely to be procured in other localities or on other occasions.

In gathering specimens, it is very important to fix with the utmost precision the localities where found, as well as the dates of capture. It has too often happened that collectors in little known regions have neglected or ignored this very essential matter, and thus their work has practically been in vain, for specimens with imperfect data as to place and time of capture are comparatively valueless. To give an illustration: All large collections contain a great many specimens, labeled simply "Brazil," or "Mexico," or with the name of some other equally extensive country. Now, Brazil, while politically one country, is zoölogically a portion of several very distinct provinces, whose bird-life is far more distinct, one from the other, than is that of North America from that of Europe, or that of the latter from the bird-life of northern and central Asia or northern Africa! Were *all* the specimens in collections labeled accurately as to precise locality and date, the problems of geographical distribution and variation and their attendant phenomena would be far better understood than they are at the present time, and human knowledge proportionately advanced.

Where collections can not be made in any region, it will be very desirable to procure lists of all the known species, giving the names by which they are generally recognized, as well as the scientific name, when this is practicable. The common local names of specimens procured should also be carefully recorded.

All facts relating to the habits and characteristics of the various species, however trivial and commonplace they may seem, should be carefully recorded in the note book, especially those having relation to the peculiarities of the season of reproduction, etc. The accounts of hunters and others should also be collected, since much valuable information may thus be secured. The colors of the unfeathered parts when the bird is alive, or soon after being killed, should always be given, when practicable, or, still better, painted on a rough sketch of the object.

As a general rule, birds of brilliant plumage, or those which are in any way very conspicuous, are much less likely to prove interesting scientifically than those of dull or ordinary plumage. Most of the collecting which has been done in tropical countries has been for commercial purposes, there being at least 100,000 bird-skins sold to milliners to 1,000 that are sold to museums or collectors, and brightly colored birds being therefore most salable are naturally those preferred. Even the collector who has chiefly in view the scientific results of his work must be strongly tempted to give preference to the humming-birds, trogons, tanagers, and other birds of "gorgeous plume," so strongly do they appeal to his sense of the beautiful. Thus, on the one hand, the wrens, ant-birds, sparrows, and others of modest attire are purposely ignored, while on the other they are half unconsciously neglected.

The collector, therefore, if he desires to make the most of his opportunities, will reverse the usual custom, and search the woods and copses, fields and river-banks for birds which would pass unnoticed by the ordinary observer, feeling sure that many new forms will be his reward.*

§ 2. OUTFIT FOR COLLECTING.

Guns and ammunition.—For "all round" collecting the best gun is a 12-gauge, double-barreled, breech-loading shotgun of approved make,† with barrels 28 inches long, length of stock and "drop" to suit the user. One barrel should be "choked," the other "cylinder bored," and the latter should have fitted to it an auxiliary barrel for .32-caliber shells. These should be loaded with American wood powder, grade D, and No. 12 shot, and the shells may be either rim or center fire, though only one or the other can be used, it being necessary to decide before the auxiliary barrel is made which kind of cartridge is to be used with it. The writer prefers rim-fire shells, for the reason that the bother and loss of time in reloading is avoided, while they are so much cheaper that there is no pecuniary loss in the end. On the other hand, there is the disadvantage that one may get out of ammunition; but this may be avoided by taking a sufficient supply.

With this auxiliary barrel, which may be carried in the pocket or in the game basket when not in actual use, the collector is always prepared for the smallest specimens. Without it he will find great difficulty in loading his 12-gauge shells with a sufficiently light charge.

For shooting about houses, in orchards, or any places where a noise is to be avoided, as well as for other considerations, a cane gun of .22 caliber is exceedingly useful. A good substitute is an ordinary .22 caliber breech-loading pistol, with the barrel lengthened by soldering to it a piece of brass tube anywhere from 12 to 24 inches in length,‡ though if a long barrel is preferred it should be made into two sections, which screw together, in order that the gun may be carried in a pocket or put into a valise. The .22 caliber shells are, of course, rim fire. They

* By following this course, a collector on the Lower Amazon, a region supposed to be practically exhausted of ornithological novelties, a few years since, discovered 19 new species in a total of a little more than 100 collected, and 3 new genera.

† There are so many individual preferences as to the particular make of guns that any recommendation in this respect would be superfluous, except to those who have not had sufficient experience to have decided upon some particular kind. Everything considered, there is probably no better gun made than the "Parker," while the "Fox," though peculiar in its action, has some points of excellence over other kinds. This, however, is a matter which may well be left to the person most concerned, providing, however, that selection be made from some one of the reliable makes, cheap guns, which are cheap at any price, being avoided.

‡ Such an arm may be obtained, in both .22 and .32 calibers, for about $5, from J. A. Ross & Co., 29 Oliver street, Boston, Massachusetts. It is called "The Favorite Collecting Pistol."

should be loaded with American wood powder, grade E, and No. 12 shot. Black powder mixed with the wood powder will give better penetration but more noise, and fouls the gun much sooner.

In addition to shotguns, a good, well tested .32 caliber rifle will prove very useful for wary birds of large size, such as the various hawks, eagles, herons, etc. With a rifle of this caliber birds the size of a large hawk may be killed without injury as specimens, while the ball is large enough for ordinary game. Even a good .22 calibre rifle would be very useful if used with the proper ammunition.

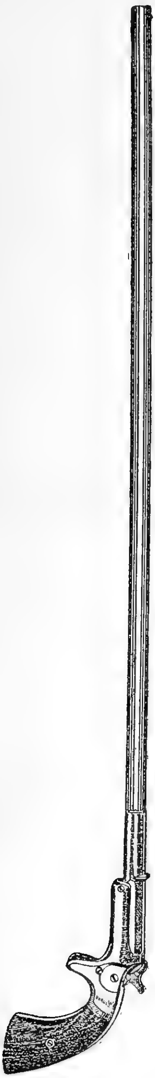

FIG. 1.—"Favorite" collecting pistol.

As to ammunition for the 12-gauge gun, paper shells which are not to be reloaded should be mainly depended on; but to guard against the possibility of being without ammunition a sufficient number of metal shells should be kept in reserve.

Regarding the use of the gun, directions are unnecessary, it being taken for granted that each person for whom these suggestions are intended has already had more or less experience, and knows enough to *always*, when in the presence of companions, consider a gun as loaded and liable to "go off" when least expected, and to *never*, under any circumstances whatever (unless harm is intended), point it towards any one, blow into the muzzle, pull it toward him muzzle foremost, or do any of the various foolish things which have been the cause of nearly all the accidents from firearms.

The kind of ammunition to be taken of course depends largely on the kind of guns in which it is to be used and the special purpose for which it is intended. Only the best of powder should be used; and in addition to a sufficient supply of good black powder, one or more cans of American wood powder (grade D for .32 caliber shells and light charges for the 12-gauge gun, and grade E for .22 caliber shells) are necessary. Plenty of good felt wads are also required. The sizes of shot needed are not easily determined; but as a general rule it is unnecessary to have more than three, or at most four sizes. For the smallest birds, No. 12 is the proper size, the finer so-called "dust" shot carrying too close and cutting the plumage too much. Perhaps the most serviceable selection would be Nos. 12, 8, and 4, or 3, for a 12-gauge gun, only the first being used with the .32 and .22 caliber pieces. Some collectors use other sizes in addition to those designated above, and possibly the substitution of No. 10 for No. 8 and No. 6 for No. 4 would work very well;* and it would perhaps be advisable to have a few extra large shot, such as No. 1 or BB, though the occasions where they are actually required would probably not be frequent. In countries where large mammals of a dangerous nature are apt to be met with, it would not be unwise for the collector to carry constantly with him two or three cartridges charged with powder and a conical ball that will pass easily through the barrel, which may be quickly substituted for a charge of shot in an emergency.† Or what will answer equally well, paper shells loaded with a full charge of shot may be cut in two (not quite severed, however) between the two wads separating the powder from the shot, which will cause the latter to carry "solid," and prove effective as a ball any distance up to seventy-five yards, or more.

Skinning tools and materials.—The fewer implements one has the better, few things being a greater hindrance to quick work than complicated apparatus. Some very skillful collectors use nothing but a pocket knife or a pair of short bladed, sharp-pointed scissors in skinning a bird; but such simplicity is hardly to be recommended to the novice, who will find the following tools essential (Figs. 2, 3, 4, 5, 6, 7, 8): (1) A sharp

FIG. 2.—Scalpel.

scalpel or dissecting knife; (2) a pair of scissors with sharp-pointed and rather short blades, either straight or curved, as may be preferred;

FIG. 3.—Scalpel.

(3) a pair of heavy cutting forceps, known as "bone-cutters," to be used for breaking the leg- and wing-bones of large birds; (4) a pair of small

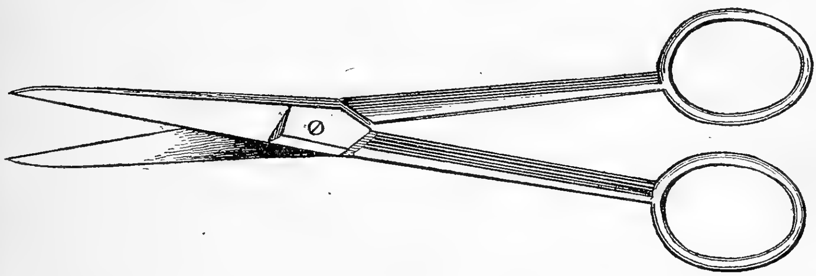

FIG. 4.—Straight-pointed scissors.

spring forceps, with rather narrow points, for adjusting the feathers, and

* If a 20-gauge gun is used, Nos. 12, 8, 6, and 4 are probably the best sizes.

† If the cylinder-bored barrel is fitted with an auxiliary barrel, as has been previously recommended, and the other barrel is choke-bored, care must be taken to select a ball that will pass easily through the "choke"; otherwise an accident may occur.

for other purposes; (5) needles and thread for sewing up incisions of the skin. All these implements, especially the scalpel and scissors, should be taken in duplicate, or even in larger numbers, to make up for possible or even probable loss, while needles may be taken in consid-

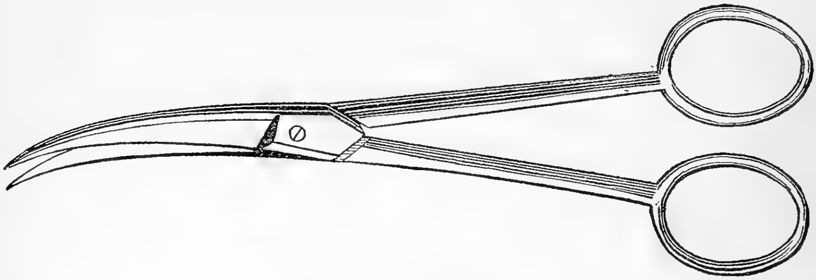

FIG. 5.—Curved scissors.

erable quantity. In addition to the articles named as being absolutely necessary, one or two large steel-handled scalpels or "cartilage knives" would be useful in skinning large birds, and a pair of long straight forceps is very handy for introducing cotton into the neck, but these may easily be dispensed with.

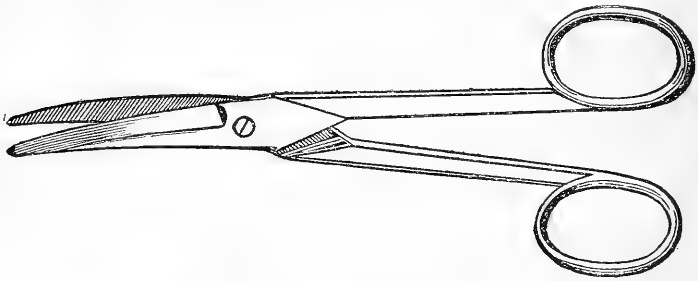

FIG. 6.—Small curved scissors with blunt point.

Many collectors and taxidermists use a hook by which to attach the carcass of a bird during the process of skinning, thus allowing the free use of both hands. If the beginner can learn to do without this appliance, however, it will in the end prove advantageous, since a complication of apparatus is one of the things much to be avoided. There can be no question, however, that at times such an appliance would be found very useful, particularly in the case of birds so large as to be difficult to handle. For making it, take a good sized fishhook (about a number 7 "Limerick" with ringed end), file off the barb, and fasten securely to a piece of stout twine 2 or 3 feet long. The other end of the twine can then be tied to a stout nail driven into a beam or post, or to a limb, and the hook stuck into the bony part of the lower back or pelvis of the carcass, immediately after the vertebral column has been severed at the base of the tail and the skin peeled from the rump for a short distance. Should the same arrangement be considered desirable for smaller birds, much smaller hooks should be used (No. 2 or 3 "Limerick"), and instead of one there should be two—one at each end of the twine, which should not be more than about a foot long. The second hook can be stuck into the top of the table on which the bird is

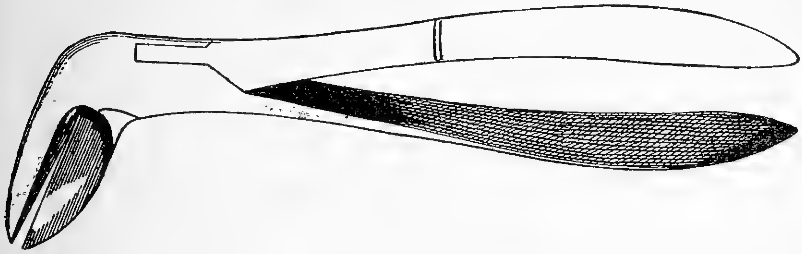

FIG. 7.—Bone-cutters.

being skinned and the line hung over the edge, the bird being skinned thus hanging conveniently in front of the operator, while its position can be changed to suit each particular stage of the operation by simply changing the position of the farther hook.

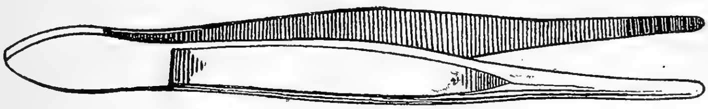

FIG. 8.—Spring forceps.

For stuffing the birds, after they have been skinned and poisoned, raw cotton or cotton batting of the best quality (long fibered) is necessary, and this should be used for all specimens of small and medium size. For larger specimens tow, oakum, or "excelsior" shavings are better and more economical, especially the last, than which, if of a fine quality, nothing can be better. In the absence of these materials any

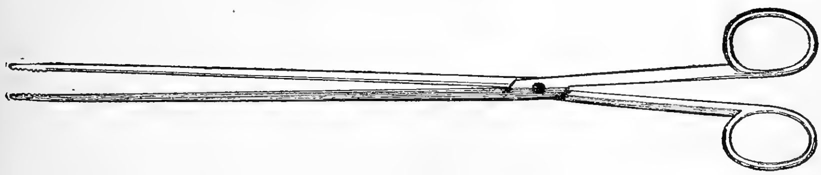

FIG. 9.—Long stuffing forceps.

dry, elastic *vegetable* substance may be used, but never any animal substance, such as hair, wool, or feathers, which would invite the attacks of insects.

Preservatives.—Altogether the best material for the preservation of skins of birds or other animals is powdered arsenious acid (common arsenic), for which there is no satisfactory substitute. It may be used either pure or mixed with finely powdered alum in the proportion of two to one. The mixture of arsenic and alum is preferable to the pure arsenic for several reasons, chief of which are that poisoning of the fingers, through cuts or abrasions of the skin, is far less likely, while the alum also greatly accelerates the drying of the specimen.

It has been stated that there is no satisfactory substitute for arsenic; but in its entire absence corrosive sublimate (dissolved in alcohol and brushed over the inside of the skin), powdered alum, or other astringent substances may be used, especially if combined with some strong-smelling substance to repel the attacks of insects, as camphor, oil of red cedar, oil of bitter almonds, naphthaline, creosote, etc.

Some persons prefer arsenical soap to the pure arsenic or mixture of arsenic and alum, but there are several serious objections to its use and it is not to be recommended.

Sometimes the application of arsenic or other substances named above, while sufficient to preserve the specimen from decay, will not repel the attack of insects, especially in tropical countries, where pests of this kind abound. It therefore would be well to paint the bills, feet, and other unfeathered parts with an alcoholic solution of the oil of bitter almonds, oil of red cedar, camphor, or some other highly pungent substance.*

Miscellaneous.—In addition to the various articles already mentioned, many other things are quite necessary for successful collecting, among which may be mentioned the following:

(1) A receptacle for carrying the birds while out collecting. The very best thing for this purpose is a tin box with sliding lid, similar to the ordinary botanical collecting box, or differing in shape only, as may suit the taste or convenience of the collector. This is to be suspended by a strap hung over the shoulder of the opposite side. The next best thing is a fishing basket or "creel," of as large size as can be conveniently carried.

(2) A box with tightly fitting hinged lid, not less than 5 by 8 by 2 inches,† to contain arsenic or the mixture of alum and arsenic, and which should always be kept about half full. It should also contain a rabbit's foot, which is by far better than any other sort of brush for applying the arsenic to the skin. When not in use this box should be kept closed and put out of reach of children, and when moving from place to place it may be wrapped in paper and packed with other implements.

(3) A similar, but perhaps smaller, box, to contain corn meal or other absorbent substances.

(5) A plentiful supply of "merchandise tags," to serve as temporary labels, and blank labels with tying-threads already attached.

(6) A box of moist water colors, with suitable brushes (see page 16).

* An alcoholic solution of strychnine has been recommended; but the writer has found this unreliable.

† One of larger dimensions would be better, so that birds of medium size may be laid inside the box while the arsenic is being applied to the skin.

§ 3. PROCURING SPECIMENS.

The collector having provided himself with the kind of gun and ammunition which seem according to his experience or judgment most suitable, he should then place in his collecting-box or basket the following implements and materials:

(1) A considerable "wad" of raw cotton, for plugging shot-holes and the throats of specimens.

(2) An insect-powder bellows filled with corn meal, and an extra quantity of the latter.

(3) A supply of paper cones or "cornucopias." These are best made of some moderately soft, bibulous paper, as newspaper or pamphlets. Some collectors prefer making the cones as they are needed, and carry with them folded newspapers or old pamphlets, but time will be saved if the cones, or some of them at least, are made before starting.

(4) A small bottle filled with strong carbolic acid. (This is needed only in warm weather.)

What to do with birds after they are killed.—Immediately after a bird is killed it should be picked up by the feet (never by the tail) and held head downward to allow the blood to drain from the mouth, which may be hastened by gently pressing the bird; "flip" off or otherwise carefully remove the blood clots which may adhere to the bill, feathers, or other parts, and apply corn meal to absorb what may remain. In the absence of corn meal clean sand will do, and in the case of birds with white plumage plaster of Paris will answer, but should be carefully removed before it becomes hard. The holes made by the shot, together with the throat and the internal (but never the external) nostrils, should be plugged with cotton, to prevent the escape of blood and the juices of the stomach. Before plugging the throat a small quantity of corn meal or clean sand should be inserted, as this will absorb the blood, etc., and prevent its escaping around the cotton.* Should an eye be broken by the shot, the liquid should be carefully pressed out and what can not be otherwise removed absorbed with corn meal or sand, as nothing is more difficult to remove from feathers after it once becomes dry.

It is very important that as much pains be taken as time and other circumstances will allow to clean blood and other stains from the plumage before becoming dry, as neglect of this precaution will in the end involve far greater loss of time or perhaps necessitate loss of the specimen itself.

In very warm weather, before the throat is plugged the gullet should be swabbed with carbolic acid by saturating a small wad of cotton which has previously been wrapped around the end of a small stick,

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* Perhaps a still better plan is to push one plug of cotton down the gullet nearly to the stomach, before the throat plug is inserted, to prevent the juices of the latter from collecting in the throat, since, if allowed to do so in warm weather, they cause the feathers to slough off.

straw, or wire, or held in small spring forceps, with the acid, and then a small quantity of the acid should be applied to the skin along the median line of the abdomen, the feathers having of course been previously parted. In both these operations great care should be taken to prevent the acid from coming in contact with the feathers.* Some persons use for this purpose a hypodermic syringe, but this instrument is quite unnecessary, besides being cumbersome and expensive.

When the bird has been properly cleaned and plugged it should be carefully dropped, head downward, into a paper cone of suitable size, the end of which should then be folded over the tail—care being taken not to bend or break the latter,† and also to avoid doubling the head, which is likely to be done unless the bill is kept exactly in the middle of the cone and guarded from too forcible contact with the paper during its insertion.

The bird thus enveloped should be carefully placed in the collecting basket, which should never be closely packed with specimens, as the pressure thus caused will not only force the blood through to the plumage, but in hot weather will also hasten decomposition. The larger specimens should be placed at the bottom, the smallest on top; and if the box or basket is only partly empty the space should be loosely filled with grass, leaves, or paper, to prevent the specimens shifting about.

How to kill wounded birds.—A wounded bird should never be killed by thumping or pounding the skull. If the specimen is of small or medium size much the easiest and best way is to take it between the thumb and fingers, underneath the wing, and squeeze it tightly, thus causing its death almost instantly by suffocation. If of large size this can not be done, and the collector sometimes has a difficult problem to solve, particularly in the case of the larger birds of prey, whose sharp talons are to be avoided, it being very often extremely difficult to release one's self from their powerful grip, which, besides being exceedingly painful, may lead to serious results. A bite from the beak of such birds, even the most powerful, is comparatively a trifling matter, and in the case of the larger hawks and owls may safely be quite ignored. These birds when wounded usually throw themselves on their backs, with open feet presented for defense. In such cases the legs of the bird should be quickly seized and held firmly, which can easily be done by a careful and alert person. Then, while the feet are held, a sharp-pointed knife or scalpel should be quickly plunged into the anterior portion of the breast, so as to strike the heart or its vicinity, and the bird held head downward to allow the blood to drain from the mouth. All these methods are more or less cruel, and therefore naturally dis-

* An experienced collector informs me that by this method he has kept birds for three or four days on the hot coasts of Central America.

† Crumpled or bent feathers may have much of their elasticity and original shape restored by dipping in hot water. Steaming will answer the same purpose.

tasteful to a sensitive person. But there can be no question that it is far more merciful to dispatch at once a wounded bird than to delay putting an end to its suffering. When practicable, chloroform can be used advantageously by simply saturating a handkerchief and holding it tightly over the bird's head for a few moments.

Care of specimens on reaching camp or quarters.—In very hot weather, when specimens decompose rapidly, a drop of carbolic acid should be put into the throat and another into the intestines, to retard decay. This is most easily done by means of a "swab," improvised of a small stick and a little cotton. Care must be used not to allow the acid to come in contact with the feathers. When camp or quarters are reached, the specimens should be taken out of the cones, one at a time, carefully examined, and the cotton in the throat removed and a fresh plug substituted. *Never delay skinning a specimen until it begins to bloat or until it begins to smell offensively*, although, should it be impracticable to prevent this, very desirable specimens should be skinned even in this condition. The best way is to skin the birds as soon as possible, though in cold weather they may of course be kept several days without danger of decomposition. At the same time, however, allow a specimen to relax somewhat before you begin skinning it.

§4. PREPARING AND PRESERVING SPECIMENS.

How to skin birds.—Before the process of skinning is actually begun, certain preliminaries are necessary, if the work is to go on smoothly. A suitable table, stand, or workbench must first be provided and placed in a good light. A paper cover should then be put over it (an old newspaper is as good as anything). Then the box containing the arsenic or mixture of arsenic and alum; that containing the corn meal; the skinning and stuffing implements; the cotton, needle and thread; labels or tags; pencil, cleaning sponge and brush; cup of clean water, etc., are to be placed in convenient positions on the table, room for the specimen and the hands of the operator being of course reserved. A basin of water and towel, for cleaning and drying the hands, should also be within reach.

When everything is ready a label or tag should be securely fastened to one leg of the specimen, and the locality and date, as well as a number, inscribed on it, the same data being written in the collector's field catalogue, after the corresponding number. No measurements are necessary, since all measurements of scientific value are best taken from the dried skin, though in the case of very large birds (and smaller ones also, if the collector has plenty of time) the total length and the spread of the fully outstretched wings may be taken, and for convenience may be written with the length first and the spread last, with a multiplication sign between, thus, 36.×84.50, the measurements being best taken in inches and decimals. Then, if there are any noteworthy features as to color of the soft parts, they should be carefully noted, this being a very important matter and one sadly neglected by collectors. If the collector can provide himself with a small box of good water colors and suitable brushes, together with some pads of drawing paper, rough sketches of bills, feet, etc., may be made and the colors exactly reproduced.* If not thus provided, or even as an additional aid if he is, a set of named colors on paper should be at hand to help him in naming the different hues.†

The girth of the bird may then be taken by means of a band of stiff paper passed round the middle of the body over the wings, and pinned in the form of a ring. It is then slipped off towards the feet and, after the skin is prepared, is replaced, the stuffing inserted being enough to keep it from falling off. The exact circumference of the original bird can thus be readily maintained. In fact, the ring may be slipped on before the stuffing is commenced and enough cotton inserted to fill out the shoulders within the paper.

After these preliminaries, relax the wings and legs by pulling and stretching; then make an incision through the skin only, from the lower portion of the breastbone to the anus. Should the intestines protrude in small specimens, they had better be extracted, great care being taken not to soil the feathers or to mutilate the sexual organs, thereby rendering it difficult or perhaps impossible to determine the sex. Now, proceed carefully to separate the skin on one side from the subjacent parts until you reach the knee, and expose the thigh, when, taking the leg in one hand, push or thrust the knee up on the abdomen and loosen the skin around it until you can place the scissors or knife underneath and separate the joint with the accompanying muscles. Apply a quantity of corn meal to the space between the skin and the carcass to prevent adhesion and to keep the feathers clean. Repeat this operation for the other leg. Loosen the skin about the base of the

* The writer would, from practical experience, recommend that a japanned tin box with spaces for 18 to 24 half pans (or 9 to 12 full pans) be obtained, and filled with the following moist water-colors, all half pans, except the Chinese white, which should consist of a full pan:

1. Lamp Black.	7. Lemon Yellow.	13. Burnt Umber.
2. Payne's Gray.	8. Pale Cadmium.	14. Raw Umber.
3. French Blue.	9. Scarlet Vermilion.	15. Bistre.
4. Permanent Blue.	10. Carmine.	16. Yellow Ochre.
5. Viridian.	11. Light Red.	17. Chinese White.
6. Emerald Green.	12. Burnt Sienna.	

The above list is indispensable and will enable one to imitate almost any hue found in nature; but, if the collector does not mind increasing the number of pigments, the following might be added with advantage:

18. Hooker's Green, No. 2.	20. Cadmium Orange.	22. Purple Madder.
19. Olive Green.	21. Indian Red.	23. Antwerp Blue.

† For this purpose a small book entitled "A Nomenclature of Colors for the use of Naturalists," published by Little, Brown & Company, Boston, Massachusetts, is specially adapted, and may be obtained at a cost of $4.

tail and cut through the vertebræ at the last joint, taking care not to sever the bases of the quills. Suspend the body by inserting the hook into the lower part of the back or rump,* and invert the skin, loosening it carefully from the body. On reaching the wings loosen the skin from around the first bone and cut through the middle of it, or, better, separate it from the body through the joint. Continue the inversion of the skin by drawing it over the neck until the skull is exposed. Arrived at this point, detach the delicate membrane of the ear from its cavity in the skull, if possible, without cutting or tearing it; then, by means of the thumb nails, loosen the skin from other parts of the head until you come to the eyes, where extreme care is necessary in cutting through the white nictitating membrane to avoid lacerating the ball. Scoop out the eyes, and, by making one cut on each side of the head, through the small bone connecting the base of the lower jaw with the skull, another across the roof of the mouth behind the base of the upper mandible, and between the jaws of the lower, and a fourth (horizontally) through the skull behind the orbits and parallel to the roof of the mouth, you will have freed the skull from all the accompanying brain and muscle. Should anything still adhere it may be removed separately. In making the first two cuts care must be taken not to injure or sever the zygoma, a small bone extending from the base of the upper mandible to the base of the lower jaw bone. Clean off every particle of muscle and fat from the head and skin of the neck, and invert the skin of the head to the very base of the bill.

Then skin the wing down to the wrist joint, detatching the roots of the larger feathers (secondary and primary quills) with the thumb or finger nails; remove the muscle from the bones, leaving all of the latter.† The legs should then be skinned down to the lower joint of the thigh (the heel, or tibio-tarsal joint), and the flesh removed from the bone. Remove all the muscle and fat, including the oil gland, from about the base of the tail, great care being taken not to cut the roots of the feathers, which would cause them to drop out.

During every stage of the process of skinning the following very important things should be specially remembered: (1) always handle the skin, when detatching it from the body, as close as possible to the point of adhesion, to prevent stretching, a stretched skin being far worse than one full of holes or rents; (2) always keep the fingers between the feathers and the flesh, to prevent soiling the plumage; (3) apply plenty of corn meal or other suitable absorbent whenever a bloody or fatty place is exposed.

Certain kinds of birds require deviation from the above rules in some

* As mentioned on page 10 this hook may, with practice, be dispensed with. In fact, many collectors and taxidermists never use one.

† Many prefer to clean the wing by an entirely different method, an incision being made on the under side along the bone, and the flesh removed through the opening thus made. This is the better way with large birds.

particulars. Most woodpeckers and ducks, for instance, have the head so much larger than the neck, that it is quite impossible to skin over the head by the ordinary method. In such cases the neck should be cut off before the skull is reached, and the skin turned "right side out;" then make an incision from the top of the occiput down to the base of the skull and skin the head through this opening. Of course the incision should be sewed together after the skinning is completed, or at least after the specimen has been stuffed. Pigeons, cuckoos, and some ducks, as well as other birds, have the skin very tender, and adhering so closely to the rump and lower part of the back (sometimes the breast also), that its separation is a matter of very great difficulty. Such birds should be kept until they are fully relaxed before work on them is commenced, and the operation of skinning should be done with extreme care.

In warm weather or in hot countries very large birds (as herons, cranes, hawks, etc.) should have an incision made below the heel (tibio-tarsal) joint and the tendons cut off; then, by making another incision on the sole of the foot the tendons can be drawn out. The space made by the removal of the tendons should be filled with arsenic. This will prevent fermentation of the juices in the leg and generation of gases, which so often cause the skin to "blister" or separate, thus entirely ruining the specimen for mounting.

Birds having a pure white and very compact plumage on the lower parts should be skinned through an incision made under one wing, along the side, or on the back, which will be found very easy after a little practice.

Poisoning the skin.—The skinning and cleaning of the specimen having been completed,* the next thing is to apply the preservative. For this, as has already been stated, only arsenic or a mixture of arsenic and powdered alum should be used. This may be applied either dry or as a paste, by mixing with alcohol or water (alcohol being preferable). If the dry powder is used, it should be kept in a shallow box large enough to hold a medium-sized bird, and while the skin is in every part turned "wrong side out," it should be laid upon the arsenic and the latter applied thickly to every part, care being taken to put plenty of the poison about the head, particularly close up to the base of the bill, about the lower end of the denuded wing and leg bones and about the base of the tail. This is best done with the foot of a common rabbit (or, better still, that of the northern species, which has longer hair on the soles); but if one can not be had, a substitute may be made by securely tying a wad of cotton to the end of a stick. After the skin is covered with the arsenic (which should be applied while its inner surface is moist),†

* Special instructions for cleaning bloody, greasy, or otherwise soiled specimens are given on pages 19 to 21.

† If the skin has become dry it may be moistened by gently touching the surface with a wet sponge; but if the paste is used, this is of course unnecessary.

it should be held over the box and gently tapped to loosen the superfluous powder.

Should the alcoholic paste be preferred, it may be applied with a bristle brush, or better still with a wad of cotton tied to the end of a small stick, the advantage in the latter being that it can be thrown away when a day's work is done and a new one quickly made when another is required.

Cleaning soiled or greasy specimens.—While blood-stained specimens are supposed to have been partially cleaned immediately after they were shot, as directed on page 13, further cleaning is necessary before the bird can be considered a good and finished specimen. This final cleaning should be done when the bird is entirely skinned, but before the preservative is applied. *Bloody specimens should never be washed before they are skinned*, as the application of water only serves to draw out more blood through the shot holes.

After the bird has been skinned, however, and the inner surface of the skin thoroughly freed from blood by sponging or wiping, then the feathers may be washed clean, using a soft sponge and warm water, and dried with corn meal or some other clean absorbent substance, care being taken not to allow any of these substances, especially plaster of Paris, to dry on the feathers, each application being thoroughly removed as soon as it becomes saturated with moisture. Repeated applications and much patience are required to clean a specimen thoroughly, but the result is well worth all the trouble and loss of time, unless the specimen is one of no value.

Corn meal is probably the best of all substances for drying moistened feathers, but can not always be obtained. In its absence, clean dry sand, whiting, or plaster of Paris may be used, although the two last named should not be used on birds of dark plumage, since it is next to impossible to remove it all from the feathers, which ever after have a dusty or powdered appearance. On birds of white or very light-colored plumage, however, plaster of Paris is better than anything else; but even on these as much as possible should be removed by persistent whipping and blowing of the feathers.

Dry blood stains should not be washed, but should first be pried or chipped off with the finger nail, or back of a knife, and then carefully scraped and manipulated with a stiff brush, such as a jeweler's brush or a toothbrush.

Fat birds are very difficult to clean, but the removal of every particle of fat is very important, since, in addition to the certainty of the fat which is allowed to remain on the skin gradually working out through the shot holes and other openings and greasing the feathers, the combination of the fat with the arsenic produces a chemical compound which is very injurious to the skin, rendering it "rotten," or brittle.

A bountiful application of corn meal, plaster, etc., during the process of skinning is a great help toward removing the grease, and in the case of large birds a piece of calico or cotton cloth sewed to the skin along each edge of the incision will serve to keep the feathers from contact with the fat, though even then an absorbent substance should be freely used.

Ducks and some other water birds when fat are particularly difficult to clean, owing to the fact that the roots of the feathers form numerous prominent points all over the inner surface of the skin, the spaces between them being filled with fat. In such cases the surface of the fatty coating should be slightly gashed with the knife or scalpel to release the oily substance, which should then be gradually absorbed by a persistent application and "rubbing in" of the absorbent substance. Of course all free pieces of fat should be first cut away.

Should the feathers have become greasy they should, after the bird has been skinned and the inside of the skin itself cleaned, as above directed, be washed with spirits of turpentine, and the latter removed by absorption with corn meal, whiting, or plaster, repeatedly applied and removed, the absorbent substance, when saturated with the turpentine, being first shaken off and the feathers then carefully whipped with a light elastic stick, until no more remains. This process is tedious, but the excellent results amply repay for the time and trouble expended.

The cleansing of water birds, especially sea birds, requiring special treatment, the following directions (prepared, at our request, by Mr. William Palmer), should be closely observed:

As prevention is better than cure, time employed in taking proper care of sea birds when first killed is well utilized; but it seldom happens that one is able to do this, and therefore it becomes necessary to spend more time in cleaning specimens than is desirable. When freshly killed, if a sea bird is immediately hung up by the legs for several hours, much vexatious work is spared the collector, but if one is on a lonely shore, with miles to travel, this is impossible. A box, open on top, but with movable slats on which to suspend the birds, is perhaps the best plan to adopt in a boat or on shore where several hours are spent. When tramping, specimens may be hung up or laid on a rock or hummock until return, the object being to prevent friction and pressure while the body is warm and lax. When cold and hard it is best to wrap in cheese cloth, corn meal being freely used at the shot holes, and the mouth and internal nostrils plugged *just before wrapping.* But with even the greatest care the feathers will soil and it becomes necessary to clean them.

If a bird is very bloody when picked up, wipe off the excess of blood with a piece of raw cotton, and do not, if possible, allow the blood to get dry on the feathers; *never* wash it until you are ready to skin, unless you can dry also, and never wash in salt water if by any means you can get fresh.

When ready to clean, provide a vessel of warm water and dip the bloody feathers into it, working it the while with the fingers; do this in several waters until the blood is all dissolved out, then dry by pressure with a towel or cheese cloth; now, with a piece of raw cotton partly saturated with turpentine, gently wipe the wet feathers downwards, so as to leave, as it were, a thin layer of turpentine; on this place dry plaster an inch or more thick, according to the size of the bird, etc. In a few minutes replace with more plaster, and continue until all the moisture is drawn from the feathers, when the plaster adhering may be wiped off with raw cotton and the feathers blown apart with a bellows, or by taking it to a windy place and smartly striking and alternately raising the feathers, the plaster will be blown away. A second application may be needed if the feathers are stained.

This cleaning is usually done after the bird is skinned, but sometimes it will be found convenient to do it before. Benzine may be used instead of turpentine, and sometimes soap or washing compounds will be found useful.

With small dirty spots the water may be applied with a piece of raw cotton, a sponge, or cloth, and the feathers gently stroked downward toward the tail, parting the feathers with the left hand while the right applies the water. Cotton is much the best, as when dirty it can be thrown away and a new piece used.

The essential points in cleaning a bird skin are (1) never let the blood get dry on the feathers; (2) always use the plaster immediately after washing, and (3) always blow out the plaster from the feathers. At its best cleaning feathers is a nasty job, but by following the above an otherwise worthless bird may be made almost as good as an unsoiled one.

How to stuff a bird-skin.—There is far more art in stuffing a bird-skin properly than in getting the skin off the bird, a skillful taxidermist being able to make a good specimen out of a skin which had been badly torn or otherwise abused, while an inexperienced operator will naturally make a poor specimen out of one that has been properly prepared for him. The most essential of all things, in the way of material, is a good quality of raw cotton, that with a long staple or fiber being necessary.

The orbits (holes from which the eyeballs were removed) should first be filled, a smoothly rounded, elastic wad being inserted in each, with the smoothest and roundest side outward. This is best done while the skin is reversed and the first thing after the preservative is applied. A moderately compact, elastic roll of cotton, free from irregularities and about the thickness of the natural neck, is then inserted through the neck and pushed forward until the end of it can be grasped by the fingers or a pair of forceps within the mouth, where it should be firmly held until the foreceps are withdrawn, when the anterior end within the mouth should be carefully pushed back so that when the bill is closed no part of it is exposed.* While a pair of long foreceps is usually used for inserting the cotton through the neck, a far handier tool for the purpose is an ordinary knitting needle, around which the cotton may be deftly twisted and shaped, while the smooth needle can be much more easily withdrawn than can a pair of forceps. This same needle may also be used for shaping the eyelids, by pushing from the inside the wad of cotton which fills the orbit, and is convenient for other purposes.

The next step is to take a wad of cotton and manipulate it into an oval, loose or fluffy, ball, as near as possible the size and shape of the original body. Insert one end of this into the opening of the skin, *beneath* the end of the neck roll, which should be carefully raised and held while the body stuffing is worked beneath it; then taking hold of the edge of the incision, first on one side and then on the other, push the cotton into place, or else, by holding the cotton, gently pull the skin over it. A single stich, about the middle of the incision, is sufficient to close the opening, but even this is not necessary.

Should the bird be of medium or large size, the leg bones should be wrapped with cotton (or whatever material has been used for stuffing), so as to give the thigh its proper shape.

All birds with long necks or tender skins should be stiffened by wrapping the neck stuffing as well as that of the body around a wire or stick. If a wire, it should be sharpened at both ends, the anterior end being forced through the anterior portion of the head and the opposite end through the root of the tail. If a stick is used the anterior end may be blunt and fitted into the cavity of the skull, or it may be sharpened and forced into the bones of the palate or anterior portion of the head. All water birds (especially ducks and small waders), as well as doves, trogons, *Caprimulgidæ*, and other tender skinned birds, should be thus strengthened.

Now comes one of the most important and in some respects the most difficult parts of the whole operation—the shaping or "making up" of the specimen. No matter how faultlessly the bird has been skinned, or even stuffed, if badly "made up" it will be a bad specimen, while on the other hand many defects of either skinning or stuffing may be hidden by careful manipulation at this important stage of the process. To do this properly proceed as follows:

Take a thin sheet of long-stapled raw cotton (the thinner the better, if it only holds together and will stand the least strain) of sufficient size to entirely inclose the bird when wrapped around it. Lay this on

* Many taxidermists, instead of passing the cotton along the throat to the mouth, push the end of it into the cavity of the skull, and fill the throat with bits of loose cotton passed through the mouth. This is a very good method, especially if the head is bent so that its axis reposes at more or less of an angle with that of the body, specimens thus prepared being far easier to mount than those which have been made with the axis of the head continuous with that of the body.

the table in front of you, with the fibers running toward and from you; lay the bird carefully on this, on its back, with head to your left.* Fluff up the long, loose feathers on each side until the thumb and forefinger can be placed beneath them and then gently press the sides beneath the wings together, just as you would squeeze a wounded bird to kill it, only the pressure need not be so strong. Then bring the wings up against the sides in a natural position, allowing the feathers of the sides to fall or lay over them, and adjust the wing-tips beneath the base of the tail. Lay the feet in a natural position, spread the tail as much as may be desired, and touch up the plumage wherever there is any disarrangement of the feathers. When the specimen has been thus properly shaped and smoothed take up one edge of the cotton and lift or wrap gently over that side of the bird and hold until the opposite edge is brought up and lapped over it, drawing less where the circumference is greater and more where it is smaller—the main object being to have the cotton envelope fit as exactly as possible the contour previously given to the specimen. Care should be taken to see that the feathers of the abdomen overlap and cover the incision and that they are held thus by the cotton envelope. The cotton about the head may be twisted around the point of the bill, so as to keep it closed, but it is better to first close the bill by passing a slender needle and thread through the nostrils and tying beneath the lower mandible.† This had best be done immediately after the neck filling has been inserted.

Different collectors, however, have almost as many methods of wrapping skins. One of the best, and perhaps easier to follow, as well as more satisfactory in its results, is the following, practiced by Mr. C. W. Richmond, of Washington, whose specimens are particularly admired for their fine shape and smoothness.

After the incision on the abdomen has been stitched together,‡ the feathers arranged and the legs crossed, the skin is ready to be wrapped. For wrapping, physicians' absorbent cotton is the best. Take a strip of this about three times as wide as the diameter of the bird's body, and, finally arranging and smoothing the feathers on the under parts, lay the sheet of cotton over the bird, which should be held, on its back, in one hand, between the thumb and forefinger to prevent the wings getting out of place. One end of the cotton should be brought over the head, and the bird then placed on the table or skinning-board, belly downward, resting on the cotton. Any excess of that portion of the cotton which has been brought over the head may be removed, the plumage of the back arranged, and the corners of the cotton sheet

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* If the operator is left handed the position should of course be reversed.

† Thick, short bills (such as those of grosbeaks) cannot thus be kept closed, but this may be done by sticking a pin (not too large) through the extreme anterior angle of the chin into the under surface of the upper mandible.

‡ As mentioned on page 22 it is not absolutely necessary to sew the edges of the incision together; in fact, many good collectors dispense with this entirely.

brought up over each wing, taking care that they bind somewhat firmly at the shoulders, so that the wings will be kept in the proper position after the opposite edges of the cotton have been lapped and blended together. The two posterior corners of the cotton sheet should then be brought together over the rump, to hold the tips of the wings in place. Care should be taken to have the sheet of cotton of uniform thickness, otherwise the skin will present, after drying, irregularities of contour, corresponding to the varying thickness of different parts of the wrapping. It is very important to avoid drawing the cotton too tight and thus squeezing the skin too much, a very common and very serious fault with many collectors, an undersized skin being far more objectionable than one which is overstuffed, for the reason that the defect is practically irremediable.

After the bird has been wrapped the wings may be properly adjusted, care being taken to have the tips even with one another and not crossed or overlapped. In fact, at this stage the skin may be so manipulated that any desired degree of smoothness and regularity of shape may be given it, practice being of course required before the beginner can become really proficient. The finishing touches should then be given and the skin laid aside to dry, the last thing being to see that the feet and tail are properly adjusted.

The proper wrapping of a specimen, as described above, simple as it may seem, is one of the most difficult of all things connected with the preparation of a bird skin, and requires some patience as well as considerable practice. Some experienced collectors and taxidermists, though able to make first-class specimens in their own way, never become expert in it, and consequently do not adopt this method. If the beginner can learn, however, to make up his skins in this way he should do so, since there can be no question as to its advantages, the most important of which are that specimens dry much quicker than when put away in a paper cylinder, hold their shape better, and when dried are all ready for packing. The only serious defect is the danger of wrapping the skin too tightly, thus making it "undersized," alluded to above as a very common fault with those who have adopted this method. This may be avoided by first taking the circumference of the bird before it is skinned, by means of a paper band or hoop just wide enough to hold the wings up against the sides (as recommended on page 16), and then putting this hoop around the stuffed bird before the cotton is wrapped around it.

Very large birds should never be stuffed to their full size, which would involve unnecessary waste of space—a very serious thing when traveling. Just enough cotton, tow, or excelsior, or whatever is used for stuffing, to keep the opposite sides of the skin from coming in contact with each other is sufficient, the neck, however, and the thighs being stuffed to nearly, if not quite, the natural size.

Large birds with very long necks or legs should also have these members folded or doubled over to economize space in packing.

If the tail has peculiar markings which can not be satisfactorily seen unless it is spread, they can be easily displayed by the following very simple process: The base of the tail having been properly cleaned by cutting out the wedge-shaped piece which projects into the middle portion, removing the oil-gland, etc. (as described on page 17), pass a needle and thread from one side of the base to the other across the intervening angle, and then tie the thread after it has been drawn sufficiently tight—the tighter it is drawn, of course, the more the feathers will be spread apart at the end.

The primaries can be spread for a similar purpose by passing a sufficiently small sharpened wire through their stems, near the base, and separating the individual quills to the desired distance from one another.

Birds with crests should have the head turned so that while the bird lies upon its back one side of the head lies upward, the feathers of the crest being erected and kept in that position until the skin is dry.

Determining the sex of specimens.—The sex of a specimen should never be guessed from the character of the plumage, as is unfortunately very often done, but always by dissection. Sometimes the generative organs have been so injured by shot that this is impossible. Should this be the case, the sex mark* should be wholly ignored or else queried, as circumstances most justify. If the organs have not been injured, the sex of the specimen may be ascertained after skinning by making an incision in the side near the vertebræ and exposing the inside surface of the "small of the back." The generative organs will be found tightly bound to this region (nearly opposite to the last ribs) and separating it from the intestines. The testicles of the male will be observed as two spheroidal or ellipsoidal whitish bodies, varying with the season and species from the size of a pin's head to that of a hazelnut. The ovaries of the female, consisting of a flattened mass of spheres, variable in size with the season, will be found in the same region.

A good magnifying glass is of great assistance in determining the sex of small birds, particularly the young, in which the organs are but slightly developed.

Labeling specimens.—The labeling of a specimen is a very important matter; in fact the label is part of the specimen, whose value is in direct ratio to the conciseness of the data inscribed on its label.

While tags have been recommended for temporary use, a permanent label, attached to the specimen as soon as it is prepared, is far better, and should, if practicable, be used in preference. *Tie your labels on securely*, and *do not tie with a string longer than is necessary.* Essential data are *precise locality*, *date*, *sex*, and *name of the collector*, but other items of information may be added if the collector sees fit.

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* The signs used to denote the sex are ♂ for *male*, ♀ for *female*.

To tie the label to both legs (where they cross one another), is possibly an advantage as making it less easy to tear the label off; but this doubtful advantage is much more than counterbalanced by several disadvantages, which are unpleasantly realized when a measurement of the tarsus has to be made or when one is describing or making a drawing of the specimen. It is recommended, therefore, that the label be always tied to one leg only, preferably the right.

Drying skins.—Skins should be dried before they are packed for shipment, otherwise they may mold. This may be done by exposing to the sun for a short time (a longer time is of course required for larger specimens), or keeping in a warm dry room for the necessary length of time. They should not be dried *too* quickly, however as this will cause them to become brittle, and, above all, never attempt to dry them by baking.

Protection of skins against insects.—No matter how well poisoned with arsenic, skins are apt to be attacked by insects, which destroy or disfigure parts not protected by the poison, as the bill, feet, shafts of the quill- and tail-feathers, etc. In order to prevent this, the parts liable to such injury should be painted with an alcoholic solution of oil of bitter almonds, oil of red cedar, or some equally pungent substance, and the box in which the specimens are packed should be tight as possible, and tobacco leaves, naphthaline, or camphor placed in with the specimens. An alcoholic solution of corrosive sublimate is very effective, but is also dangerous to the health, and its use is not to be recommended unless other equally efficacious substances can not be obtained. An excellent way to protect specimens from destructive insects is to wrap each one in a piece of paper and gum together all the openings so that insects can not enter—a drop of oil of red cedar or oil of bitter almonds, a few crystals of naphthaline, or something of the kind being inclosed with the skin.

§5. PACKING SPECIMENS FOR SHIPMENT.

If specimens are not properly packed they can not be expected to reach their destination in good condition, but it is very easy to pack them in the right way if the following rules are observed:

(1) Never pack bird skins in the same box with geological specimens, stone implements, deer heads, or other hard and heavy objects.

(2) Place the largest birds at the bottom of the box, the smallest on top.

(3) Fill spaces between the specimens with "excelsior" packing or some other dry elastic vegetable substance (not cotton, which is too light, except for small birds alone).

(4) Pack the box quite full.

(5) Line the box, if practicable, with thick paper before the birds are put in.

§ 6. RECORDS.

The field notes of a collector may be nearly as valuable as his specimens. They should include observations on the habits, notes, etc., of the various species met with, the kinds of localities they frequent, their food, and all matters which concern their life history. These notes may be written either in a book or on separate scraps of paper (preferably the former), *but should never be written on both sides of the paper*, unless the supply runs short, in which case it will be necessary to have one page of each leaf copied before the notes can be properly utilized.

In addition to these field notes, the collector should catalogue his specimens as they are obtained, beginning with No. 1, and he should have a single set of numbers. The catalogue number of each specimen should be given both in this catalogue and on the label of the specimen itself, and the full data also duplicated in the same manner.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR COLLECTING RECENT AND FOSSIL PLANTS.

BY

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Assistant Curator of the Department of Botany.

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CONTENTS.

DIRECTIONS FOR COLLECTING RECENT AND FOSSIL PLANTS.

By F. H. Knowlton,

Assistant Curator of the Department of Botany, U. S. National Museum.

A.—RECENT PLANTS.

INTRODUCTION.

In compiling this series of directions for collecting and preparing plants for the herbarium, I have taken as a basis the admirable account prepared by Prof. Lester F. Ward, and published as an appendix to his "Guide to the Flora of Washington and Vicinity,"* having simply extended the limits so as to include directions for collecting the lower as well as the higher plants. I have therefore quoted freely from Professor Ward's Bulletin, and have taken the directions for preparing plants for the herbarium with but little change. I have also consulted various published accounts and collector's manuals, such as Bailey's Botanical Collector's Hand Book, the Herbarium Number of the Botanical Gazette (vol. XI, June, 1886), scattered notes in the various botanical periodicals, etc., for which due acknowledgment is rendered in each instance. Many of the suggestions are the result of an extensive personal field experience.

I wish further to acknowledge the assistance rendered by Messrs. Waite, Holm, Holzinger, Burgess, and others, who have contributed directions for collecting among the various lower groups of plants.

I. List of Implements and Appliances Required for Collecting:

(1) Portfolio, botanical case.
(2) Knife, trowel, cane, dredge, gloves.
(3) Plant press, drying papers, thin papers, papers for dried plants.
(4) Notebook.

II. Directions for Collecting:

(1) Phanerogamous and vascular Cryptogamous plants.
 (*a*) Ordinary flowering plants and vascular Cryptogams.
 (*b*) Cactaceæ, fleshy plants, etc.

* Bulletin of the U. S. National Museum, No. 22, Washington, 1881.

II. DIRECTIONS FOR COLLECTING—Continued.
- (2) Cryptogamous plants. [Cellular.]
  - (*a*) Mosses and Liverworts (Bryophyta).
  - (*b*) Lichens.
  - (*c*) Algæ.
    - Fresh water.
    - Marine.
  - (*d*) Fungi.
    - Fleshy fungi, Agarics, etc.
    - Parasitic fungi.
- (3) Preservation of plants in alcohol.

III. PREPARING PLANTS FOR THE HERBARIUM:
- (1) Care of the dried plants, poisoning, etc.
- (2) Making a herbarium.
- (3) Care of duplicates.

I.—IMPLEMENTS AND APPLIANCES FOR COLLECTING.

PORTFOLIO.

The first thing to be decided upon is the receptacle which is to hold the plants while actually in the field, and before they have been prepared for the drying process. Long experience has shown that a portfolio of some form is the most serviceable, and admits of being used under a greater variety of conditions and for a greater diversity of objects than any other form of receptacle. A great many modifications of the portfolio have been used and recommended by various botanists, but the simpler it is the more satisfactory it will usually prove to be. A very serviceable and convenient portfolio may be made by taking two pieces of thick pasteboard or strawboard 12 inches wide and 18 inches long, and fastening them together by running two strings or straps through the bottom and top. These strings or straps should be long enough to tie or buckle at the top so as to apply a slight pressure to the containe l plants and also to prevent the plants from falling out. By this process the thickness of the portfolio may be varied at any time. Another very good method is by lacing the pieces of strawboard together at the back only by means of strong cord, and using a strap about the middle to supply the pressure and keep the plants in place. This strap will also serve as a handle, or, when long enough, to pass over the shoulder.

Strong rubber bands may also be used in place of the leather straps. The covers of an old book, when of suitable size, may be made into a portfolio that will do good service.

A still more perfect portfolio may be made "of binders' boards, either united at the back by leather, as in a book, or left so far separate as to allow pressure to be applied by means of the two straps which pass around it near the ends, free or attached to one side only. It should be covered or bound with strong cotton cloth, well glued in every part, painted black and varnished, making it as nearly waterproof and as durable as possible." (Bailey.)

Still other forms of the portfolio have been recommended by botanical collectors. The wire-press, or portfolio, is one of these. It consists of two frames of wire fastened as in the others with straps or bands of rubber. A lattice-work portfolio has also been suggested. But these fancy styles are, on the whole, not to be recommended, as they frequently defeat the object in view. They allow a rapid escape of moisture, and the plants may become partially dried and brittle before the end of the day's trip, and no appliance can possibly do away with the necessity of properly pressing the plants.

Having decided upon the portfolio, it should be filled with four or five quires of light but strong paper, which may be fastened into the covers in a variety of ways, or left loose. It is not desirable that this paper be bibulous, for the object is to keep the plants as fresh as possible until they can be arranged and put into the press, which may often be several hours after they were collected, particularly when making long marches. If the traveling is done on horseback it is best to have the handles of the portfolio arranged so as to slip readily over the horn of the saddle, where it will be accessible at a moment's notice.

"No attempt need be made to keep a portfolio genteel, especially within. By the time it has been well filled out a few times with moist plants and muddy roots, all the fancy paper that is put into it will have lost its charm. * * * Any paper that is put into it is destined to get wet and torn, and to require renewal several times a season, and it should therefore be cheap. * * * Moderately thick and firm manilla paper is upon the whole recommended." (Ward.)

BOTANIZING CASE (VASCULUM).

In place of the portfolio some collectors prefer a metallic case (tin or zinc) and for certain kinds of collecting it has decided advantages. It should be elliptical in cross-section, about 20 inches long and 7½ inches in greater and 4½ or 5 inches in lesser diameter. A closely fitting door or lid is placed in one side, which should be 6½ by 18½ inches in size; it should be hinged below and fastened by a simple clasp above. It is carried over the shoulders by a broad strap.

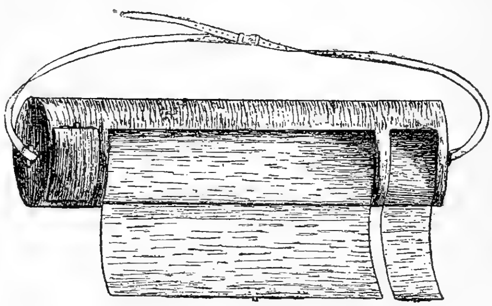

FIG. 1—Botanizing case.

In some cases it may be desirable to make the box of larger size, and to have one or more compartments partitioned off inside for small or delicate specimens that might be injured by other plants in the large compartment.

Plants collected in a box of this kind will remain perfectly fresh for a considerable time and may then be examined to much better advantage than if preserved in a portfolio, where they will unavoidably be more or less crushed.

"The box requires less time to open, is more manageable in windy weather, preserves the plants fresh for examination at home, and is especially serviceable when some time must elapse before the plants can be placed in the press." (Gerald McCarthy in *Botanical Gazette*, XI, p. 134.)

POCKET-KNIFE.

The collector should always be provided with a strong pocket-knife, which is useful in a great variety of ways, such as cutting branches of trees, trimming specimens, removing fungi and lichens from the bark of trees, and even for digging up small plants.

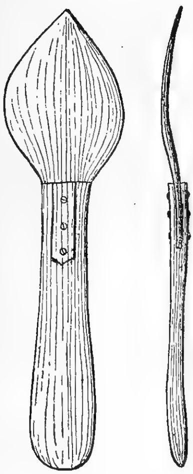

FIG. 2—Trowel.

TROWEL.

Some sort of a digging instrument will be found indispensable in taking up plants by the roots, or in securing rootstocks and other underground stems. The style of trowel used by gardeners is very good, and should be strong and not likely to be easily broken. An old flat file ground down and provided with a wooden handle is also very serviceable. The trowel may be conveniently carried in a leather sheath attached to the belt or fastened by some simple device to the portfolio.

DREDGE.

It is often very desirable to have some sort of an implement that may be used in securing water plants that can not be reached with the hands.

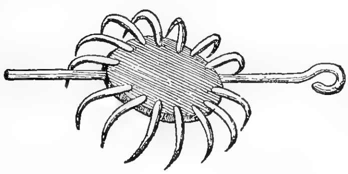

FIG. 3—Dredge for aquatic plants.

For this purpose a dredge made as follows is recommended: An iron rod five-sixteenths of an inch in diameter and about 12 inches long, bent to form a small ring at one end, passes through and carries below its center a disk of lead about 3 inches in diameter. This disk holds embedded in it 12 to 14 iron hooks all bent toward the same side. The hooks project about an inch from the leaden disk and curve inward about an inch. The iron rod projects about 3 inches beyond the leaden disk, so that the end of the rod strikes the bottom first. The lead should be heavier on the side towards the hooks, so that the dredge will fall with hooks downward. (T. F. Allen, in *Botanical Gazette*, XI, p. 141.)

GLOVES.

The collector should also be provided with a pair of thick, heavy gloves, which will be used when collecting thorny or spiny plants such as Cactaceæ.

PLANT PRESS.

As in the case of the portfolio, many forms also of the plant press have been devised and recommended. The best press for general use consists of two pine boards 1 inch thick, 12 inches wide, and 18 inches long, having each two cleats on one side, one across near each end. The pressure is obtained by means of a stout leather strap, which should be 6 feet long and 1½ or 2 inches wide and provided with a very strong buckle securely riveted to the strap. Tongue holes should be punched in the strap 1½ inches apart for a distance of 4 feet from the end. It is desirable that this strap should be supple, as a stiff strap is unmanageable. If the collection is to be stationary for a considerable length of time, heavy weights, such as flat rocks, bricks, a box of sand, or something of the kind, may be used to obtain the requisite pressure, and the straps dispensed with except when traveling. The lattice-work presses can not be recommended, as they are much more liable to damage, and moreover the plants depend in drying more upon the absorptive qualities of the paper employed than upon the evaporation which can take place from the surface of the package.

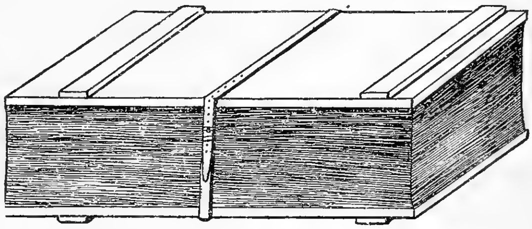

FIG. 4—Plant press closed.

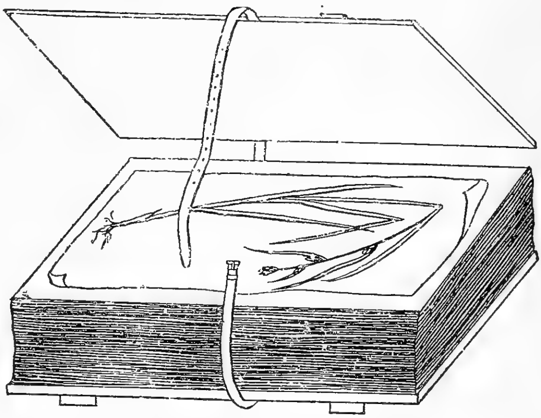

FIG. 5—Plant press open.

DRIERS.

The ideal driers are made of blotting paper cut into sheets 12 inches wide and 18 inches long, but as these are expensive it is best to employ the driers sold regularly by dealers in botanical material. These are made by cutting to the requsite size the paper used to put under carpets. This paper is thick, felt-like, and very bibulous and perfectly satisfactory for all purposes. If this can not be obtained, the common coarse brown wrapping paper will answer very well, and even old newspapers may be used if nothing better can be had. The only thing is to have papers that will readily take up moisture and as readily part with it.

THIN PAPERS.

The so-called thin papers are the papers between which the plants are placed while they are undergoing the process of dying. They should be cut to the same size as the driers and may be either half or double sheets; that is, a single sheet 12 by 18 inches or a sheet 24 by 18 inches folded through the middle so as to produce the required size. These papers should be thin but strong, and unglazed. The grocers' tea paper, as it is called, which may be obtained of any grocer or paper dealer, is the best. Old newspapers, however, may be substituted if the other can not be obtained. As these thin papers may be used over and over again it is only necessary to be provided with as many sheets as there are driers, or if single sheets are used, with twice as many.

PAPERS FOR THE DRIED PLANTS.

Many good collectors use the double sheets of thin paper mentioned above and allow the plants to remain in them after they are dry, and if the supply of thin papers is sufficient this may be a good plan, but usually they are taken out of the thin papers and put into thicker papers, or old newspapers cut to the requisite size. The plants as soon as thoroughly dry can be made up into packages of convenient size, and the collector should always be provided with some means of so caring for them, as otherwise the full capacity of the collecting outfit may be impaired by using the thin papers or driers for this purpose.

NOTE BOOK.

Lastly, the collector should always be provided with a note book of convenient size, in which everything of interest relating to the plants or their habitat should be recorded. It is best to have it of uncalendered paper, for the reason that it is often desirable to make sketches, which can not be so well made on a smooth surface. "It should have strong but light flexible covers, and be of such a form as to be readily carried in the coat pocket, and in it there should be a place for one or more pencils and the field labels." (Bailey.)

"In this book should be jotted down any such observations as one can not trust to memory, as the color of flowers (a very fleeting thing), the height of the plant, perhaps the character of the soil, the association and prevalence of particular plants in the vicinity, and the correlative insects. As in these days sciences are so interwoven with each other, it may even become necessary or desirable to record altitude or meteorological phenomena." (Bailey.)

II.—Directions for Collecting Plants.

PHANEROGAMOUS PLANTS AND VASCULAR CRYPTOGAMS.

FLOWERING PLANTS, FERNS, HORSETAILS, ETC.

"It is an art to collect plants properly. As regards their collection, plants may be divided into two general classes—herbaceous and shrubby plants. All herbs of moderate size and height should be collected entire. It is not sufficient to break or cut them off at such a point on the stem as will insure a specimen of the proper length. Every part of a plant has a character of its own and one which should be represented in the collection. The leaves of most herbs vary in form at different points on the stem, and the same is generally true of the degree of pubescence, which is a character of the first importance. Even the dead leaves about the base are distinctive and should never be torn off. If radical leaves exist, they should be collected with great care, and to secure these it is often necessary to collect them at a different time of the season from that in which the flowers are obtained. No part of the plant is more characteristic than its root. It must not be forgotten that every plant, except epiphytes and parasites, has a subterranean as well as an aërial portion, and where only one is exhibited only half of the plant is represented. Of course there are many plants, even herbaceous ones, whose roots can not be reduced to dimensions adapted to a herbarium, but wherever it is possible the entire specimen, root and stem should be secured. Much larger plants may thus be collected than is often supposed possible, as will be explained presently.

"For large herbs with spreading branches the best that can be done is to collect the flowering portions in specimens of suitable size and supplement them with leaves selected from lower parts of the stem.

"As regards shrubby plants and trees, the flower and leaf-bearing twigs should be collected, and if the leaves vary on different parts of the plant the different forms should be collected. Occasionally it is desirable to strip off a portion of the bark as a distinctive part of the species in question.

"The representative parts of every plant are flowers, fruit, and leaves, and no specimen can be regarded as complete without all these parts. Often, as in many Cruciferæ, all these can be found combined in the same specimen at once, but in most cases it requires at least two separate collections and different times in the season. When fruit can be found attached to the stem and leaves, this is of course the preferable way, since it leaves no possible doubt as to the identity of both. This should therefore be done as long as the size of the fruit will permit, and is recommended in the case of all acorns and even in hickory-nuts. In the case of larger fruits, such as the walnut (Juglans), the crab-apple, or the persimmon, the fruit can be collected separately." (Ward.)

The above statements regarding the necessity of visiting a plant at different times or seasons in order to secure a complete representation of course only apply when the collector is able to remain in the vicinity for a considerable period of time. When the collector is passing hastily through a country he will always find many things that can only be collected in an imperfect state, but they should by no means be neglected on this account, for, on the principle that "half a loaf is better than no loaf," valuable things may often be secured in this way. Leaves unaccompanied by either flowers or fruit, or fruit without flowers or leaves, can usually be identified, and even the exceedingly difficult willows, as I am informed by Mr. M. S. Bebb, the eminent salicologist, can be collected without either flowers or fruit and yet be identified. In the case of such plants as the willows, however, this course should only be adopted when everything else fails.

"For most herbaceous plants enough has already been said to guide the beginner in securing good specimens. Nearly all botanists take a pride in this, and, aside from its purely esthetic aspect, it is of the first scientific importance. The plant should in all cases be represented, and, as art only aims to imitate nature, so good taste coincides with the scientific requirement that the plant after collection should resemble as nearly as possible the plant before collection.

"Small annuals growing in loose soil can usually be pulled up by the roots without injury to the latter, and this is then the best course; but if the plant is very rare it is best not to trust to this, for fear of injuring the only specimen. It is but the work of a moment to insert the trowel below it and carefully shake the roots clean. Nearly all biennials and perennials require to be dug up, but this will be found less labor than might be supposed. A little practice will render any one skilled enough to take up nearly all ordinary plants with one or two strokes of the trowel. As it is impossible to tell in what direction a horizontal rhizoma may extend, it is best to strike in at some distance from the base of the plant and at a considerable angle, so as to go beneath it. If it can not be raised upon the trowel at the first thrust, make a similar one on the opposite side, meeting the former. In soddy ground it is often necessary to cut out a conical clod, with the plant in its center, and then remove the earth from the roots after it is taken out of the ground. This is frequently the case with *Carices*, which should never be broken off at the top of the ground.

"In placing plants in the portfolio it is usually worth while to take a little pains with them. They will never again be as firm and easily placed, and if the above directions about not allowing them to move afterwards are followed, it will be found that every minute so employed will save many at the second handling. Still there is a limit of economy in this, and in many cases it is fully as well to pay no further

FIG. 6—Scripus showing method of holding in place during drying process by means of a paper slip.

FIG. 7—Showing method of bending a plant.

attention to the specimens than to see that they are snugly inclosed in the folds of the book. No end should, under any circumstances, be allowed to project. Whatever portion does so is sure to be ruined; for, in the first place, it is exposed to the air and sun and dries up, and, in the second place, it is certain to rub against bushes and other objects and be torn and bruised. The specimens must go wholly inside the portfolio. This suggests a remark upon specimens longer than the book they are to be placed in. How is this to be done? If only a little less than twice the length, a bend in the middle is the thing required. But do not guess at the middle; place the full-length plant upon the book; see that one end clears by at least an inch; then bend the stem over your finger an inch from the other end. If the stem is tough and wiry and refuses to remain in position after it has been bent, a piece of paper with a slit, as shown in Fig. 6, may be put over the end, If the stem is disposed to break, bend it over a larger object, as your knee or the palm of your hand. If it breaks, this can not be helped and does not materially detract from the value of the specimen. Keep the parts always together as if it had not been broken. If the specimen is too long for one length, but less than twice the required length, do not bend it in the middle, but nearest one end, so as to maintain the proper length. (See Fig. 7.) In most cases the upper should be the short end, and naturally droop or lop over, but occasionally it is better to bend next the base. For specimens of more than two lengths two bends are necessary. They should be made with care in two respects: first, to see that the bends are *in the same plane*—*i. e.*, that they be so made that all three of the parts of the specimen will lie side by side upon a level surface; and, secondly, to see that they are in *opposite directions*, zigzag, or like the letter N (see Fig. 8). If care is taken in this latter particular, a three-lengthed specimen may be made to look better than a two-lengthed one. The basal and upper sections will be upright on the sheet and be nicely joined by the middle section, forming a diagonal between them. This is as far as the process of bending need be carried. Plants more than four feet high are generally too large to be collected entire. But sometimes it becomes important to give a specimen still a third bend, and this I very frequently do (see Fig. 9). The rule of making each angle the opposite of the one next to it must, however, be strictly adhered to in these as in all other cases; otherwise parts of the stem will cross each other and spoil the specimen. Neither must the idea be entertained that this is a matter that can be attended to afterwards; it must be correctly done in the field, and mistakes in measurements of lengths or in direction of bending can never be properly remedied in the herbarium.

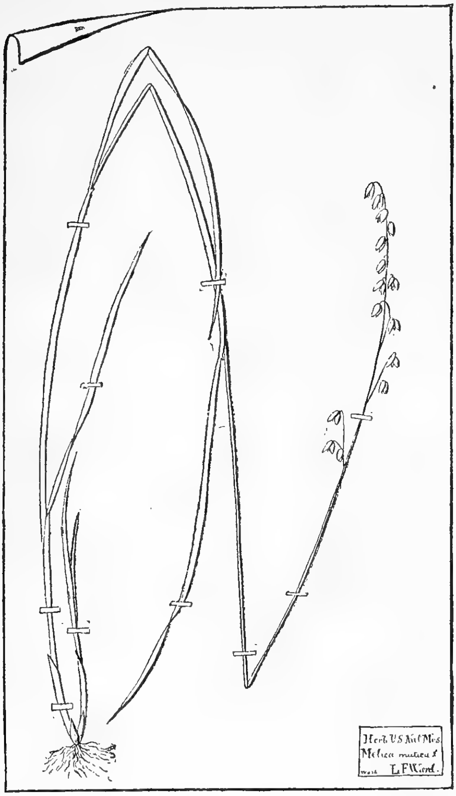

FIG. 8—Showing method of bending plant in shape of letter N.

"It is never a good plan to put two different plants between the same two leaves of the portfolio. The leaves adhere to each other, and become doubled, wrinkled, and matted in the effort to separate them. If the portfolio has not leaves enough to hold all the collections of a day, this of course may become necessary.

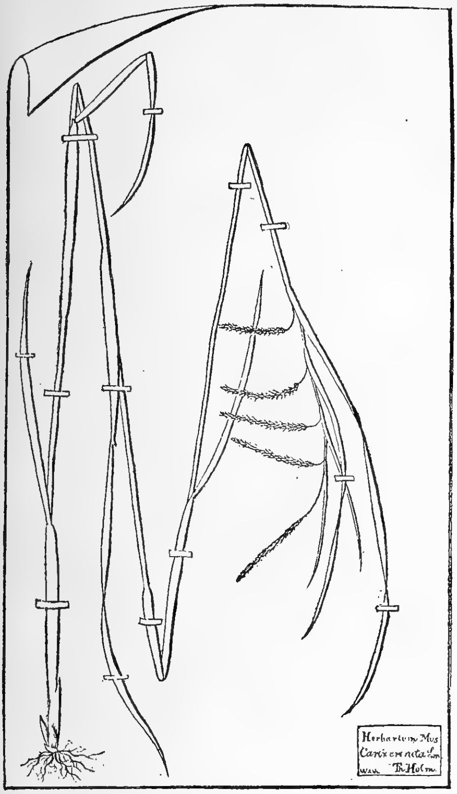

FIG. 9—Showing method of budding plant in shape of letter M.

"It is better to have a systematic method in filling the portfolio during the excursion. The plants should be placed next to one another between successive leaves, and not put in at random. This, besides giving an idea of the capacity of the portfolio at any time and showing how much has been done, is a great help in finding unoccupied space, which, when the book becomes nearly full, is very difficult where empty leaves are as likely to occur in one part as another." (Ward.)

The question of labeling the specimens is next presented. If the day's collection is only moderately large and made in a locality with which the collector is familiar, it is not necessary to attempt any kind of labeling in the field, as a glance at the plants as they are being put in the press will usually immediately call up numerous instances connected with its station and collection. The chronological arrangement of the specimens in the portfolio as recommended above will also be a great aid in this labeling.

If, however, the collection is made in a new locality it is always best to affix some sort of a label in the field, and it is always best to decide beforehand how many sets of specimens are to be made. If the expedition is a purely botanical one to a new region, it may be desirable to collect as many as 25 or 50 specimens of each species, but if the locality is better known or the time or space limited, 10 or even 5 specimens of each species may be selected as the number. Having decided upon the number the collector should *be sure to collect enough material to make up the full number of sets.* It is also a good plan to put in a few extra flowers or seed-pods or any of the characteristic parts of the plants collected, which may be used in dissections and study without the necessity of mutilating the specimens which are to be made up into the sets. Each species should be given a number in the field, as soon as collected. Opposite this number in the note book should be recorded everything of interest that relates to the plant; its particular habitat, relative abundance, size, color of its flowers, altitude at which collected, and everything in fact that the specimens themselves will not clearly show. This number, which may be conveniently written on small pieces of paper an inch or two square, should hereafter *always accompany the specimens*, for upon it depend all the data relating to them. If, when the plants are placed in the press, they occupy more than a single sheet, duplicates of this number must accompany them. *Never use the same number for two sets of specimens*, for, even if they appear similar, they will be collected at a different date and locality, and *never use the same numbers twice during the same collecting trip*, as it will almost certainly lead to confusion.

"The next step in the botanist's work is to preserve the specimens which he has collected. They should not be allowed to lie in the portfolio over night, but if it is imposible to attend to them all, then as many should be pressed as possible, beginning with those first collected (and this is another advantage in a methodical way of filling the portfolio). Those last collected may perhaps lie till the next morning, but if of a tender character or very juicy, it is best to slip in a dry paper on both sides of each specimen." (Ward.)

If it has been decided not to number the collection, as indicated above, temporary labels must now be written for each species, placed with them and kept with them throughout. All data not furnished by the specimens themselves must be placed on these labels.

Everything is now ready to put the plants in the press, the driers, thin papers, blank labels, or papers for numbers being at hand. Two or three driers are placed upon the one of the press-boards (cleat side down) and upon them is laid a sheet of thin paper. The plant is now placed on this thin paper with its leaves and flowers spread out, and all its parts placed in the position in which it is desirable for them always to remain. If the parts that have previously been bent are refractory and refuse to remain in the positions desired, they may usually be fixed by slipping over them pieces of paper in which slits have been cut (see Fig. 6). Grasses and carices often require treatment of this kind.

Thick rhizomas, tubers, or other thick stems must also be prepared before being placed in the press. Tubers had best be cut in half and a part of the inside removed. The cavity may be filled with cotton or they may be simply pressed flat. Rhizomas should have a slice cut from one side and the cavity made and filled as above described, or it may be pressed. They may become somewhat distorted by this process, but they will be less so than when kept entire, and the time required for drying them will be much less.

Having arranged the plant or as many plants as the space on the sheet will economically admit of, another thin sheet is placed over it and one or two driers placed on top. Upon this another thin paper is spread, the plants arranged as before and covered with a thin paper, and so on until the portfolio is exhausted or the pile becomes too unwieldy for convenient management. If the press is likely to become very full it is a good plan to have two or three half-inch pine boards of the same size as the press boards, which are occasionally inserted and will help to even up the pile. The number of driers required for each plant of course varies with the nature of the specimen. If it is large, thick-stemmed, or succulent, as many as four or five driers may be required, but if a small, delicate annual one drier will be sufficient.

The press being full or the number to be pressed having all been arranged, the upper press-board is placed on the top of pile and the pressure applied by means of the strap.

"How hard to press plants is still an unsettled question, and botanists differ widely upon it. My own experience has led me to make my first pressure quite light. The easiest way to strap up a press full of plants is to place them on the floor, with the knee upon the upper board, draw up the strap, and buckle it. The buckle should be made to come on the side from you, and be at first quite low down; as it is drawn it will rise, and should never be allowed to come up to the upper press-board.

"How long should plants remain in press? Never over 24 hours for the first time, and certain plants will suffer if left in so long. Much, however, depends upon the pressure. Those who press their plants hard must change them oftener. If the above suggestions are followed it is best to change the driers at the end of 12 hours. The second time they may, in most cases, be allowed to remain in 24 hours; after this they should be changed every day for about 4 days. The pressure may be slightly increased after each change, and after the fourth day it is usually safe and advisable to leave them in the press 2 days, then change and leave in 2 days more under hard pressure, after which they may be taken out, the driers renewed, and the package laid aside for a week, with merely a board or a book upon it." (Ward.)

The process of changing the driers is even more simple than that of pressing. The press, filled with the plants to be changed, is placed before you, on a table if possible, or on the ground, and the upper press-board taken off and placed beside it. The pile of fresh driers is placed by the side of the empty press-board, and one or two of the driers laid upon it. The wet driers above the first thin papers are taken off and the thin papers containing the plants are carefully removed to the new pile. Fresh driers are placed on the plants and another plant in the thin papers is added, and this process is continued until all the plants are changed from wet to dry papers.

"No amount of curiosity should tempt you to remove the upper white [thin] paper to look at a specimen. After a plant has been placed between thin papers, it should never again be in the least disturbed until it is fully dry. The access of the air and the separation of the leaves and flowers from the intimate contact which pressure gives them with the thin sheets deaden the lively color which the plants otherwise will preserve, and injure the specimens." (Ward.)

Sticky plants or seeds may be prevented from adhering to the papers by a liberal powdering of lycopodium spores or soapstone powder. Small pieces of oiled paper placed over adhesive fruits may often be practiced advantageously.

CACTACEÆ (CACTUSES.)

"Living cacti bear transportation well if young or medium-sized specimens are selected. The entire plant, or, if large, a joint or cutting, is thrown in the shade for a few weeks to shrivel, after which the specimens are wrapped in dry hay or moss and loosely packed in well-ventilated boxes.

"Treated in this way they preserve their vitality for from 6 to 16 months. Seedlings are easily raised from seeds thoroughly dried and packed in situ. If the fruit is large and pulpy it is sliced to facilitate the drying, and should be kept from moisture, but exposed to a free circulation of air.

"Herbarium specimens are best made by removing the flowers from the plant and pressing them separately in the ordinary way, after first sectioning some of them.

"When not too large the fruit may be dried in the same way, otherwise it is halved and excavated before being put in press, the seed being air-dried. The entire stem if small, or characteristic joints if it is compound, may be pressed till dry after allowing it to shrivel, or if it is too large for this, a piece is removed showing the top, the insertion of several bunches of spines and of the flowers, and some of the tubercles or ribs. Sometimes it is necessary to split and excavate these specimens, and cross-sections dried under light pressure are desirable. If the means of transportation permit, entire plants or well-selected parts are rough-dried without pressure. These 'skeletons,' preserved in boxes in the herbarium, are often more instructive than the more ornamental pressed fragments. When possible, it is also desirable to make alcoholic specimens of the flower and fruit.

"Cacti are at best poorly preserved for the herbarium, and should always be accompanied by the fullest possible notes and sketches made on the spot. Aside from the usual notes of locality, habitat, date of flowering, and period of fruit ripening, others should be taken upon the following points: In the trunk note habit, presence or absence of aerial roots, form and direction of branches, if compound; shape, form of articulations, if jointed; glabrous, granular, pubescent, or mammilated surface; and form of ribs and grooves when present, both in section and profile, especially near the apex of the stem. The last features are best shown in diagrams. Leaves are present in few groups, but when they occur their duration, size, form, and direction are to be noted. All cacti produce more or less wooly or prickly buds, known as areolæ, on which the flowers and spines are inserted. It is important to observe whether they are immersed or prominent, and their form and usual distance apart. Young and old areolæ should be compared, and particular attention given to the character and color of their wooly or bristly covering. The very characteristic spines occur on the areolæ, and differ greatly in number, relative location, size, form, direction, and color, all of which are to be observed. Diagrams aid in showing the form of the areolæ and the location and section of the spines. An important character is the stability of the spines, for in some species the areolae increase in size, and the spines become more numerous from year to year, while in others this change does not occur, and the spines may fall with age.

"Flowers usually come from areolæ on the sides of the trunk or on undifferentiated branches, but in some genera (*Melocactus ? Pilocereus.* etc.) the sterile and flowering parts are very different. The origin of the flowers (from old, 1-year old, or nascent branches) and their time of expansion (diurnal, nocturnal, or diurnal persisting through the night) should be observed, together with size, shape, color, and fragrance. The form and size of the (inferior) ovary and the shape, approximate number, and character of the reduced sepals that often cover it, with the nature of the wool, hairs, or spines in their axils, are all important, as are the shape, size, and coating of the tube of the flower. In a longitudinal section it is to be observed whether the lower part of the tube is naked or nectariferous within or not, together with the distance from the top of the ovary to the lowest stamens, the presence or absence of a vaulted arch partly closing the tube, and the form and disposition of the stamens. Any color peculiarities of these, and the color, form, and relative length of the style, and especially the stigmas, are to be noted. The shape, color, texture, taste, and odor of the fruit, the presence of scales, and the character of their auxiliary products should be observed, as also whether the flower is withering-persistent on the fruit or deciduous, and in the latter case the form of the resulting scar (umbilicus). The occurrence of few or many seeds is also important." (George Engelmann in *Botanical Gazette*, xi, pp. 135, 136.)

CRYPTOGAMOUS PLANTS.

MOSSES AND LIVERWORTS (BRYOPHYTA).

MOSSES.*

To collect mosses well one ought to have first made a study of their structure. However, an intelligent and enthusiastic collector will be able to distinguish between good and useless material, and to find rare species, even without such previous training.

First, then, learn to look for *mosses in fruit.* Most of the common species have the small capsules, which contain the spores, raised on slender pedicels, or setæ; other species, and these are more rare, have the capsules "immersed," that is concealed among the leaves. And it requires a more experienced eye to find such in the right condition. *Ripe* fruit is desired, since only in such the delicate fringes around the mouth of the capsule, and called the "peristome," are developed enough for study. But if the capsule is too ripe it loses its "lid" and "calyptra," two little cap-like bodies fitting into each other and covering its upper part and mouth. Some species need to be collected at two different periods to secure all these parts. Mosses are useless for study if the capsules are either too green or too old and weather-beaten.

Some mosses are diœcious, that is, the two sexes grow in separate patches, either near each other or quite apart. And since it is not possible for one not a student of mosses to determine whether a sterile sod consists really of male plants belonging to a fruiting species near by, it may be best that everything looking like a moss be included in the collection. However, unless there is plenty of time, the collector will do well to restrict himself to mosses with well-matured fruit.

Second, *where* do mosses grow? At first the collector will see only the larger common mosses. But gradually his eye becomes trained to see the smaller plants, and to discern those with immersed capsules. Every green patch is subjected to scrutiny. Mosses will be found to grow where none had been suspected: on a shady wall, moist precipice, a weathered bowlder, an old stump or fallen log, the trunk of a tree, a clay bank—even on the driest sandy prairie these little plants are found

Third, *how* shall the mosses when found be collected and cared for? Some species grow in dense cushions. These it is best to separate from the soil and then cut into perpendicular slices in the direction of the upright stems. Or, after removing the soil and rubbish, the sod may be separated into slices with the fingers. The plants thus prepared are put away into paper pockets, which are conveniently folded before starting on the trip.

Other mosses grow in dense tangled mats. If time permits, these should be taken up, the fruit-bearing plants picked out and put away in pockets. So should all small mosses from clay banks, bowlders, or

* By John M. Holzinger, assistant botanist, U. S. Department of Agriculture.

trees be put in pockets. The object in thus disposing of the material is to prevent the mixing of the species and the loss of the smaller parts. Always write the date and place of collection on the pocket. These can then be tied into bundles of ten each. Pressure greater than this is not necessary, and frequently harmful. The bunches are laid in the sun or near a warm stove to dry. The only care needed is to turn them over frequently the first few days, and change the inside pockets to the outside.

In case there is neither time nor facilities for disposing of the mosses as directed above, it is sufficient to take common newspaper and carefully wrap up the separate cushions or sods. On long trips extending over weeks it may be found necessary to let material dry, bunched in this way. This answers fairly well if the bunches are dried promptly and are then protected against crushing. Whenever convenient they may be remoistened and separated and cared for properly.

Lastly, a word on *how much* to collect of each species. When a moss is found in good fruit, *always collect abundantly*. There are several reasons for this precaution. First, a sample of a moss should not be understood to mean a few plants with fruits, but of a pocket comfortably full of plants. And a number of such samples ought to be secured for each species if possible. Secondly, a new species may be discovered. In such a case to have gathered only a small amount would always be a source of regret. Still another reason is the fact that some species are found to be common in a locality one year, and then to disappear from it for a long period or entirely.

With these suggestions it is hoped that new collectors will be able to secure useful and valuable material.

LIVERWORTS (HEPATICÆ).

"Hepaticæ in general are best collected late in the fall, during the winter or early spring, the Jungermanniaceæ about the time or a little before they send up their fruit stalk. All are best collected before they shed their spores." (E. A. Rau in *Botanical Gazette*, XI, p. 141.)

Much of what has been said in regard to searching for and preparing mosses will apply to the liverworts. They grow on old logs and stumps, trunks of trees, stones, and on damp ground. They may be removed entire from the matrix or may be taken with a thin shaving of the log, tree or soil, upon which they grow. They should be dried under very moderate pressure, and may be kept in envelopes or pockets.

LICHENS.

Lichens are to be found in a great variety of places, but principally on rocks, trunks of trees, stumps and decaying logs, and on the ground. When they are found growing on a soft matrix, such as soil, logs, or trunks of trees, they can usually be removed with a strong sharp knife by cutting just under them and removing a thin layer of the matrix;

but when they are attached to rocks it will be found next to impossible to remove them, and as thin a stratum of the rock as can be obtained without injury to the plants must be taken with them. These rock-growing lichens are generally very brittle, and care must be taken not to crush them. On this account lichens can best be collected during or just after a rain storm, as they are then less liable to injury, being freely hygroscopic.

"In collecting lichens I find it a great convenience to have along with me some small paper bags, such as grocers use. They take up very little room until wanted, and lichens put into them may be prevented from rattling around and breaking to pieces, as many of them will do if thrown into a box." (F. Le Roy Sargent in *Botanical Gazette*, XI, p. 142.)

The crustaceous forms will require no care in drying, but the larger foliaceous ones may be dried under a very light pressure. All should be collected, as near as can be determined, in fruit.

FRESH-WATER ALGÆ.

Fresh water algæ occur in a great variety of situations, such as ponds, quiet or sluggish waters, cascades, ravines, shaded and dripping rocks, shallow, quiet angles of lakes, and even rapid running brooks or rivers. The implements required for collecting them are simply some appliance for securing them from the water, such as a dredge or dip-net, and a number of wide-mouthed vials. The larger filamentous forms may be well preserved in pieces of brown paper a few inches square. The bottled-material may be preserved in good condition for many months by the addition of a few drops of carbolic acid.

"It may be well to bear in mind that the freshest and brightest green forms are not usually the most desirable. Among the older and more unsightly material more mature and fruiting specimens may be found."—(Francis Wolle in *Botanical Gazette*, XI, p. 148.)

Desmids are most frequently found in abundance in clear, pure water, as pools fed by springs, ponds of clear water, etc. They are found attached to the stems of aquatic plants and other submerged objects. They may be obtained by dipping or by stripping the stems and leaves of water plants. Sphagnum moss which is growing under water is a very fruitful source for them. They may be preserved in vials or mounted as microscopic slides in cells of glycerine, water with a small amount of preservative fluid, or in the especially prepared mounting media.

Nostocs may be preserved between sheets of glass or put on pieces of mica and dried in the air.

MARINE ALGÆ.*

Marine algæ may be collected (1) by hand, as from uncovered rocks

* From notes communicated by Prof. Edward S. Burgess.

and stones and tidepools, and from heaps of refuse, especially tangled masses of eelgrass (Zostera), after storms. (2) By net (a shallow net of fine mesh on a stout rod; net not over six or eight inches in diameter) from the margin, especially of the *incoming* tide. (3) By a scraping-net, from piles at the sides of wharves; scraping-net like the preceding net, but the net deeper and attached to an iron rim shaped like ᗜ, the straight side to be used as a scraper. (4) By dredge or grappling-hook from the bottom in deeper water.

Succulent or slimy algæ must be exposed to the air or soaked in fresh water before mounting. Coarse or wiry or cartilaginous or firm species, especially if composed of many fine branches, may be preserved temporarily by rolling them up dry in a little sand in newspaper or other packages.

Card mounts.—To mount seaweeds at the shore: Having brought in your specimens in a pail of sea water, or, if delicate or particularly choice, each separate in a wide-mouthed bottle of sea water.

(1) Wash the plant in sea water; few species will bear fresh water.

(2) Float the plant in a basin of sea water (as a washbowl), or fresh water if it will bear it without change of color or substance.

(3) Place under the floating plant a card of requisite size, or sheet of thick unsized firm paper, on which the plant is to be mounted. See that the paper or card is uniformly wet and as clean as practicable.

(4) Raise up the card with plant on it; let the center of each coincide; distribute and arrange the branches in as natural and separate a manner as may be; this is best done by the action of the sea water itself, as it flows off from the card in raising it out of the water.

(5) Let the specimen drip a moment, then press under light weight between driers or between newspapers under a board.

In pressing, specimens may be treated much as flowering plants, with these differences:

(1) Put a piece of cotton cloth over each specimen to prevent its adhering to the paper over it.

(2) Use little weight; much weight will leave the print of the cloth in the specimen.

(3) It is well to note on the paper before immersing into water *date, place, and habitat.*

To mount microscopic slides of marine algæ:

(1) Do it at once from sea water or later from specimens preserved in alcohol.

(2) Firm specimens may be mounted in cells in glycerine jelly (a few will bear Canada balsam).

(3) Delicate specimens may be mounted in cells in King's marine algæ mounting-fluid (obtained from Queen's, Philadelphia, 912 Chestnut street; Educational Supply Company, Hamilton Place, Boston, or from Rev. J. D. King, Edgartown, Massachusetts).

(4) Dried specimens should be soaked first in the fluid or in brine; a few will bear glycerine.

(5) Slides of some service for microscopic use may be quickly prepared at the shore by drying small specimens or fragments on thin pieces of mica (1 by 3 inches or less), moistened by water when studied.

FUNGI.*

SAPROPHYTIC FUNGI.

The woody fungi found growing like shelves from the sides of old logs, stumps, and trees should not be avoided by the collector since they are the easiest of all specimens to collect. Many of the thin small specimens of this sort found on dead sticks may be put in press along with other plants and tied up in the same packages. All the larger and thicker forms may be simply wrapped in paper with their labels tied or pinned on them and packed away in boxes.

With the moister and more fleshy fungi the difficulties of preservation are very great, so much so that with most of the fungi known popularly as mushrooms and toadstools it is simply impossible to make satisfactory herbarium specimens. Some of the species are gelatinous. Others break down into a jelly a few hours after maturity. With all these extremely fleshy species the only way to preserve their form and color is to make colored sketches soon after collection. These with the spores saved on paper will help make up the deficiencies of the specimen. The spores are saved by cutting off the cap from its stalk and laying it on a sheet of white paper with the gills down. In a few hours the paper will be found covered with the spores. If the gills are light-colored black paper may be used, as light-colored spores will be more readily seen on it. The best way to preserve the specimens themselves is to dry them out in the sun or with artificial heat properly regulated. Under this treatment the more leathery ones will retain their form and color fairly well, but the putrescible species will not amount to much. After the specimens are thoroughly dry they may be exposed to damp air either in a box or out of doors in the evening, and while so softened put under pressure for a day or so. Do not sprinkle water on the specimens. The object is simply to dampen them enough to take away their brittleness. It is not necessary to press these dried specimens. They may be simply wrapped in paper and packed into boxes.

PARASITIC FUNGI.

The various kinds of parasitic fungi known commonly under the names of rusts, smuts, mildews, blights, etc., are important objects for the collector. While many thousands of species have been described from various parts of the globe new ones are continually being found even in the best studied regions. Extensive collections in almost any

* By M. B. Waite, assistant mycologist U. S. Department of Agriculture.

section are seen to yield returns in new species and new forms. The number of species of these tiny plants, spoken of under the various names of parasitic fungi, microscopic fungi, and leaf fungi, often nearly equals that of the flowering plants in the same area. The great bulk of the species are found on flowering plants, but a few occur on ferns and mosses and some are found parasitic on other parasitic fungi. Some of the species on account of their unusual size and abundance on their host plant or their unusual destructivness are sufficiently obtrusive to be seen by everybody. Such are the orange rust of blackberries and raspberries, the so-called cedar-apples and their alternating forms, the rusts on thorn-apples and crab-apples, the smut on Indain corn and many others. Other species are easy enough to find as soon as they are looked for, but might readily pass unobserved. Such are most of the rusts and mildews and many of the spot diseases. Again others are so inconspicuous as to be seen only by the experienced mycologist. To excel in collecting these plants it is necessary to know something of the science of mycology, and like most any other department of natural history it is of great aid in collecting to know at least a little about the botany of the group in order to know what to look for.

In general one looks for discolorations of the host plant, for spots on leaves and stems, and for languishing or diseased portions of the plants; for, looked at from the standpoint of the host plant, these minute fungi and their injuries on their hosts are called plant diseases. Close examination of the diseased spot, with perhaps the aid of a lens, will reveal the delicate dustlike spores or minute tufts of the parasites themselves.

In starting out on a collecting trip one should provide himself with a good hand lens of rather high power (a $\frac{1}{2}$-inch Coddington or Triplett answers very well), a good pocket knife, some wrapping paper and string, and either a portfolio or a tin collecting box, according to whether it is desired to press the plants in the field or after return to quarters. One should also carry some envelopes and a few pill boxes. Where large quantities of material are to be collected and when time in the field is more valuable than time at home the box will be found preferable, for the specimens can be hastily gathered into it in the field and then put in press at leisure at home. On the other hand, when it is desired to do most of the work in the open air some form of portfolio or hand press may be carried.

First the procedure with the box will be given. Most of the fungi will be found on the leaves. These the collector picks off the plant and ties up in a bunch with a bit of string or rubber band. Unless the leaves are particularly characteristic of the host plant the collector should secure the flowers, fruit, or other parts of the plant which will aid in its identification or which will be a guaranty for this identification. A small branch with the leaves attached is a good deal better than the mere leaves. With grasses always secure the panicles. Wrap the flowers, panicles, etc., with the bunch of leaves, and if you wish to write the label in the field insert it also. With grasses and all narrow-leaved plants it is best to gather them into a straight wisp and cut them with a knife into sections about 6 inches long. These will make herbarium specimens of convenient size and are easy to tie up and pack away tightly in the box. In case of plants with small leaves, sprays of a suitable size (4 to 6 inches long) may be cut with the knife and tied up in a bunch. Large leaves may be cut into smaller sizes. A leaf over 6 inches square is usually best cut up. In case of small specimens, which may be lost or scattered, they should be wrapped up in paper or in a large leaf or else put into envelopes. Small fragile things, such as slime-molds (*Myxomycetes*), may be put into pill boxes.

In regard to the quantity of duplicates of each number, the collector must of course depend largely upon his judgment. Botanists usually secure greater quantities of a rare fungus or one in unusually fine condition than of the common things. Where it is the object to secure a certain number of sets, it is of course desirable to collect sufficient of each for that purpose. In case of fungi, a single infected leaf may be made to constitute a specimen, but it is better to count about three or four average sized leaves as a specimen, and if sparsely affected, more, and one or two of the sprays of small leaves.

In collecting fungi try to get the parasite on as many different parts of the host as it can be found. Do not be satisfied at finding it on the leaves alone, but get it on the stems, flowers, and fruits if it occurs there. Some fungi produce their different forms on different parts of their host. Others again produce these different forms on different hosts, and the skilled mycologist will keep an eye out for the associated host plants and their fungi.

Upon your return home the specimens are to be put into press. Most leaf fungi will keep in the tin box for a day or two in a cool place without injury, but since others will scarcely keep overnight, it is best to put them in press as soon as possible. For this purpose a supply of driers and thin paper are needed of the same quality and size as that used in pressing flowering plants. The folded sheets of thin paper will be found better for fungi than the single sheets, because it is easier with them to keep the leaves from falling out of the packages. The packages of fungi are taken from the box and, if not labeled before, are labeled. The leaves are spread out over the sheet of pressing paper until it is completely covered. If there are still more of the same number, another sheet is taken until all are in the papers. These extra sheets should receive the same number as the first, and should always be kept next to it in all the subsequent changes of driers. Another number is then taken out and treated in the same way. Never put specimens of two different numbers in the same sheet. The pile is pressed and dried precisely the same as in flowering plants. In case of some of larger and more delicate forms, like *Æcidia* (cluster cups) and *Rœstilicæ*, it will be wise to take them out of the general pile and put them under very slight pressure to avoid crushing the cups.

If the portfolio or hand press is chosen, the operations are about the same, only that the folded sheets of pressing paper and a few driers are carried into the field. The specimens are labeled and placed between the papers just as described above as soon as gathered. Upon returning home the sheets of specimens are placed between fresh driers and put under pressure.

A very light, strong, and serviceable portable press may be made with some thin slats of tough wood and a rather large shawl strap. The slats are made into two lattice-work frames, which enclose the papers, the shawl strap going around the whole.

When the sheets of specimens are dry they are taken out of press and usually the contents of two or three sheets combined into one, provided they all have the same number. If there are still two or more sheets of the same number, they should be placed together in a folded sheet, so that in the pile of finished specimens each folded sheet represents one number. These are then tied up into packages about three inches in thickness, and if desired a tag may be pasted upon one corner, which will hang down over the end, so that the package can be identified from the outside. If the package is to stand shipment, it should be inclosed in rather tough wrapping paper and a cardboard or a drier placed on each side and firmly tied up with stout twine. Such a package of plants will be found elastic and durable, and will stand any reasonable amount of rough handling without injury.

PRESERVATION OF PLANTS IN ALCOHOL.*

COPPER TANK.

For the satisfactory preservation of alcoholic specimens of plants the following articles will be found useful and economical: Four one-gallon copper tanks, each to contain three-fourths of a gallon of 75 per cent alcohol. The four tanks should fit tightly into a strong wooden box so that they will stand with the covers up, and the box should be furnished with strong hinges and lock.

TEST-TUBES.

The common chemical test tubes are satisfactory. They should be five inches long and be provided with cork stoppers. The number to be taken will of course depend upon the extent of the expedition. A small label of strong white paper should be tied by a strong string to each test tube. The tubes should be kept in some kind of a box, so arranged as to have them packed in closely, and should, like the other box, have a strong lock.

* By Theodore Holm, Assistant in Botany, U. S. National Museum.

LABELS.

The labels may be made of strong white paper cut into pieces one by two inches and each provided with a strong string. These are to be used for the larger specimens that are put into the tanks.

DIRECTIONS FOR COLLECTING.

The collector should then, besides preparing specimens of plants for the herbarium, also preserve some of the material in alcohol. Many larger flowers, fruits, rootstocks, and roots are so fleshy, that their preservation by drying does not give very satisfactory results. These should therefore be preserved in alcohol—the larger specimens in the copper tanks, the smaller in the test tubes; and the collector must needs show great care in the preservation of the larger flowers, for instance, in not putting these in the same tank with fruits, rootstocks, etc. It is a good plan to wrap up the large flowers loosely in a piece of paper or a leaf before putting them in the tank.

As to the labeling of the specimens, it is to be recommended that the collector keep a diary and write up very carefully the character of each locality from which specimens have been collected. It would be easiest for the collector to give each species a number, written on the label, and which should refer to the same number in his notebook. He could then, as prescribed above, make several notes in the diary, without needing to copy them on the labels attached to the specimens. It will always be a great help to the botanist who shall later identify the collection if the accompanying notebook contains as much information as possible. The collector should therefore never forget to indicate the station, for instance: Pond, swamp, shaded wood, sunny hillsides, etc., besides a few remarks upon the plant, as, for instance, a tree, vine, herb, etc., and the color of the flowers and fruits, if observed ripe. The diary should then contain notes, as for instance:

(1) "Fruit of a tall, woody, climber; very fleshy, deep red. Flowers and leaves dried as number 54."

(2) "Flower of aquatic, floating plant, light blue. Leaf dried as No. 73. Lake near X, State Y; depth nearly 2 fathoms."

(3) "Rootstock of herb, whitish, bitter taste. Leaves and flowers dried as number 90. Dry plains near X, State Y."

In regard to the material, which it would be advisable to preserve in this manner, the following list might be quite sufficient to give the collector a general idea about it:

FLOWERS.

Large and rather succulent flowers, like those, as for instance, of orchids, pond lilies, etc., are to be carefully wrapped as prescribed above, labeled, and put into one of the tanks.

Very small flowers, with minute details, should be preserved in test tubes, and never more than one species in each tube. These do not need to be wrapped up. It would be the best to take the whole inflorescence, or at least a part of it, if too large, instead of removing the flowers.

FRUITS.

Of large fleshy fruits, as, for instance, berries and drupes, at least one should be preserved of each species. Each should be carefully labeled and put into the tanks, and it will not hurt them to be mixed in the same tank with the several others if they are securely labeled.

A few drupes or berries of smaller species may be preserved in test-tubes.

ROOTSTOCKS.

Succulent, thick rootstocks, as, for instance, tubers, bulbs, etc., should be preserved in tanks or test tubes, according to their size. The collector must dig the plants up very carefully, and always dry a few specimens entire, while he, concerning the rootstocks for the preservation in alcohol, can cut off the stem above ground with the flowers and leaves if the specimen is too large; if not, one specimen might be preserved entire in alcohol.

ROOTS.

If the collector should meet with plants of which the roots seem to show peculiarities in regard to their size or shape, a few of such should be preserved in alcohol.

AQUATIC PLANTS.

Branches with flowers, fruits, leaves, and a few roots of floating or submersed plants, should be preserved in this manner, besides those to be dried for the herbarium. The collector must always, when collecting aquatic plants, pay attention to the green water-mosses (*Algæ*), of which some specimens should be preserved in the tanks; they should then be wrapped up in paper, tied closely together, and labeled.

FUNGI.

All soft and fleshly specimens of mushrooms can merely be preserved in alcohol. Larger specimens can easily be divided into smaller pieces, but the section must be made in such a manner that the shape of the fungus will be recognized; the sections must therefore always be made vertically through the middle of the mushroom.

It is, however, to be remarked that the collector must always take into consideration the consistence of the plants or parts of these before he decides to preserve them in alcohol. He must never put larger fruits in the tanks if he is not certain that they can not just as well be dried, and in regard to the smaller flowers, only the more delicate forms, as small orchids, etc., should be preserved in the test tubes. The minute flowers of rushes, grasses, sedges, and other dry flowers will usually be able to keep their shape as dried for the herbarium.

COLLECTION OF SEEDS.

There is a general lack of seeds in collections, since little or no attention has been paid to this important branch of botany. The collector should look carefully for the seeds of plants, and should secure a good quantity of as many species as possible. They may merely be wrapped in paper, kept dry, and marked with the same number that has been given the other parts of the species collected for the herbarium. The collector should also dry with the herbarium specimens some of the smaller succulent fruits, besides those prescribed above, as well as preserve a few in alcohol.

III.—Preparing Plants for the Herbarium.

CARE OF THE DRIED PLANTS, POISONING, ETC.

After the plants have been collected and thoroughly dried, there still remains a considerable amount of work outside of their scientific identification that must be done to them before they can be finally incorporated in the herbarium.

After the plants have lain a week without pressure and become thoroughly dry, they may be taken out of the driers and thin papers and placed in the herbarium. They are usually first transferred to rough paper of some kind, either double, and placed between the folds, or, as I prefer, single, and simply laid on with their labels. System is useful in all things, and many valuable specimens will be saved by observing certain rules even in such simple matters as this. The papers upon which the specimens are placed should be ample, say 18 by 12, or at least 17 by 11 inches, and should be of uniform size. Many such papers will be in constant use in the herbarium, and a reserve package should be kept on hand. They need not generally be bought, as nothing is better than common newspapers, especially if the paper is moderately strong and heavy, and nearly every one has a surplus of these; but it is well worth while to cut them to a measure. In laying off the plants the thin papers should be systematically restored to their general package without having to move them twice, and the driers released for further use. Only one or two driers will be needed for each specimen after the last change, when they are laid away to dry out. It will often happen that there are several specimens of the same plant. These are to be placed either on the same sheet or on sheets immediately following them. No sheet should ever be left without the proper number or label for the specimens accompanying it, for, as stated above, everything depends upon the proper labeling of a specimen.

A botanist's collection always consists of two departments: the *herbarium* proper and the *duplicates*. The former he arranges in strict botanical order, sees to it that it contains a perfect specimen fully represented of every plant he has ever collected, and adds to it as many other plants as he is able to obtain through the process of exchanging, or in any other way. The latter contains a large number of specimens of each of the rarer plants of his local flora, and eventually he will add to it other rare plants obtained from other sources. It does not aim at completeness, but simply to supply a foreign demand and serve as a means of increasing and enriching his herbarium proper. As this approaches completion, therefore, the other is reduced in volume.

In putting away the fully dried plants they are accordingly divided into these two classes, a part going into the herbarium and a part to the duplicates. Where several specimens of the same plant are collected, which should only be done where the plant is in demand, all but one, of course, are relegated to the duplicate department, and usually without further ceremony. Specimens selected for the herbarium, however, require still another form of treatment. They must be *poisoned.* Let no one think that this can be dispensed with. As certain as that it requires the proper cycle of seasons for it to grow, so certain will the time come when if left unpoisoned it will be devoured by the insect pests of the herbarium. Neither have much confidence that this can be done after mounting, and thus waste neat and costly glazed paper by mounting them first. The insects naturally work on the under side of the plant, where the poison can not be applied after it is down. The labor of poisoning is, perhaps, the least pleasant of all kinds of herbarium work, but its absolute necessity should at once dispel all hopes of evading it.

There is an almost complete uniformity among all botanists as to the kind of poison to be used, the accepted substance consisting of corrosive sublimate and alcohol, the proportion being one ounce of the former dissolved in one quart of the latter diluted 25 per cent. The mode of applying it varies considerably. The use of the camel's hair brush is slow and tedious, but consumes the least poison, and may be defended on economical grounds, though not likely to be as thorough as other methods. Probably the best way, all things considered, is first to fill a trough or large platter with the poison and then dip the entire plants in the liquid, handling them with tweezers, and letting them drip before laying them aside. After poisoning, they should be immediately placed in dry papers; otherwise all the pains taken to press them nicely will be in vain, and their colors will vanish after all. This can be prevented by care, and once changing will be sufficient. It is not necessary to use regular driers for this purpose—newspaper is good enough; and it will be found very salutary to use, for drying out the poison, sheets of paper designed for the duplicate department or for general use. The habit of the insects is to bore through the sheets on which the plants are laid. They never go round the ends of them, but eat circular tubes downward or upward through the paper until they find a suitable habitat. If all the papers in the herbarium are saturated with the poison, they find themselves greatly restricted in their operations, and as it is not usually deemed worth while to poison duplicates, it is a great protection to them to have them in poisoned papers. The temporary label should be kept with the plant throughout the poisoning as throughout every other process.

It will not be found necessary to poison most of the cryptogamous plants, such as mosses, liverworts, horsetails, algæ, and sterile ferns, as they are mostly of loose cellular structure. But fruiting ferns had best be poisoned, and this can be done by sprinkling better than by immersion, as they are likely to have the color destroyed if again thoroughly wetted. The fleshy fungi and all leaf fungi must be poisoned or they will be speedily destroyed. The specimens should be immersed in the alcoholic solution of corrosive sublimate as recommended for flowering plants.

MAKING AN HERBARIUM.

The poisoning of plants is the last strictly preservative process, and we are now ready to consider the more advanced stages of botanical work necessary to the orderly disposition of the plants identified, collected, and preserved.

The usual course, upon which no useful innovation can be here proposed, is to keep each genus, unless too large, in one folded sheet of very heavy paper, called the "genus cover," to be labeled with the name of the genus on the lower left-hand corner, and to mount the plants on fine white paper, about 16 by 11 inches in size, and place these sheets in the genus covers. The specimens thus prepared should be kept in the latest approved order according to the natural system of classification, in cases either permanently made for the purpose or portable. These cases should consist of partitions, 13, or better, 14 inches wide, 4 or 5 inches high, and 19 inches deep, arranged one above another in several vertical tiers; these dimensions to be all in the clear, and clear of door jambs. The doors, which should consist as much as possible of glass, should, if practicable, be so hung that when swung back the edge will be flush with the inner vertical sides of the cases, *i. e.*, leaving no shoulder for the genus covers to catch upon in drawing them out.

The labeling of the orders is somewhat difficult on account of the perpetually growing and changing character of the herbarium. If labels or tickets are attached to the edges of the shelves, they are sure to require removal in a short time, which disfigures the cases. The best arrangement known to me to avoid these consequences and label the families is that of portable *order covers*. These consist of good, stiff boards (pasteboard) of the same width as the genus-covers and a little longer, to one end of which flaps of the same material are attached by means of strong binder's muslin pasted to both pieces, so that when the large board lies on the package of genus-covers the flap will fall down over their ends and present a vertical surface, upon which the name of the order or orders in the package is placed. The flaps will be 3 or 4 inches wide and as long as the board to which they are attached is wide. In the course of time it will often happen that orders once placed in one partition and labeled on the flap will have to be taken out and put in another. In such cases the names must of course be erased from one flap and written on another. The principal objection to this system is that it requires time and trouble to remove the order-covers every time a plant is wanted. Upon the whole, it is perhaps better to do without order-covers entirely until the herbarium becomes quite large and complete. If the plants are kept in the natural order, you will soon become so familiar with it that you will know within one or two partitions where any plant is at any time.

It is not a mere accident that I have mentioned the general character of the herbarium before mentioning the important process of *mounting* plants. This is the finishing stroke of the whole work and should not be hastily rushed into. A plant once mounted is generally fixed for all time, and this should presuppose that it is not only known botanically, but approved as a suitable specimen to adorn a cabinet. If rare, and not likely to be found again, of course it should be mounted, even though in itself imperfect, but in so far as the local flora is concerned, this is very seldom the case.

For these and other reasons I would advise the postponement of the work of mounting until after considerable experience has been acquired in collecting and in a general herbarium work. Some botanists never mount plants. They urge with considerable force that this renders them incapable of further study or examination, which any plant is always liable to require. A specimen once mounted can not be turned over for the purpose of seeing the other side, where the two sides differ, as is generally the case. To meet this objection, such plants when mounted must be in duplicate, or so much so as to exhibit both surfaces. In the case of ferns, for example, nothing less than the mounting of two entire specimens will generally suffice.

Plants may be nicely kept without mounting by placing them in double sheets of ordinary paper, and these in genus-covers the same as if mounted. For increased safety, the fold of the species-cover may be placed in the reverse position to that of the genus-cover. The name of the species may then be written on the species-cover or on a white slip and pasted on the outside of it, to save opening any that you may not wish to examine. No two species should ever be placed in the same cover, and where it is desired to preserve several specimens of the same species these may go inside the species-cover on separate sheets of paper.

The objection to this plan as a final one is that much handling, especially after the specimens become old, breaks them up and destroys them. It is also more trouble and requires more time to open the species-covers than to look at the mounted page. In the latter case there is a quick method of looking a large genus through as you would a book. It is held in the two hands, with the right (open) edge elevated at an angle of about 45° from the table, and while the two thumbs rapidly separate the edges of the sheets from the upper towards the lower ones the eye glances at each label attached to the lower right-hand corner of each sheet until the plant sought is reached. This would scarcely be worth mentioning were it not for the fact, as every one will early find out, that by far the greater part of the references to the herbarium will be in search of species belonging to large genera. Very large genera should be divided and kept in several genus-covers, and it is an excellent plan to write on the outside the names of all the species in a genus cover.

Upon the whole, then, it is doubtless best to mount the specimens of the herbarium, but this should not be undertaken at first or until considerable experience has rendered one skilled in selecting the very best specimens both from a scientific and an artistic point of view. A new beginner will never afterwards regret having waited at least three years before mounting any of his plants. By this time he will have seen many other herbariums and received the specimens of other older botanists in exchange to compare with his own, and will then possess some valuable ideas on the whole subject. This, therefore, though probably the most complicated part of a botanist's work, is, when thus viewed, the one upon which the least pains need be expended in describing the process, since if the proper course is pursued from the beginning he will be sure to have already picked up nearly all the needed information respecting it before he undertakes to apply it to his own collection.

The two principal methods of mounting may, however, be briefly described. These are, first with glue and second with gummed strips. In the first case ordinary fish or carriage glue may be employed with complete satisfaction, since it may be used cold and thus avoid the necessity of having appliances for heating as required by common glue. The kind commonly sold as Le Page's Liquid Glue is in every way satisfactory. The manipulator should be provided with a piece of common window glass a little larger than the ordinary herbarium paper. The glue considerably thinned with cold water is to be spread in a thin layer evenly over the glass and the plant laid gently down into the glue, taking care to have all prominent parts touch the glue. The plant is then lifted from the glass and placed carefully on the herbarium sheet, which is ready at hand to receive it, and in the exact position previously determined to be the best. Each specimen should be first applied to the white sheet on trial for this purpose. A dry cloth is then used to remove any excess of glue that may have been spread on the paper, and to press down any part of the plant that is inclined to lie badly; the mounted sheet is laid down at one side, a few sheets of paper (newspaper or brown paper) are laid upon it, and a board (a press-board will do) is placed upon these. Another plant is then mounted in the same manner, the board removed, the mounted plant placed on the papers previously laid down, more papers put on this, and the board restored. This process is repeated until all the plants are mounted. The mounted sheets will be ready to place in the genus-covers the next day. When the mounting is completed, the weight on the pile should be increased.

The temporary labels should be kept constantly with their plants. Final labels should not be written until the plants have been mounted. To economize time these should consist as far as possible of printed blanks. In mounting, care must be taken to leave a sufficiently large space at the lower right-hand corner for the label, and if, as often happens, more than one plant requiring separate labels go on the same sheet, room for all the labels must be provided for prior to mounting. The following forms of labels have been used in the herbarium of the National Museum:

HERB. U. S. NATIONAL MUSEUM.

Hab.

Leg.

EX HERB. U. S. NATIONAL MUSEUM.

Hab.

Leg.

FLORA OF ARIZONA.
Collected in the San Francisco Mountain.

No.

Collected by F. H. KNOWLTON. 1889.

The method of mounting with gummed strips, while it perhaps requires more time and work, is in many respects a pleasanter one than that with glue. In this case sheets of the same paper used for mounting, or similar paper without lines, are gummed entire on one side with mucilage. It is cheaper to make the mucilage from pure gum arabic by simply soaking it in the proper amount of tepid water. To this, however, it is much better to add a small quantity of glycerine, which prevents, to a great extent, the tendency of the gummed sheets to roll up at the edges on drying. To gum the sheets, lay them on a flat board or other surface and fasten each corner with a pin gently driven through the paper into the board (which should be of soft wood). It will be found a great saving of trouble to have the board just a little narrower and shorter than the sheet to be gummed, so that the mucilage can be applied to the edges without danger of sticking to the board. A brush of any convenient size may be used to lay on the mucilage. The latter should not be too thick, otherwise the coating will be uneven, but at least two coats will be required to give it the proper adhesive power. The second coat is put on after the first has become dry. If several sheets are gummed at one time, which is the best way in order to consume all the mucilage made at once, they may, when dry, be kept in a large book or under some pressure to prevent them from rolling up.

To cut the strips shears are not to be recommended, although with skill they may be used. The difficulty will be to cut them of a uniform width. It is better to cut them with a sharp knife on a broad piece of pasteboard to a straight-edge. For this latter a thin board, six or eight inches wide and considerably longer than the sheet to be cut, is much more manageable than a narrow rule. The under surface of this board should be rough and the edge smooth. The point of the knife must be kept sharp, and it should have a thin blade. An ordinary shoe-knife is better than a jackknife or penknife. An ink-eraser is a tolerable substitute. The average width of the strips should not be over 1½ lines, but occasionally a wider one will be needed for thick stems. One sheet may be cut up at a time and when consumed another cut. The long strips thus cut may then be, most of them, cut into short pieces of from half an inch to two inches in length, the ordinary length required being about three-fourths of an inch. A few long strips should be left uncut for special cases as they arise.

In mounting with gummed strips, the specimens may be deliberately adjusted to the sheets and then fastened down. A wet sponge is needed to moisten the strips which are placed over the stems, peduncles, petioles, etc., wherever they are required to make the plants secure. They should generally be placed over the tips of pointed leaves, and may lie over some flowers without concealing their essential parts. In putting them down, care should be taken to bring the whole of the gummed surface into contact with the paper, except only as much as is occupied by the plant, which needs to be tightly encompassed and snugly held down to the sheet. This is best done by a pressure of the thumb-nails along both ends of the strip towards and closely up to the plant.

As to the relative merits of the two modes of mounting, it may be said that perhaps for very large herbariums, which are in constant use, the method with glue is the best, since the tenderer parts of the plants are thus firmly held to the sheets, and not liable to be damaged. This method, however, is not sufficient in cases of terete stems, and needs to be supplemented by strips over such parts. The objection to the strip method is that it conceals some parts of the plants and makes the sheets look less natural. But, if carefully and tastefully done, this objection need not have great weight. On the other hand, it has this important scientific advantage, that if mistakes are made the plants may be taken off, and if very essential they may be removed uninjured, turned over, or studied. With many botanists these considerations preponderate largely, and it is probable that they come to have more and more weight as experience points out the defects of the glue system. For small or private herbariums, therefore, the strip system is, I think, upon the whole, to be preferred.

In mounting plants, by whatever method, a few precautions will be necessary. The majority of specimens are small enough to admit of putting two or more on a sheet. Unless very small, no two from the same locality should be mounted together, except where they differ in some important respect, which it is desired to show. But a sheet is vastly improved where specimens of the same plant, from widely varying localities, are grouped together upon it. In the course of a botanist's travels and exchanges, he will obtain duplicates of this kind. Some seem to have an idea that if they have a plant, no matter from what source, this is sufficient; but an herbarium consisting of only one specimen of each species would be next to valueless, though it should thus embrace a large part of the flora of the country or the globe. Instead of putting everything into the duplicates of which you happen to have a representative, it should first be ascertained whether a new plant is from a different locality from that of any you already have mounted; if so, mount it at all events, and if possible on the same sheet. The first specimen mounted on a sheet ought to go on the right-hand side, so that its label will naturally occupy the lower right-hand corner. Without crowding it out too near the margin, care should be taken not to waste space by putting it too near the middle so as to prevent another specimen from being mounted on the left of it. If lacking in any of the particulars which should be represented, and can be obtained from the local flora, such as fruit or radical leaves, these should be procured and added to the sheet before specimens from other localities are given a place. The date, etc., of collecting these additional parts should be added to the label, or, if they seem to require it, a new label may be written for them. Where only two specimens fill a sheet, one of the labels should occupy the right and the other the left corner; if three go on, the third label may occupy the middle of the lower edge of the sheet. In the case of very small plants, several specimens are needed properly to represent each plant. The lower half of the sheet may first be occupied and afterwards, if additional specimens are obtained from other localities, they can occupy the upper half, with the labels under them in the middle of the sheet.

In fastening down the labels it is not best to gum the entire surface, as they will then roll up, warp, and assume a wry position which can never be cured afterwards. This can, it is true, be prevented by immediately putting that corner of the sheet into a clamp and leaving it there till dry, or by using heavy weights, but this is generally difficult or impracticable where a large number of labels are to be put down at one time. By gumming only a narrow portion of the upper margin of the label there will be no warping, and I recommend this plan. It is proper, however, to state the objection to it, which condemns it in the eyes of some. This is, that in handling the plants one is apt to take hold of the loose portion of the label and tear it off. I have never yet torn one, and do not think the objection serious, but at least it need not be, if the sheets are manipulated with the thumbs and near the middle, in the manner described a few pages back. If pains are taken in putting down the label to have its outer edges fall a trifle inside those of the sheet, there will be no danger of ever taking hold of the label.

PREPARING CRYPTOGAMS FOR THE HERBARIUM.

The directions given for preparing flowering plants for the herbarium will largely apply to the preparation of cryptogams, but several of the groups require additional manipulation. Many small plants, such as mosses, liverworts, parasitic fungi, and lichens, are best put in envelopes or pockets, which can then be attached to the regular herbarium sheets. These pockets, which should be of various sizes, may be made by folding a piece of paper so that the under part shall project about three-quarters of an inch beyond the upper; then fold the projecting part over the other, making the top of the pocket. Then turn under the right and left edges for a distance of three-quarters of an inch, and press firmly so as to make permanent creases when the paper has been folded. The pocket is attached to the sheet by a small spot of strong glue in the middle of the back. The label should be attached on the top of the pocket. These pockets may be made of different sizes to accommodate various specimens.

In some cases it may be found an advantage to use herbarium sheets of a smaller size than the regular herbarium sheet, as they can be more easily handled and are less likely to be injured and will occupy less room in the herbarium. But if the collection is likely to be very large it will probably be better to use the regular herbarium sheets, which can then be placed in proper order in the general herbarium.

Large specimens, such as lichens on rocks, may be sometimes attached directly to the sheet, but such are probably best kept in small pasteboard boxes, and the whole fitted into the trays of a cabinet. A very convenient box for such specimens can be made of the regular herbarium sheet size and three or four inches deep, which will fit into the compartments of the herbarium case.

Algæ and all plants of this character should have the sheets upon which they are floated out glued to the regular herbarium sheets.

The larger fleshy fungi (also seeds and fruits) can only be kept with satisfaction in small pasteboard boxes in a cabinet, unless preserved in alcohol.

CARE OF DUPLICATES.

Some botanists pay little attention to their duplicates; arrange them in no definite order; keep them in parcels, each summer's collection by itself, or in other unsystematized ways, and depend upon memory to hunt out anything they may want to find. This is in a high degree reprehensible, and really occasions great loss of time. Others arrange them in the alphabetical order of the genera, which is much better, but is not to be recommended. It is best to arrange them carefully, according to the natural system, the same as the herbarium.

How to label the cases of so shifting a mass has been a serious difficulty. I have heard very few plans of doing this suggested, and I think nearly all botanists leave them without labels, and depend upon memory to start in wherever they think their plant may be. I will give my own method, which has worked admirably, and which eminent botanists have admired and expressed an intention to adopt.

Strips of white paper, 19 inches in length, are cut of two widths, one kind 2 inches wide, the other 1 inch. The former are used for genus strips, the latter for species strips. Every genus is furnished with one of the wider sort, and its name is written across one end, which projects far enough in front to leave the name in full view, and when the doors are closed this end bends down so as to present it clearly to the eye. If the genus contains only one or two species, or even three, species strips are not used, but for all genera represented in the duplicates by four or more species, each species is also provided with a strip. Between the genus strip and the first species a sheet of paper intervenes, so that the two strips will not lie upon each other. Single sheets are alone used to put duplicates on, and great facility is thus secured in handling them. The plants occupying each partition are placed between large-sized pasteboards, the upper one of which is thinner and more pliable than the lower. This latter feature will be found a great improvement upon the use of two stiff boards.

B.—FOSSIL PLANTS.

I. Implements for Collecting:

Hammers, pick and shovel, iron bar, chisels, explosives, collecting bag, wrapping paper, field labels, notebook.

II. Wrapping and Packing Specimens for Shipment.

III. Collecting Fossil Plants.

IV. Care of Specimens in the Laboratory.

Implements for Collecting.

HAMMER.

The implements that are indispensable in the formation of a collection of fossil plants are really very few; in fact, it may be said that if the occasion absolutely demands it they may be reduced to a single implement, viz, a hammer. A hammer of some kind can not be dispensed with, and preferably it should be of the form indicated in the figure (Fig. 10). It should be made of well-tempered steel, and should have the striking face square. The peen should be long and moderately thin, and should be flattened at right angles to the handle, or in the opposite direction to the bit of an axe. The weight of the hammer should not exceed one pound. The handle should be very strong but light, and should not be over 12 inches in length.

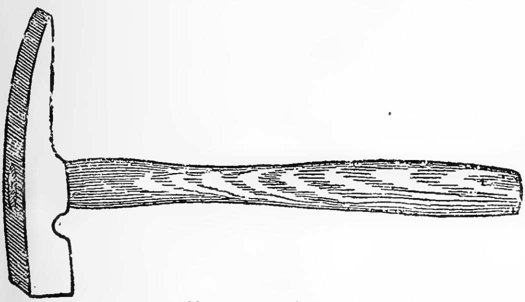

Fig. 10—Hammer.

This form of hammer will be found very serviceable in digging and prying up partly loosened material. It may be carried loose in the hand, but if the expedition is to be long in the field some other method of carrying it had best be adopted. Thus, it may be carried in a belt worn around the body, or it may be placed in the collecting bag to be described later on.

A heavy hammer or sledge may in some case be found of great service, such as breaking up hard nodules, or in reducing blocks of stone that do not split readily in definite lines. It will hardly be found profitable to carry a large hammer of this kind on a long expedition when, as is so frequently the case, transportation is an important item. Very good work can usually be done, even on refractory material, with the small collecting hammer.

PICK AND SHOVEL.

A pick, especially the kind known as a prospector's pick, will often prove of great value, when a mass of débris must be removed in order to get at a particular plant-bearing bed. This form of pick has one prong drawn out to a slender point, while the other is truncated and sharpened into a cutting edge. If a pick is to be carried from place to place it should be light, and be supplied with a slender but strong handle which can be removed from the head.

A shovel will often be of great service in removing débris from excavations, uncovering strata, etc., but usually it will not be found desirable to burden an expedition with this implement, unless a locality is to be visited in which the plant-bearing beds can only be reached by excavating. It is at all times a convenient thing to have, but can be dispensed with.

IRON BAR.

As in the case of the pick and shovel, an iron bar, such as that used by quarrymen, will frequently be serviceable; but likewise it can be readily dispensed with.

CHISELS.

Implements of this kind will not usually be found necessary, yet in some cases they may be employed to advantage, as in removing specimens that are exposed on the surface of very large blocks or on a slab that can not be removed. A furrow can be made around the specimen with a chisel, and it can then be split off. The chisels should be made of well-tempered steel and should be of various sizes.

EXPLOSIVES.

The use of explosives can only be undertaken under certain conditions, and then with caution; but when a large mass of rock is to be removed or brought down they may be employed successfully. The kind to be used and the methods of handling them must be determined for each particular case.

COLLECTING BAG.

The collecting bag is a very valuable adjunct in collecting, and can not well be dispensed with. It should be made of thick, stout leather, and should be 12 inches wide, 4 inches thick, and 12 inches deep, and should have one side extend as a "flap" over the top and fully 6 inches down the opposite side. The "flap" should have a strap and strong buckle to hold it down to the side of the bag. It should also be provided with a strong leather strap 2 inches wide, for carrying the bag over the shoulder. All parts of the bag, but particuarly the shoulder strap, should be securely riveted in place, so that it may be subjected to rough usage without readily being injured.

If the expedition is to make use of saddle animals, at least two of these collecting bags will be found desirable.

Of course anything may be used as a substitute for these regularly made collecting bags according to the exigencies of the occasion, but some sort of receptacle for convenient transportation of specimens in the field *must* be provided.

WRAPPING PAPER.

This is one of the most essential things and can *never be dispensed with.* The quality to be selected is of little consequence, but particular care should be taken that the *quantity* be sufficient. Old newspapers make probably the best wrapping paper. A very good kind is firm manilla paper, such, for instance, as the kind usually employed by hardware dealers.

The wrapping paper must be taken into the field each day and the specimens wrapped as fast as they are collected, or at least as soon as they are ready to be taken to the general headquarters or are to be packed for final shipment. Never attempt to carry unwrapped specimens loose in the collecting bag, for they will almost surely be ruined.

FIELD LABELS.

Some form of label must be prepared in the field that will supply all necessary information concerning the specimens. This information may be either carefully written out on each label or the label may bear a number or reference to the page of a note book in which all the data may be recorded. It is in all cases, however, better to put on the label the locality and date of collecting, so that the specimens may have always with them part, at least, of the data respecting them. Unlabeled and unknown specimens are of very little value. If the expedition is to be an extensive one, printed labels, like the following in form, may be found convenient and time-saving:

<table>
<tr><td colspan="2">FIELD LABEL.
UNITED STATES NATIONAL MUSEUM.</td></tr>
<tr><td>Note book
Page</td><td>Date:</td></tr>
<tr><td colspan="2">Locality:

Formation:</td></tr>
<tr><td colspan="2">Collector:</td></tr>
</table>

NOTE BOOK.

The collector should always be provided with a note book of some form, in which are to be recorded the facts and observations, usually too voluminous to be readily accommodated on the labels. The memory unaided can not be trusted to retain with accuracy the whole history of the specimens.

II.—Wrapping and Packing Specimens for Shipment.

If the specimens as they are brought in from the field still retain their wrapping in good condition, it may not be necessary to rewrap them, but in most cases, and especially if the journey by rail is to be long, they had best be rewrapped. It takes but a moment to do this, but by this precaution many valuable and fragile specimens may be transported in safety for very long distances.

The size of the packing box will depend entirely upon the character of the specimens. If they are large and preserved in a firm matrix, the packing box may safely be of good size; but if the specimens are fragile, such as thin shale, clay, etc., the box must be small, and they must be amply wrapped. In either case the specimens must be packed firmly in the box and the box *completely filled* before closing. Spaces between the specimens, if such occur after all have been put in that the box will comfortably contain, should be filled with paper or some bulky material, such as fine hay, shavings, etc. Do not, however, use hay, straw, excelsior, sawdust, etc., as a substitute for the wrapping paper, for the specimens will almost certainly be ruined.

III.—Collecting Fossil Plants.

It is difficult to give explicit directions for collecting fossil plants, for the conditions under which they occur are so various that what will apply to one locality will be of little value for the next. It must simply be borne in mind that the principal object is to get the specimens in as nearly perfect condition as possible, and, further, to get a complete representation of the flora of each deposit. It is not to be understood that only the absolutely perfect specimens should be saved, for as a matter of fact very few specimens are ever obtained that are perfect in all parts. The character of the matrix and state of preservation of the plant-remains must also be taken into account. A shale, for example, that splits readily is better fitted to preserve plants than a coarse sandstone, and a specimen that would be poor for the former would be good for the latter. Again, the geological horizon from which they come may make them of the highest interest. A few seemingly worthless fragments from a horizon that rarely bears plant-remains may often be of greater interest than a fine collection from a well-known locality or horizon. Therefore no one should be discouraged because the remains seem fragmentary, as much can frequently be made out with very poor material. But care should be taken to get as complete a representation as possible.

In collecting in any locality it is well to get out as large a series as possible before selecting the specimens to be taken. In this way many nearly valueless specimens may be discarded at once, for, with a large number to select from, the really good material can be readily picked out. Fragments that illustrate essential or important characters should be taken, such as the tip of a leaf, a petiole with a small part of the leaf attached, a good, perfect base of a leaf, or a well-preserved portion of the margin. By the comparison of a good series of such fragments a thorough and satisfactory idea of the form, size, and character of the leaf may be obtained. A leaf with no part of the margin preserved can usually be discarded at once, with, of course, the limitations mentioned above. Enough should be taken to illustrate the species if it can be obtained.

In collecting ferns the most valuable specimens are those found in fruit, and nothing, no matter how fragmentary, that shows the slightest tendency to be fruit-bearing should be discarded. A chance fragment may frequently settle important biological questions.

Specimens that are accidentally broken are not to be discarded as worthless, for they can be easily mended with strong glue and made nearly or quite as good as before. Parts of the same specimen should be kept together if possible; that is, each should be wrapped separately and the whole wrapped in a single larger bundle. The repairing is best done in the laboratory.

Counterparts or reverse impressions should be carefully preserved, and also kept together. These reverse impressions are frequently of great assistance in the study of the specimen.

Much work can be done in the field in the way of reducing the size of the specimens; that is, just as much of the matrix should be removed as possible *with safety* to the impression that is preserved upon it. The distance and means of transportation must be taken into account and the specimen treated accordingly. If it is preserved, for example, in a thinly laminated shale, very little reduction of the size of the specimen should be attempted, but if the matrix is firm much can safely be removed. On the other hand very fragile specimens, such as clay, had best be sent in in bulk and broken up afterwards.

IV.—Care of Specimens in the Laboratory.

The first thing to be done with a collection of fossil plants after unpacking and unwrapping them will be to attach a small label to each specimen. These labels may conveniently be made of green paper, which should be cut into small circular pieces three-fifths of an inch in diameter with a common harness punch of that size. Upon these labels a number is to be written that is called a lot number, and opposite this number in a book, kept for this purpose, is to be recorded all the information at hand concerning the specimens, such as locality, collector, horizon, etc. The same number will be placed on all the specimens that were obtained by the same collector, at the same place and time. They may then be moved about and grouped in various ways during the time they are being studied and yet can always be identified by referring to the catalogue. The labels should be attached to the specimens with strong glue, and care should be taken not to put them in a place that will obscure an impression preserved upon the rock or be in the way of any excavation that it may be desirable to make on the specimen.

It will often happen that in specimens brought in from the field a larger or smaller portion of the leaf or vegetable fragment will be still covered up in the matrix. With a number of small chisels and a light hammer this obscuring material can be entirely removed, thus exposing oftentimes a perfect leaf or other organ. The chisels should be sharp, of various sizes and made of the best tool-steel, as chipping many kinds of rock will be very hard on them. With a little experience the overlying material can be skillfully removed without injury to the specimen. The size of the hand specimens can also frequently be advantageously reduced without injury to the impression. For reducing the size of specimens a small hammer with square faces should be used. By holding the specimen firmly in the left hand and delivering a sharp, quick blow with the hammer a small fragment may be removed without breaking the specimen. In this way the specimen may be reduced to almost any desired size or shape, so long as it does not interfere with the impression preserved upon it.

The specimens of fossil plants after they have been prepared and studied should be kept in trays of suitable depth in a cabinet prepared for the purpose.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

NOTES ON THE PREPARATION OF ROUGH SKELETONS.

BY

FREDERIC A. LUCAS,

Assistant Curator of the Department of Comparative Anatomy.

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1891.

NOTES ON THE PREPARATION OF ROUGH SKELETONS.

BY FREDERIC A. LUCAS,

Assistant Curator of the Department of Comparative Anatomy.

These directions for preparing rough skeletons have been divided into sections, in order that the collector might turn at once to the portion bearing directly on the subject in hand. The general directions for mammals, however, apply with more or less force to all skeletons.

The extent to which these instructions can be followed will of necessity depend largely on circumstances. It is not to be expected that a collector working in the field would use the same time and care as one residing on the spot or located for some time at one place, but as one well prepared, *perfect* skeleton is worth more than half a dozen mutilated specimens, a little time spent in the work of roughing out and packing will be well repaid.

IDENTIFICATION OF SPECIMENS.

It is, of course, extremely important to know the correct name of every skeleton, and whenever possible this should be attached to the specimen, but it is a mere waste of valuable time to endeavor to identify specimens in the field.

When the animal is unknown, its skin, roughly taken off, should be kept, or the skin of another specimen should be prepared in the usual manner, in order that it may serve as a means of identifying the skeleton.

LABELING.

The best method is to have a series of numbers, stamped on pure sheet tin, and provided with a string for tying them to specimens, the numbers being recorded in a notebook.

Unfortunately these tin numbers are not always to be had, and a very good substitute may be made by cutting Roman numbers on a block of wood.

If labels are used let them be of good stout manilla, as thin paper is apt to be torn or defaced.

Do not use wire of any kind to fasten tin or lead numbers to specimens that are to go in alcohol or brine, for this sets up a galvanic action which results disastrously.

SELECTION OF SPECIMENS—FRACTURES.

Where time allows, select a series of skeletons of different ages; but where only one skeleton can be prepared, choose a fully grown, adult animal, as free as possible from fractures. If an animal is shot or trapped it is impossible to avoid breaking some bones, and such must be allowed to pass, but where it has been beaten to death, fracturing the skull and limb bones generally, the animal had better be thrown away at once.

If the skull alone is broken, select if possible another of the same size and send *both* with the body. When convenient send with a broken leg or wing another of the same size, but on no account throw away the fractured limb.

Do not neglect any animal simply because it is common, for a common species may be anatomically important.

TOOLS.

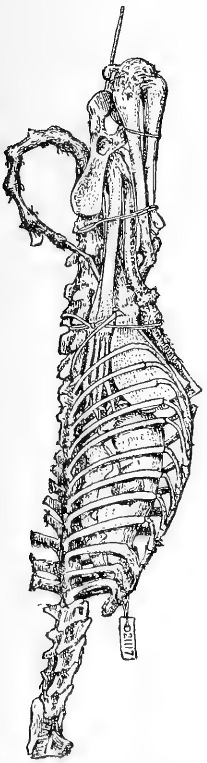

FIG. 1.—Skeleton of Fox ready for packing.

A knife and a pair of scissors are all that are absolutely necessary, but if these can be supplemented by one or two steel scrapers, the work will be greatly facilitated.

"ROUGHING OUT"—MAMMALS.

If an animal is rare, the skin should be very carefully taken off and preserved; otherwise, remove the skin roughly and disembowel the specimen, taking care not to cut into the breastbone, especially the disk-shaped piece of cartilage in which it ends. Animals destined for skeletons should *on no account* be split up the breast as though they were being dressed for market.

Detach the legs from the body and remove the flesh, taking care in so doing not to remove the collar bone or kneepan with the meat. In the cat family the collar bone is very small, and lies loose in flesh between the shoulder blade and front end the of breastbone. The collar bone of weasels is very minute and difficult to find, while, on the other hand, climbing and burrowing animals usually have this bone well developed, uniting the shoulderblade with the breastbone.

Deer, antelopes, bears, and seals have no collar bone.

In small quadrupeds it will be unnecessary to detach the legs, but, whenever convenience in roughing out or packing renders this needful, cut the collar bone loose from the breastbone and leave it fastened to the shoulder blade.

The legs being finished, disjoint and clean the skull. Be careful in removing the eyes not to thrust the point of the knife through the thin portion of the skull back of them and in deer, antelopes, or other ruminants, take care not to break through the thin bone back of the upper teeth. Also be careful not to cut off any projections of bone.

Remove as much of the brain as possible with a scraper, bent wire, or small stick.

In cleaning the ribs take care not to cut the cartilages joining them to the breastbone, and, when the tail is reached, look for a few little bones projecting downwards from the first few vertebræ.

Fold the legs snugly along the body, or, if they have been detached, tie them together with the skull on the under side, as much as possible within the chest cavity; also turn down the tail and tie it upon itself.

Roll up in a bit of rag and fasten *securely* to one of the long bones any bones which may have been detached or any splinters from a broken bone.

Hang the skeleton to dry in the shade,* where it will escape dogs, cats, and rats.

Lastly, in case a small skeleton is likely to be some time on the road, give it a very thin coat of arsenical soap to preserve it from the attacks of Dermestes and other insects.

On *short* collecting trips the poisoning may be omitted and the specimens treated when they reach their destination, but where small skeletons are to lie for some time uncared for, they should be poisoned, otherwise they may arrive in a very much mixed and dilapidated condition.

The breastbones of large animals should also be well poisoned.

The *best* method of poisoning small specimens is to dissolve arsenic in hot water, and when the solution is cold soak the skeletons in it for an hour or so. All the small rough skeletons stored in museum collections, as well as those in the stock of dealers in natural history material, are or should be thus treated. The addition of a little washing soda will cause water to take up much more arsenic than it otherwise would.

Should any of these small specimens be needed for disarticulated skeletons the arsenic can be extracted by soaking in a hot solution of washing soda.

* In this as in many other particulars the collector will necessarily be governed by circumstances, for in moist climates, or on shipboard, it may be needful to dry specimens in the sun, or even by the aid of a fire.

SPECIAL POINTS.

Embracing the upper part of the windpipe and connecting it with the base of the skull is a series of bones known as the hyoid apparatus. This should be carefully saved.

There are usually small bones, termed sesamoids, embedded in the tendons, where they play over the under sides of the toes, and on this account the tendons should never be cut off close to the bone.

There are often one or two small bones on the back lower portion of the thigh bone; these should be left in place.

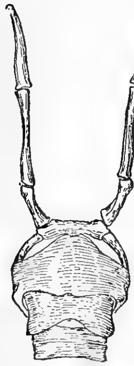

FIG. 2.—Tongue bones or hyoid of a Dog.

FIG. 3.—Right shoulder blade of a Rabbit, showing the backwardly projecting process.

In preparing the skeletons of rabbits particular attention should be given to the shoulder blade, as this has a slender projection at the lower end, which extends some distance backward.

The male organ of a great many quadrupeds, as the raccoon, is provided with a bone. As it is difficult to say when this may or may not be present, it should always be looked for, and when found left attached to the hip bones.

CETACEANS: PORPOISES, BLACKFISH, ETC.

Porpoise skeletons are very easily prepared, but one or two points, such as the slender cheek bones and the pelvic bones or rudimentary hind limbs, require special care.

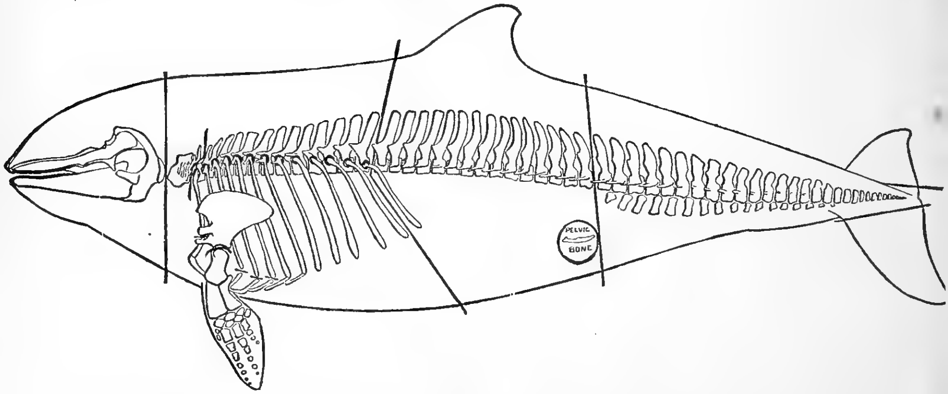

FIG. 4.—Skeleton of a Porpoise, the dotted lines showing where the cuts should be made in dividing the skeleton.

The pelvic bones are so small and so deeply imbedded in the flesh that they are only too often thrown away. The accompanying cuts show their location and their average size in a specimen 7 or 8 feet long.

FIG. 5.—Full-sized pelvic bone of a Porpoise (*Tursiops*).

It often happens that the last rib lies loose in the flesh, with its upper end several inches from the backbone. This should always be looked for.

There are no bones in the *sides* of the tail or flukes nor in the back fin, and they can be cut off close to the body and thrown away.

The hyoid is largely developed in most cetaceans, and will be found firmly attached to the base of the skull.

BIRDS.

In preparing a bird for a skeleton a little more care must be used than is necessary with a quadruped, the bones being lighter and more easily cut or broken.

The wings terminate in very small, pointed bones, and there is a similar bone—corresponding to the thumb of mammals—hidden in a tuft of feathers on the bend of the wing.

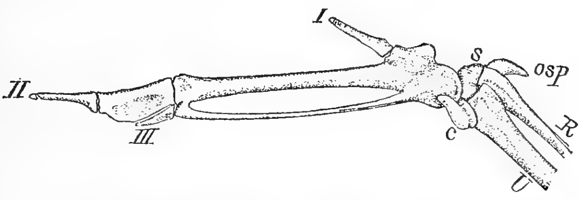

FIG. 6.—Portion of right wing of Great Horned Owl, seen from below. *R*, Radius; *U*, Ulna; *I*, *II*, *III*, First, second, and third fingers; *s*, Radiale; *c*, Ulnare; *osp*, Os prominens.

It is a good plan to leave this tuft untouched, as well as the outermost two or three wing feathers, so as to lessen the risk of removing any of these little bones with the skin.

Other parts requiring special attention are the slender points on the under side of the neck vertebræ, those projecting backward from the ribs, and the last bone of the tail.

It frequently occurs in birds that many of the tendons become ossified, as they do in the leg of a turkey. Look out for such on the under side of the neck, in the legs and wings, and along the sides of the back, and do not tear off the muscles as you would if preparing a skin.

In many, possibly most birds, the neck and back can be left untouched, as the muscles will dry up and a thin coat of arsenical soap will serve to keep out the Dermestes which would otherwise attack these places.

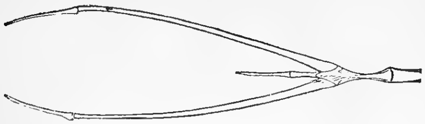

FIG. 7.—Tongue-bones or hyoid of a Great Blue Heron.

The hyoid bones, which support the tongue and are attached to the windpipe, should be saved, as should also the windpipe itself whenever, as in many ducks, it has bony structures developed in part of its length.

FIG. 8.—Eye-bones, sclerotals, of a Great Blue Heron.

In many birds, and especially in birds of prey, there is a ring of bones surrounding the pupil of the eye. It is therefore best—unless you are an expert—not to remove the eyeball, but to simply puncture it to allow the escape of its fluid contents.

Remove the brain carefully.

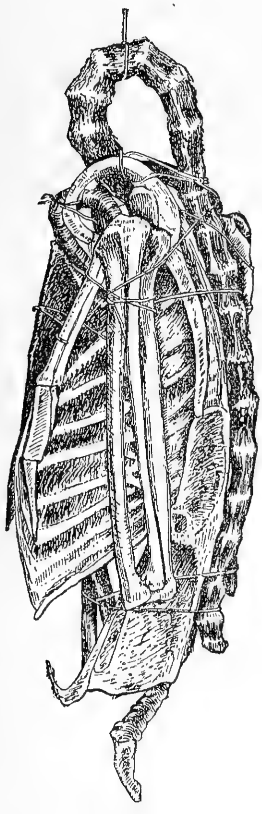

FIG. 9.—Skeleton of a bird ready for packing.

In making the skeleton into a bundle for packing, bend the neck backward, detaching the skull if necessary, and fold the legs and wings closely alongside of the body.

SPECIAL POINTS.

Cormorants have a small bone attached to the back of the skull, and in Auks and many similar birds there is a small bone at the elbow.

Sometimes there is a little bone at the hinder angle of the lower jaw, so that it is a good rule not to trim up a bird's skull too closely.

The easiest, and in many ways best, way to collect small birds is to place them entire in alcohol first making an incision in the lower, part of the abdomen to allow the alcohol to reach the viscera.

Alcohol should not be used of full strength (95°), the proper proportion being one-quarter water and three-quarters alcohol.

TURTLES.

In order to rough out a turtle it is usually necessary to remove the under shell or plastron, although some species, such as certain of the large land tortoises, can be roughed out without doing this.

In sea turtles and a few others the plastron can be cut loose by taking a little time to the operation, but in the more solidly built tortoises and most fresh-water turtles it is necessary to saw through the bone, following the line indicated in the accompanying diagram.

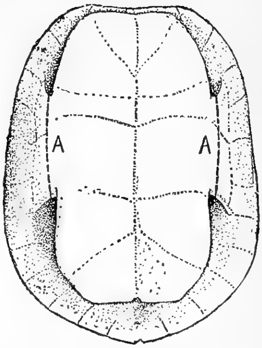

Fig. 10.—Shell of a Turtle (*Chrysemys marginata*). A A, where cuts should be made to remove the lower shell or plastron.

The interior of the body being exposed, it is a comparatively easy matter to cut away the flesh.

Usually this can be done without disjointing any of the legs, and it is better, especially in small specimens, to leave them attached to the body. Beware, however, of cutting into any bones, as they are frequently soft in texture and easily damaged.

SNAKES.

Snakes require very little care in their preparation after the skin has been removed, but in the larger serpents, such as boas and pythons, rudimentary hind legs are present and should be carefully preserved.

Fig. 11.—Limb of a Python (*P. molurus*), full size.

Externally the legs appear as two little claws situated on either side of the vent; internally they are slender bones, about an inch and a half in length, loosely attached to the ribs.

It is a comparatively easy matter to preserve both the skin and skeleton of any good-sized snake by exercising a little patience.

Do not try to skin through the mouth, but make a long cut on the under side and skin either way from it.

Coil up the skeleton and it will make a very compact bundle.

CROCODILES.

The breastbone of crocodiles extends the entire length of the body, and although the hinder portion of it is not attached to the backbone, yet great care is necessary in disemboweling not to cut away any of the slender bones of which it is formed.

There are also cartilaginous projections on the ribs which should not be sliced off in roughing them out.

FISHES.

Fishes vary so much in their structure that it is a difficult matter to giver any directions for preparing their skeletons that would be of much service. Almost invariably there are two rows of ribs present, and these extend backward for some distance.

Proceed slowly and carefully, as the edge of the scalpel will often give notice of some unsuspected bone.

Be especially careful about the head. There is a chain of bones encircling the eye, and the eyeball itself is often a bony cup.

Occasionally there are two or three bones attached to the back part of the hinder portion of the head, and the patch of flesh on the cheek is about all that can safely be removed.

When the skeleton is hung up to dry place bits of wood or other material between the gills so that the air may circulate freely and dry them rapidly.

Fishes, small reptiles, and toads and frogs can be best collected by placing them in alcohol.

PACKING.

First be sure that a skeleton, and especially a small one, is thoroughly dry. Otherwise it is apt to " sweat" and rot the ligaments.

In the case of a large skeleton this would do no harm, but as the bones

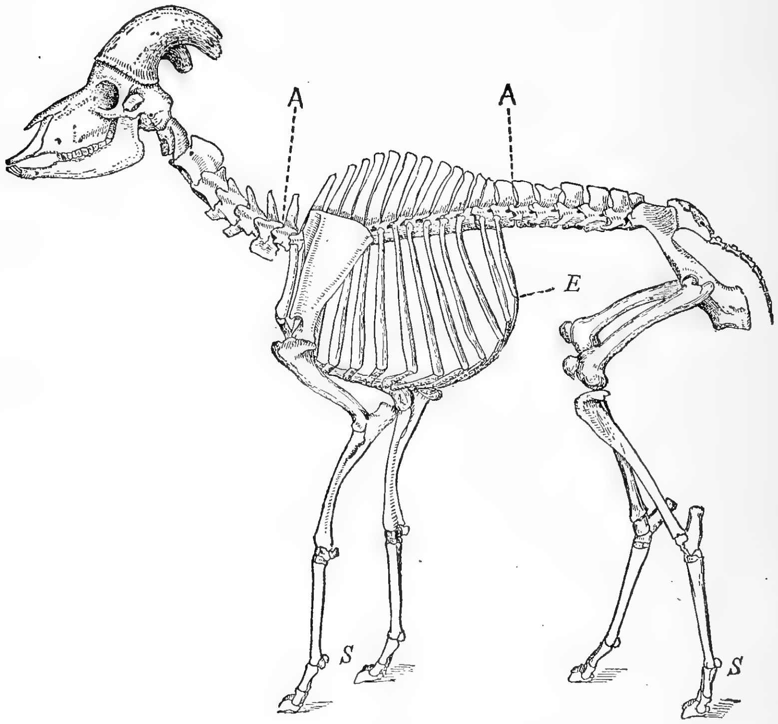

FIG. 12.—Skeleton of Mountain Sheep; AA, places where backbone may be disjointed; E, place where cut should be made to separate rib from breast-bone; S, sesamoids.

of small animals are left attached to one another by their ligaments and are not wired together, any such separation causes serious injury.

If the specimen is the size of a deer, it will be necessary to disjoint the backbone just behind the ribs in order to make a compact bundle.

A moose or buffalo can be cut up still more by separating the leg-bones at each joint and making several sections of the backbone.

Occasionally it is necessary to reduce a skeleton to its smallest possible dimensions, and then, in addition to the above measures, the breast-bone must be separated from the ribs by cutting through the cartilage *just below the end of each rib.* The ribs can then be detached from the backbone, and thus dismantled a good-sized skeleton can be packed in a flour barrel. Barrels, it may be remarked, are very useful for packing purposes.

Boxes should be tight, so as to shut out hungry dogs and prevent entirely the attacks of rats and mice. I have frequently seen valuable skeletons that were ruined in a single night by the ravages of one or two rats.

Care should also be taken not to leave boxes open over night while being packed, lest mice should make a nest in the packing material and be shut up with the specimens.

Straw or hay is the best packing material, but Spanish moss, shavings, "excelsior," or cocoa fiber will serve the purpose. Usually but little is needed, the main point being to prevent the skeletons or loose bones from rattling about.

Beware of sea weed for packing. No matter how dry it appears to be, it contains so much salt as to become wet when exposed to a moist atmosphere.

Never put alum on a skeleton, nor soak any bones in a solution containing alum.

In hot, moist climates it is occasionally allowable to sprinkle a little salt on the bones of a large animal in order to keep the flesh from putrefying instead of drying. Some aquatic animals, such as seals and porpoises, can be packed in salt without detriment to their bones, a fact that is often of great advantage when such animals are collected on shipboard, where it is often difficult or even impossible to dry large skeletons.

Small skeletons should on no account be salted, nor should large ones be boiled to remove the flesh.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR COLLECTING, PREPARING, AND PRESERVING BIRDS' EGGS AND NESTS.

BY

CHARLES BENDIRE,

Honorary Curator of the Department of Oölogy.

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INSTRUCTIONS FOR COLLECTING, PREPARING, AND PRESERVING BIRDS' EGGS AND NESTS.

By Charles Bendire,

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In making a collection of nests and eggs, it is of the utmost importance that the identification of all specimens taken should be absolutely correct. The only sure way to accomplish this is to secure the parent at the same time. This should at least be done with all the less known and rarer birds, and continued until the collector is thoroughly familiar with the breeding habits, nesting sites, and eggs of the species in question.

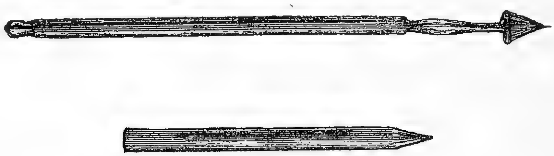
Unless the would-be collector intends to make an especial study of oölogy and has a higher aim than the mere desire to take and accumulate as large a number of specimens as possible regardless of their proper identification, he had better not begin at all, but leave the nests and eggs of our birds alone and undisturbed. They already have too many enemies to contend with, without adding the average egg-collector to the number. The mere accumulation of specimens is the least important object of the true oölogist. His principal aim should be to make careful observations on the habits, call notes, song, the character of the food, mode and length of incubation, and the actions of the species generally from the beginning of the mating season to the time the young are able to leave the nest. This period comprises the most interesting and instructive part of the life history of our birds.

Do not start in with the idea that because a certain species may be common with you everything must consequently already be known about it, and that your observations would be useless. Rest assured that some new and interesting fact can still be learned by the observant oölogist about even our commonest birds.

A small, thoroughly identified, well prepared, and neatly cared for collection, even if only a local one, is worth far more scientifically and in every other way than a more extensive one obtained by exchange or purchase. One of the most important matters is the preparation of the specimens. Eggs, when first taken and before blowing them, should as far as practicable have all stains and dirt on the shells wiped or washed off. Care must be taken, however, not to scrub the shell too much or too hard, as such treatment may result in breaking the specimen or injury to the coloring matter, which in many species is not thoroughly fixed in a fresh-laid egg. This applies especially to the eggs of many game birds and hawks, as well as to others. The shells of some of the water birds, as the Pelicans, Gannets, and Cormorants, are covered with a more or less uneven deposit of lime. This should not be scraped or scrubbed off. Especial care should be taken to thoroughly clean all white eggs both inside and outside, particularly those of Woodpeckers.

Eggs should be blown or emptied through a *single* small hole neatly drilled on one side, as shown in the figure on page 8. It is well to commence making this hole with a needle and finishing it with an egg drill, which is given a rotary motion between the thumb and forefinger. In marked or spotted eggs the poorest or least marked side should always be selected for this purpose. Great care should be taken to remove the entire contents.

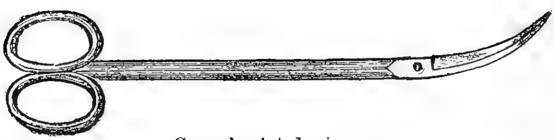
A simple blowpipe and a few different sized drills, like those figured below, which may be obtained at any natural-history dealer's establishment, are all the implements required to blow an egg.



Drills.

Blowpipe.

Embryo book.



Curved pointed scissors.

Tweezers.

Many collectors use very fine glass points attached to a rubber bulb, others use an instrument manufactured by Mr. E. W. Ellsworth, of East

Windsor Hill, Connecticut, which, although somewhat more expensive, is one of the best egg-blowers known to me. A short blowpipe like the above, with a rubber tube about 3 feet in length and a horn mouthpiece attached, makes a very satisfactory instrument for general use.

To blow an egg.—Drill a small hole on the side and in the center of the egg, insert the tip of the blowpipe for a very short distance, and remove the contents as far as this can readily be done. In fact an egg can be blown without inserting the point at all, simply holding it close up to the hole and forcing air through it. Should the albumen be thick or stringy, and not run out freely while blowing the egg, push aside such parts as may be forced out of the hole with the end of the blowpipe or a small pair of forceps, and shake the egg; this will facilitate matters. Small portions of the albumen and yolk of the egg will usually remain in the shell, and this is best removed by forcing water into the egg with a small syringe, holding the point of the latter *over* the hole and an inch from it. This will always allow a part of the water to enter. When about half full shake the egg, holding it between the fingers, and then blow out the contents. If the water does not come out perfectly clear repeat the process until it does. Eggs that have been thoroughly cleaned will retain their original color much better, and insects or mice are not so apt to injure them. After the egg has been cleaned it should be put away, hole downward, and allowed to drain. The best material to place an egg on to absorb whatever moisture may remain in it after cleaning, is corn meal. Particles of this substance that may remain sticking about the hole of the egg are easily removed by a slight touch of the fingers. I find coarse corn meal to be by far the best article to drain eggs on, as it will not stick tightly and is always readily removed; the danger of chipping small pieces of the shell around the edges of the hole, which often happens where blotting paper or fine sawdust are used for this purpose, is in this way reduced to a minimum.

In cases where eggs are nearly hatched when found, excepting very small and thin-shelled ones, which beyond a certain stage can not readily be saved, and should not under such circumstances be disturbed, drill a slightly larger hole in the shell and puncture or lacerate the embryo with a needle or a sharp embryo hook. Care must be taken not to run the instrument through the opposite side of the egg. Then try to force out such of the contents, consisting of fluid portions and parts of the yolk, which have not been entirely absorbed by the embryo. This may be accomplished either by the blowpipe or, perhaps, more readily by holding the point of a small syringe, filled with water, directly over the hole and about an inch from it, and forcing a steady stream of water into the egg. Never insert the point of the syringe directly in the hole, unless you wish to burst the egg. Do not attempt to force out too much in the beginning. After getting out some of the softer contents of the egg, fill it with the water, wipe it dry and clean and put the specimen so treated in a covered box, in which you have first placed a layer of corn meal about an inch in depth. The object of this treatment is to allow the water injected to come in contact with the more tender parts of the embryo and to accelerate decomposition. In order to remove the contents through a small hole, these must be allowed to decompose. A strong solution of Caustic Potash injected as before stated accelerates matters, reducing the embryo to a soft soapy mass, and such treatment does not injure the shell of the egg. Next place the box, after closing the lid, in a warm place, either in the sun or under a stove, and let it remain undisturbed for about 48 hours. Repeat this operation two or three times, always assisting the removal of any small particles which may be forced out of the hole by cutting such away with a thin-bladed pair of scissors; curved pointed ones are the best for this purpose. Do not try to pull the embryo out, nor to empty the egg at one operation; use a little patience, and in this manner most far-advanced eggs can be emptied through a reasonably small aperture. The egg should be refilled with fresh water after each operation. Do not try to take the inner lining of the shell out, in case it becomes detached during the rotting process; it does no harm by remaining, while the chances are that you will break the egg, which is naturally much weakened without this skin, if you attempt to remove it. Occasionally a collector may obtain rare unblown specimens in which the contents have completely dried up and hardened, and it may puzzle him how to empty such eggs. Unless they contained large embryos when first found, or when abandoned by the parents, they may easily be blown by the following directions:

Take common bicarbonate of soda, dissolve about 3 tablespoonfuls to a pint of water and simply inject this solution in the egg and treat as previously mentioned. Repeat this once or twice at intervals of 48 hours and you will probably have no great difficulty in emptying your specimens through a moderately small hole, and the shell will not be injured by this solution.

In blowing small and delicate eggs, I find the use of an egg-holder of considerable assistance, and consider this mode of holding a small egg much safer and far more convenient than taking the specimen between the tips of the fingers. To make one, take a piece of thin wire, say from 6 to 8 inches long, bend both ends in the shape of a circular loop of the required size, again bend the wire exactly in the center, so that the loops face each other somewhat like a pair of sugar tongs, and you have a holder. The wire used should be springy and elastic, so that it will readily give somewhat and hold the egg securely, but not too tightly at the same time. Brass wire answers the purpose very well.

It is always preferable to blow eggs at home, or after returning to camp. You have usually better facilities then to do your work neatly than in the field, where one is apt to be in a hurry, and often to have no water to rinse the inside of the eggs thoroughly after blowing them.

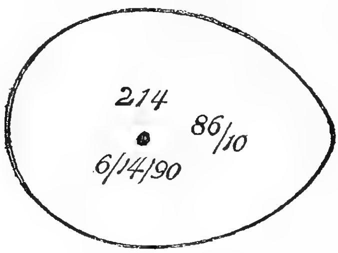
This is positively necessary to insure good clean specimens. I found an old flat piece of sponge, say about 2 inches thick by from 4 to 6 inches wide and long, placed in a tin basin partly filled with water to soften and saturate it, very handy during the operation of blowing eggs. The sponge forms a convenient and elastic cushion for the eggs to rest on, while I injected with water to rinse the inside thoroughly, and should one drop out of the egg-holder the chance of breakage is small. The coarse kind of bathing sponge is best, lasts for years, and can easily be kept clean and sweet.

For packing unblown eggs while out in the field I find small boxes (cigar boxes will answer the purpose very well), fitted with different sized subdivisions, very convenient. Each of these small partitions may be lined with open cylinders made of blanket or heavy cloth. They may be from 2 to 4 inches long, according to the depth of the box, and from 1 to 2 inches in diameter, according to the sizes of the eggs one may expect to find. The bottom of the box should be extra well lined with either sheet cotton, cloth, or blanket cut the required size to fit this closely all around, on which the frame forming the subdivisions is then placed. A piece of heavy cloth or blanket, cut to fit, is placed on the open top of the box, or it may be glued to the lid. The sides of the different partitions are lined by the cylinders already mentioned, each forming thus a little compartment of its own, avoiding all pressure from the contents of the others, and each of these should be provided with some extra cotton. One or two eggs may then be placed in each cylinder, with cotton on top and between them, to keep them from moving around, and if the eggs are of small size sets of four may be placed together, but in such a case each egg must be wrapped in cotton separately. Under no circumstances should the eggs be put in loose, with the shells touching each other. Placed in this way, some are sure to be either cracked or broken. If the eggs are of fair size more than two should never be put in the same compartment, as their combined weight might crush the lower ones. With ordinary care and packed as above frail and unblown eggs will nevertheless stand considerable jolting.

Many rare and valuable specimens are also lost through improper packing when sent by mail or express; by observing the following rules, such losses may be to a great extent avoided. Egg-shells, even after having been blown, should (during transit, at least) never touch each other. Each egg should be wrapped separately in cotton, and they should not be packed too close. In sending eggs through the mail, they should be packed in stout wooden boxes, the box being first lined with cotton all around and the eggs placed in afterwards, rather loosely, each egg wrapped in cotton by itself. Tin boxes are not as good as wooden ones. Cigar boxes answer well, provided they are partitioned off through the middle, to prevent the lid being crushed in on top of the eggs, which often happens where this precaution is not taken.

Each setting, clutch, or the full complement of eggs, usually called a "set," should at once after finding them be marked, temporarily at least, so that in case several sets of eggs of the same species are taken at the same time, each individual set may be readily separated from others of the same kind.

In marking eggs permanently, I consider the following a good way: Eggs should be marked with a soft pencil in preference to anything else, as these marks can always be washed off clean, when it is desirable to do so, which can not be done when certain inks are used. A good way is to place the catalogue number of the eggs on one side of the hole, and the set number and number of the eggs contained in the set on opposite sides. The date of collecting can, if desired, be placed below, and it is well to mark this on at least one egg of each set. For example, I desire to mark a set of ten eggs of the Sora Rail, *Porzana carolina* (Linn.), taken June 14, 1890. The check list published by the American Ornithologists Union, is most generally used at present, and I use its numbers in this case. The Sora Rail stands number 214 on this list, and I mark the eggs of the set as follows:



No. 214 is the A. O. U. check list number of this species. No. 86 the running number of the set No. 10 indicates the number of eggs in the set.

and the numbers below the hole, which need only be put on a single specimen in each set, indicate the date. The next set would also be 214 if of the same species, but the running or current number in this case would be 87, followed below by the number of eggs the set contained. Aside from this a regular record should be kept for each set of eggs taken.

Many collectors use regular blank forms for this purpose, which are carefully filed away. A good sample of such a blank is about 6 inches square, printed on a good quality of paper, and these may be kept like the card catalogues generally in use in libraries.

These blanks may be printed as follows:

Oölogical collection of ———. Current No. ——.
A. O. U. check list No. ——. Date ———.
Name { Scientific ———.
Name { Common ———.
No. of eggs in set ——. Set mark ——.
Identification ———. Incubation ———.
Locality ——— ———.

Nest diameter, outside, —— inches; inside, —— inches.
Nest depth, outside, —— inches; inside, —— inches.
Nest composed of ——— ———.
Situation of nest ——— ———.
No. of parent ———. Collector ——— ———.

On a blank of this size, everything of interest can be readily noted, using the reverse side also, if more space for details is required.

A small printed blank (those used in the U. S. Nat. Museum collection measure $2\frac{1}{4}$ by $1\frac{1}{4}$ inches, but can be made still smaller if desired) should also be kept with each set of eggs in addition to the above.

This should give the following information:

Oölogical collection of ———.
Current No. ——. Set No. ——.
Scientific name ———.
Collector ——— ———. Date ———.

The marks on both blanks should correspond with those on the set of eggs in question.

Aside from keeping the data previously mentioned, it is well to keep a regular record book with an index, in which to note down anything of interest relating to every species observed, such as, in the case of migrants, the dates of their first arrival in the spring, the date when last seen in the fall, the localities most frequented by each species, their various call notes, notes of alarm, and song, the contents of the stomachs of such specimens as are shot, and their relative abundance, in fact everything of general interest. Field notes should be written on one side of the paper only. Unblown eggs, a part of whose shells have been indented, may be restored to their natural shape by first drilling a hole on the same side of the egg, where the injury is located, but a little distance away from this if possible. Then insert the blowpipe in the hole and force air gently in the egg; as soon as the indentation has disappeared and the shell has taken its natural shape, take a camel's hair brush dipped in collodion and cover the injured surface of the egg with a small quantity, place the specimen away until the collodion has hardened, then finish blowing it. Eggs which have been cracked before blowing, or during the process, may be treated in the same manner, as well as broken specimens.

The best way to collect and preserve nests is not to detach or lift them from their immediate surroundings, but to leave them in their natural positions, cutting off the branches, if placed in a tree or shrub, a couple of inches or more above and below the nest. In this way they can be much better preserved in their original shape and are less liable to injury. Nests of the ground-building species should have a thin section of the sod on which they are placed taken up and preserved with them. The inner cavity of each nest should be filled with a ball of soft paper, old newspapers answer the purpose very well, or old cotton wrapped in tissue paper and tied in place. This assists materially in preserving the exact contour of the nest mold, especially where from want of space a number are packed on top of each other. Where the inner lining of nests consists principally of feathers or fur, a small quantity of naphthaline should be sprinkled among them to keep moths and insects away; otherwise many interesting specimens are soon destroyed by such pests. The nest belonging to each set of eggs should be labeled similarly and the label attached to the side of the nest. Many collectors keep each set of eggs in the respective nests, but, unless the collection is a small one and excellent care is taken of it, this is not advisable, as many nests are more or less damp when taken and are apt to become moldy, affecting the eggs in a like manner.

It is not the intention to give instructions through this circular just where to look for the nests of our birds. An observant oölogist can soon find out the different modes of nidification by watching the species found in his vicinity.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR COLLECTING REPTILES AND BATRACHIANS.

LEONHARD STEJNEGER,

Curator of the Department of Reptiles and Batrachians.

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DIRECTIONS FOR COLLECTING REPTILES AND BATRACHIANS

By Leonhard Stejneger,

Curator of the Department of Reptiles and Batrachians.

INTRODUCTORY NOTE.

The following directions are prepared for the use of collectors who, without being herpetological experts, desire to procure for the Museum specimens of the reptiles and batrachians which they may be able to gather in the neighborhood of their residence or while traveling. Persons who devote themselves to collecting these animals exclusively are but rarely met with, but there are numerous collectors of other objects of natural history who would be willing to preserve the reptiles and batrachians, if they only knew how to do it in the easiest and most satisfactory way. Such persons have usually very limited space and time to devote to this branch of zoölogy, a circumstance which has been taken into consideration in preparing these directions.

The herpetological specialist will know how to collect better than I can tell him, and the scientific explorer who goes into distant lands far from communication with the civilized world, with a large outfit and for a protracted period, will need special instructions and extensive apparatus (soldering outfit, distilling apparatus, etc.), which can be more advantageously prepared in each individual case.

APPARATUS.

The following articles are more or less necessary for successfully collecting reptiles and batrachians, though many of them are not exclusively used for this purpose. By checking off on this list before starting the collector may at once know whether he has supplied himself with the essential means of collecting.

1. Gun with auxiliary barrel, or collecting pistol (see Directions for Collecting Birds, pp. 7–9).
2. Dip net.
3. Fishhooks and tackle.
4. A pair of stout leather gloves.
5. Bags of cotton cloth, or cheese cloth (see page 9).
6. Fishing basket, or botanical collecting box of tin.

7. Collecting can with strap. The one-gallon copper can (described under the following number) with two loops fastened on top for the insertion of the strap will do good service.

8. Chest of tanks filled with alcohol. A very compact and handy outfit is figured in the appended cut (fig. 1). It consists of two copper tanks and a tin case inclosed in a wooden box. The latter is made of half-inch boards and measures outside, exclusive of strips, length 13, width 12, height $9\frac{1}{2}$ inches. The hinges are fastened on the inside, and there is a handle on the top of the lid for carrying. It is locked by means of a brass padlock. The larger tank measures, outside, $9\frac{1}{4}$ inches

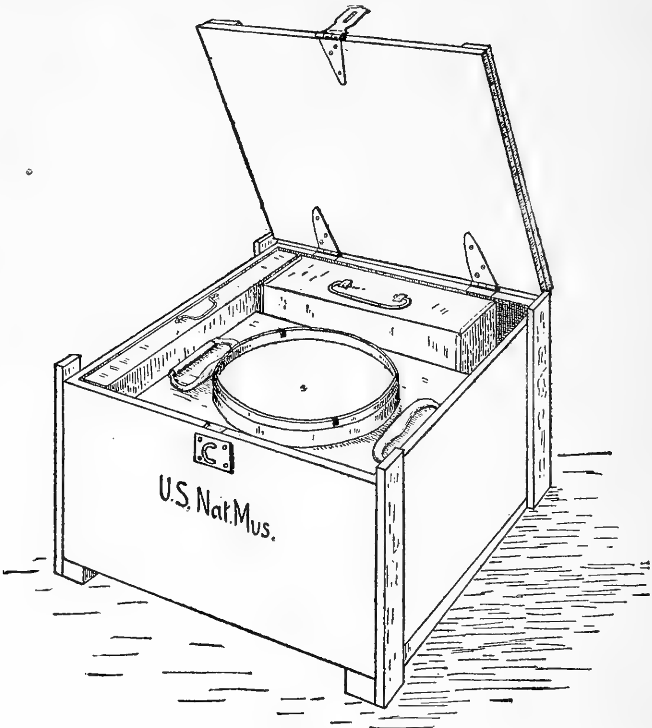

FIG. 1.—Chest of tanks.

long, $6\frac{3}{4}$ inches wide, and $7\frac{5}{8}$ inches high, and holds about 2 gallons of alcohol; the smaller holds a little less than a gallon, with the following measurements: length $8\frac{3}{8}$, width $3\frac{1}{8}$, and height $8\frac{5}{8}$ inches. Both have brass screw tops with rubber packing, the larger with an opening $4\frac{1}{8}$ inches in diameter, the smaller $2\frac{1}{2}$ inches. To lift them out of the box the larger has two handles on top, the smaller one on the side. The tin box has the following dimensions: Length $9\frac{7}{8}$, width $8\frac{5}{8}$, height $2\frac{5}{8}$ inches, and should also have a handle. In the box is room enough for the hypodermic syringe, forceps, notebook, writing materials, labels, cheese cloth for wrapping, bags, cotton, etc. The whole outfit when filled weighs only 40 pounds.

It is always the best policy to use the best quality of alcohol, but when this cannot be had, methylated alcohol will do for temporary use, at least. Even native whiskies, brandy, or other alcoholic liquids may be used in cases of necessity, if of sufficient strength. As a practical test for ascertaining this point, it may be said that an alcoholic liquid will preserve the specimens as long as it can be ignited without first being heated.

9. Iron bar or "key" for unscrewing top of tanks.

10. One pair of Bond's placental forceps, 12 inches long (see fig. 2). Invaluable in the field both for picking up specimens and for handling the alcoholics. In the field it may be carried conveniently by the side like a sword. I found one of the buttonholes of my suspenders quite the thing for this purpose. Price, about $2.50.

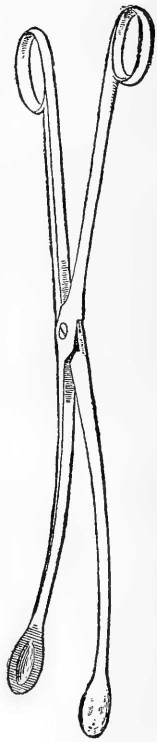

FIG. 2.—Bond's Forceps.

11. Long spring forceps, not less than 8 inches long, for handling alcoholics (same kind as described in Directions for Collecting Birds, p. 11, fig. 8).

12. Hypodermic syringe with needle point for injecting alcohol into specimens (see fig. 3). Its capacity should not be less than 60 minims. A syringe similar to the one figured, in neat case, can be had for about $3. Those in nickel-plated metal case (the "Phenix," for instance) are to be preferred.

13. Stringed labels (see fig. 5, page 10).

14. Cheese cloth for wrapping. Use only white cloth for wrapping as any dye is sure to be extracted by the alcohol, discoloring the specimens.

15. Knife, or scalpel, and a pair of pointed scissors (see Directions for Collecting Birds, pp. 9–10).

16. Fine metal thread, twine, and cotton thread.

17. Note-book.

18. Ridgway's "Nomenclature of Colors" (see page 9).

19. Adhesive shipping labels (see page 13).

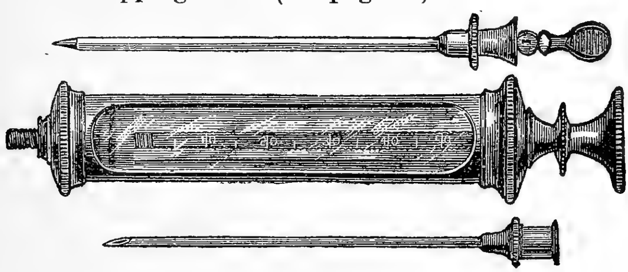

FIG. 3.—Hypodermic Syringe, three-quarter natural size.

GENERAL REMARKS.

I wish to impress upon the collector that one well-labeled and well-preserved specimen is worth more than ten mutilated or half decomposed specimens without labels. A man who is not willing to take the trouble of properly labeling his specimens need not go to the trouble of collecting them, for in our days specimens without data as to the exact locality, at least, are not worth the alcohol they are kept in. Follow, therefore, explicitly the directions relating to labeling given further on.

In any given locality try to collect specimens of all the species occurring there, no matter whether they are common or not, and invariably preserve the first specimen of any species whether bad or good. But do not be satisfied with one specimen of each kind; if they are not too large try to get at least six specimens, and, if any kind shows great individual variation or you happen to know that it is a rare species in collections, two dozen are not too many.

As a general rule the largest and most conspicuous species are the least interesting. Small and insignificant forms of secluded habits, particularly those living in holes or burrows in the ground, are most likely to be novelties or great desiderata of our museum.

If you can not, for one reason or another, preserve all the specimens you are able to procure, make your selection of individuals in the following way: Of the largest species select individuals of medium and small size; of the smallest species take care to get most of the largest specimens. Be sure that the individual variation exhibited among the specimens caught is well represented in the series selected.

WHEN AND WHERE TO COLLECT.

While reptiles and batrachians may be found occasionally at any season, spring is *the* time for systematic collecting, the beginning of the collecting season depending of course upon the meteorologic conditions. In a climate not too severe batrachians may be looked for on the first mild days signaling the breaking up of winter, while the reptiles, as a rule, require warmer weather to rouse them from their hibernation.

The differences between these two classes manifest themselves not only in their structure, but quite as much in their habits, and their collecting is therefore essentially different. The batrachians, generally, prefer dark and damp places, and the best time for collecting them is, therefore, very early in the morning or late evenings. Many of them will be found in dense woods or swamps, among decaying leaves, in old stumps, under fallen logs or stones, and in wet moss, while the purely aquatic species have to be looked for in springs, ponds, rivers, or lakes.

Most of the reptiles, on the other hand, love the light and the heat of the sun, and usually no locality furnishes more species and specimens than the hot and sandy desert or the sun-baked rocks on the southern slopes of a mountainous country, though in the tropics the dense forests abound with their own particular species. The aquatic reptiles, chiefly snakes, will have to be looked for in their own element. A number of reptiles are more or less nocturnal in their habits, for instance many of the poisonous snakes, and these may often be gathered in numbers on warm moonlight nights. A fire or lantern may then be used to advantage. They are also often found after a mild thunder shower, as are likewise many of the inoffensive, particularly the burrowing species.

The latter are usually the most interesting as well as the rarest species in collections. Special care should therefore be taken to obtain as many of them as possible, and the collector should always be on the lookout whenever any digging of ditches or plowing of ground goes on in his neighborhood.

In very warm and dry climates the best time for collecting reptiles is just after the first summer rain.

SECURING SPECIMENS.

A good many reptiles and batrachians are easily enough secured by simply picking them up with the hand. A quick grab with five or ten fingers, as the case may be, will bring many others in the collector's power, though sometimes he will find himself the possessor of only the wriggling tail, while the rest and more important portion of the lizard scampers away and disappears in the nearest crevice. But other animals are either too quick in their movements, or they are too shy, or they live among the thorny cactus, or in the water, and for these other means of capture are to be devised.

The latter have either to be caught with line and hook, baited with raw meat, as certain turtles, or with a dip-net; but as to the others I know of no better way to secure them than to shoot them with the .32 or .22 caliber auxiliary barrel or collecting pistol, or to catch them with a slip-noose.

As to the arms mentioned I refer to what Mr. R. Ridgway has said in the Directions for Collecting Birds, with the only addition that for shooting reptiles I would not advise the use of "wood" powder. I am not thoroughly satisfied that this powder is reliable under all circumstances, and the greater noise of the black powder is of no consequence in this kind of collecting. The latter fouls the gun more, but the auxiliary barrel is so easily cleaned that but little is gained by using "wood" powder.

Specimens are often badly mutilated by shooting, but more specimens are so easily obtained in this than in any other way, and the collector can therefore make his selection for preservation from a greater number of specimens.

During my collecting trip in Arizona, in 1889, most of the lizards obtained were shot, as well as all the frogs. The latter would sit motionless along the border of the river, but as soon as they caught a glimpse of my dip net they jumped into the creek and immediately disappeared in its muddy waters, and not until I learned that a light charge of No. 12 shot would cause them to turn their white bellies up without even a kick did I secure a specimen.

Very often a snake or lizard, if caught alive, will turn upon its captor and bite him furiously; but with the exception of the distinctly venomous kinds their bite, even though it may draw blood, will cause no harm. A stout leather glove is in such cases of great service.

The poisonous snakes, of course, require more care in handling. They may either be shot, or if it is preferred to capture them alive, a long stick bifurcated at the end may be used in pinning them to the ground by placing the fork over their neck just behind the head. They are also sometimes secured by spearing with a long stick, to the end of which is fastened a stout fishhook straightened out. This instrument may also be found useful in reaching specimens which have taken refuge in some otherwise inaccessible place.

Another method not uncommonly adopted by collectors is to slip a noose over the head of the unsuspecting lizard or snake as illustrated by fig. 4. Formerly a noose of horsehair was considered the best

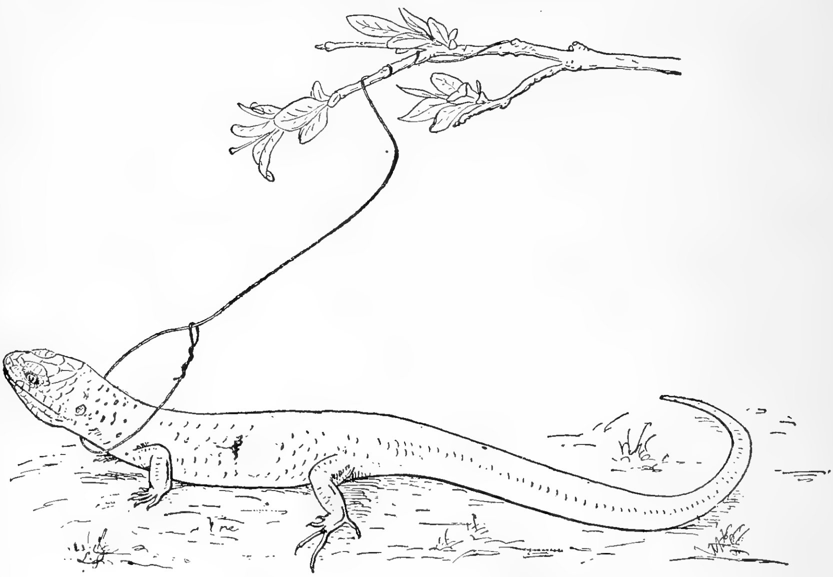

FIG. 4.—Catching Lizard with a slip-noose.

thing for small animals, but Mr. Benedict, who has had a good deal of experience in collecting reptiles when resident naturalist of the U. S. Fish Commission steamer *Albatross*, has demonstrated to me the superiority of fine annealed iron wire, such as is usually sold in hardware stores wound on spools. Various sizes, from Nos. 22 to 34, may be found useful; the larger sizes might probably be quite as serviceable if of copper. For larger snakes a noose of waxed twine will be found to work well in many cases, and is to be recommended to persons who are too nervous to grab a live snake with an unprotected hand.

The noose should be fastened to the end of a long stick, or a light switch, as the case may require, and if a few leaves are left at the end so much the better, as they will attract the reptile's attention from the noose. Slip the noose gently over its head and a sharp jerk towards the tail will usually put the prize in your possession.

The specimen as soon as secured should be immediately transferred to one of the small cheese-cloth bags which the collector carries in his pockets. A good supply of these bags of various sizes, from 2 x 4 inches to 4 x 10 inches, each one with a string for tying it up, should be laid in before starting, enough to average one bag for every three specimens. A paper label with the exact locality written in lead pencil should be slipped into the bag with the specimen. If the collector carries with him a small glass or metal jar with alcohol the bag with the specimen may be placed in it at once, if not it is put in the pocket or in whatever receptacle the collector carries for that purpose. I have found a medium-sized fishing basket or a botanical collecting box of tin to answer every purpose. The live specimens are also put in bags, but are not transferred to alcohol until the day's collecting is over.

Frogs, toads, and salamanders, when brought in alive, should be kept moist by wetting the bag occasionally or wrapping it in wet moss.

TAKING CARE OF THE SPECIMENS.

Having returned to his quarters the collector gets ready for "curing" and labeling his specimens, attending first to those which were killed.

The blood should be washed off in water, and while the specimen is soaking there is time for making the necessary entry in the notebook and for preparing the label.

The entry in the notebook should contain (1) the running number of the specimen; (2) the exact locality where captured, besides county and state; (3) if possible the altitude above sea; (4) the character of the soil and vegetation where the specimen was found, whether on sand, among rocks, under logs or stones, in holes, in a swamp, meadow, desert, forest of pines or deciduous trees, among sagebrush, cactus, or any other observations of a like nature; (5) date of capture; (6) color description of fresh specimen (it is not necessary to describe the pattern, as that is usually preserved in alcohol, but the exact shade of the ground color and of the markings should be carefully determined by actual comparison with the standards in Ridgway's Nomenclature of Colors*); (7) local vernacular name, if determinable with certainty; (8) other remarks.

*A Nomenclature of Colors for Naturalists, etc., by Robert Ridgway. Boston: Little, Brown & Co., 1886.

From the entry in the notebook the label is now made up. The most satisfactory label is made of first quality strong parchment paper and the writing should be done either with a No. 2 lead pencil or with good fluid India ink, care being taken in the latter case not to immerse the label in alcohol until it is perfectly dry. It saves a good deal of work to have the labels printed, cut, and stringed before starting on the trip; the printing may to great advantage contain the general locality where the collections are to be made (as for instance name of state or country) as well as the name of the collector. In addition to the exact locality and date the label should contain the collector's running notebook number. On the back may be written such additional information or notes as may be deemed desirable. A label of good size and shape is shown in the accompanying cut (fig. 5) which also indicates how to string it.

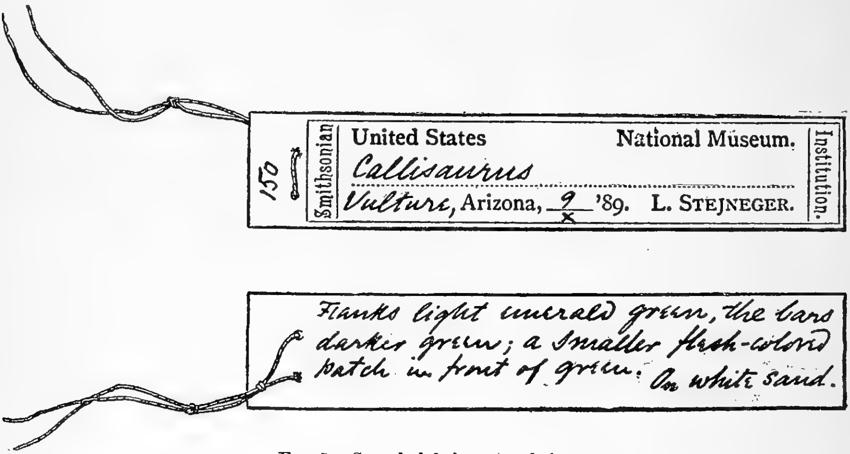

FIG. 5.—Sample label; natural size.

In tying the label on be careful not to fasten it tighter than necessary to prevent the label from slipping off. Never tie a label round the neck of a specimen; in lizards and salamanders fasten it round the body just behind the fore leg; in frogs and toads in front of the hind legs; in snakes round the body at about the anterior third; finally, in turtles tie the string to one of the legs, and only in this case is it necessary and permissible to draw it very tight.

Before finally placing the specimen in alcohol the preserving fluid should be made to enter the body cavities, as the specimens are almost sure to spoil if the alcohol is only allowed to act on the outside. To prevent its decomposition from the inside I have found it most useful to inject a quantity of strong alcohol by means of a hypodermic syringe. The point of the latter is run down the throat and under the scales into the alimentary canal, in one or more places according to size, and in large specimens it will be found advantageous also to inject alcohol into the larger muscles. In this way the appearance of the specimens is not injured in the least and the preservation is perfect. If a syringe is not at hand the abdominal cavity should be opened with a pair of pointed scissors to allow the fluid to enter; by this process snakes should be cut open in several places along the middle of the under side across the wide ventral plates, the so-called gastrosteges. Should a large lump indicate that a snake contains food not yet digested, the belly should be opened and the contents of the alimentary canal removed—or preserved separately, if desired.

Before placing turtles in alcohol head and feet should be drawn out from the shell, the mouth should be opened, and a small piece of wood placed between the jaws so as to prevent the mouth from closing. If the mouths of lizards, snakes, salamanders, and frogs can be kept open without injuring their teeth so much the better, as some of the most important systematic characters are derived from the dentition and the shape of the tongue, and it is very difficult to open the mouths of specimens which have become hardened in alcohol. A wad of cotton or paper may be found useful for this purpose.

The specimen is now ready to be placed in *alcohol*, the only really effective and reliable preserving fluid. When starting out the collector should provide himself with alcohol of about 95 per cent strength, but he should *not* use alcohol of this strength. The full strength alcohol should be kept in stock in the large tank, while the specimens themselves are kept in the smaller tank in alcohol of about 75 per cent. But the best result will be obtained, if the collector has opportunity to put his specimens in still weaker alcohol during the first 24 hours, so as to allow the preservative fluid to penetrate the tissues thoroughly before placing them in the 75 per cent alcohol. It should also be remembered that this strength only applies to reptiles, as 50 to 60 per cent alcohol will do better for batrachians, which are apt to shrivel up entirely in too strong alcohol.

If the specimens can remain undisturbed in the same place for some time no further precautions are necessary, but if the collector is traveling all the time each specimen should be placed separately in one of the cheese-cloth bags, so as to prevent it from being rubbed during transportation. However, quite a number of smooth-skinned specimens, or such with scales which do not come off easily or are provided with spines, may be accommodated in one bag. In default of bags they may be wrapped in cheese cloth, mosquito netting, or any other suitable material at hand.

Specimens brought home alive may be sent to the museum in that condition, if the prospects for their safe arrival are favorable. This will be found especially practicable with turtles, which can usually be kept a long time without food. If the specimens, however, are to be killed this can best be done by drowning them in strong alcohol. For that purpose they should be placed in an empty vessel and the alcohol poured into it through a narrow opening. The vessel should be so full as to exclude every particle of air from it and then be covered up to prevent the animal from breathing. Even with these precautions some kinds require a long immersion before they die.

The above directions apply chiefly to small and medium sized specimens which can be accommodated whole in an ordinary collector's outfit. He will occasionally, however, come across large specimens, which have to be treated in a different way.

Crocodiles, alligators, and very large lizards may be *skinned* in the same manner as indicated for large mammals, only that no attempt is made at removing much less mutilating the skull. The crocodiles and alligators may be dried or salted, while the lizard skins are better placed in alcohol, in which case the entire head and the limbs are left in the skin.

Snakes too large to be preserved in alcohol should be skinned in very much the same manner. After having noted the total length of the specimen carefully in the note book make a longitudinal section *along the middle line* of the entire underside from a little behind the head to a few scales from the anal opening, taking great care not to injure the last scale in front of the vent. The skin is now removed from the body by gradually loosening it on each side from the cut toward the median line of the back. The body is cut off behind the skull, and a little in front of the anal opening, and the tail, like the head, left in the skin. Properly labeled, the skin is then placed in alcohol.

For skinning chelonians the old "Smithsonian Directions" (Misc. Coll. 34) contain the following:

Turtles and tortoises are more difficult to prepare in this way, although their skinning can be done quite rapidly. "The breastplate must be separated by a knife or saw from the back, and, when the viscera and fleshy parts have been removed, restored to its position. The skin of the head and neck must be turned inside out as far as the head, and the vertebræ and flesh of the neck should be detached from the head, which, after being freed from the flesh, the brain, and the tongue, may be preserved with the skin of the neck. In skinning the legs and the tail, the skin must be turned inside out, and the flesh having been removed from the bones, they are to be returned to their places by redrawing the skin over them, first winding a little cotton or tow around the bones to prevent the skin adhering to them when it dries."—RICHARD OWEN.

Another way of preparing these reptiles is as follows: Make two incisions, one from the anterior end of the breastplate to the symphysis of the lower jaw, and another from the posterior end of the breastplate to the vent or tip of the tail; skin off these regions and remove all fleshy parts and viscera without touching the breastplate itself; apply the preservative, stuff, and sew up again both incisions.

TRANSPORTING.

The collector should make it a point to transmit his specimens to the museum *as soon and as often* as possible, and not allow them to accumulate on his hands when in the field.

If he is within reach of a United States post-office the question of transportation is a comparatively easy one. His specimens after an immersion in alcohol of one to two weeks duration, according to size, will be found hardened, and once in this condition they will stand transportation in a nearly dry state for considerable time.

A cigar box, an old tomato can, or better still, an empty baking-powder can, answers the purpose very well. Take some cotton-batting, soak it in alcohol and squeeze it nearly dry; then wrap each individual specimen up and pack them solidly in the box or can; when the can is full add so much alcohol as the contents will hold without dripping; wrap the parcel in several thicknesses of strong paper, and tie a string securely around the whole; finally, paste on a Smithsonian frank label, which will be supplied upon application, and the package is ready for the mail without the sender having to go to any expense for postage.

The specimens may also be packed in their original cheese-cloth bags or wrappings, in which case it will only be necessary to fill up the vacant space with cotton saturated with alcohol.

Specimens thoroughly cured and packed in this way will arrive at the museum in good shape even after the lapse of weeks. They can, therefore, also be sent from foreign countries, not too remote, through Express Companies with but little risk or trouble. It is doubtful if they could be sent through foreign parcel post on account of the written labels.

For long distance transportation it may be necessary to employ sealed tin cans, screw-top collecting tanks, or wooden kegs, which will allow the use of more alcohol. But even in this case the specimens should be packed dry and as closely as possible without crowding, and the vessel filled entirely so as to admit no rubbing of the contents. If there are not enough specimens, fill the vacant space with cotton or other suitable material, being careful not to employ any from which the alcohol will extract any discoloring matter; alcohol is then poured in until all vacant space is filled, and the vessel sealed hermetically. If a metal vessel is used it should be inclosed in a solid wooden box. Glass jars should be avoided, if possible, as too liable to break.

"DON'T."

Finally, to sum up a few of the more important things to be avoided—

Don't tie a label around the neck of the specimens.

Don't forget to give the alcohol access to the interior of the specimens.

Don't slit the specimens open with a knife, but, if you have no hypodermic syringe, use pointed scissors.

Don't forget to label the specimens properly.

Don't wrap the specimens in dry cotton, but soak it first in alcohol.

Don't use glass jars, if you can possibly help it.

Don't put sealing wax on the cork.

Don't be satisfied with one specimen of a kind, if more can be obtained.

Don't let your hypodermic syringe dry up; keep the top screw tight with ample packing between.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR COLLECTING AND PRESERVING INSECTS.

BY

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INTRODUCTORY.

There is a constant demand, especially from correspondents of the Museum and also of the Department of Agriculture, for information as to how to collect, preserve, and mount insects. There is also great need of some simple directions on a great many other points connected with the proper packing of insects for transmission through the mails or otherwise; labeling; methods of rearing; boxes and cabinets; text-books, etc. Interest in the subject of entomology has, in fact, made rapid growth in the last few years, and now that nearly every State has an official entomologist connected with its State Agricultural Experiment Station, the number of persons interested in the subject may be expected to increase largely in the near future. I have hitherto made use of the Smithsonian Miscellaneous Collections, No. 261, which is a pamphlet on collecting and preserving insects prepared by Dr. A. S. Packard. This is out of print, and I have been requested by Prof. Goode to prepare for Bulletin 39, U. S. N. M., something that would cover the whole ground and give the more essential information needed for collectors and students of insect life. I have deemed it unnecessary to go too much into detail, but have studied not to omit anything essential. Customs and methods vary in different countries and with different individuals, but the recommendations contained in the following pages are based upon my own experience and that of my assistants and many acquaintances, and embrace the methods which the large majority of American entomologists have found most satisfactory.

Much of the matter is repeated bodily from the directions for collecting and preserving insects published in my Fifth Report on the Insects of Missouri (1872) and quotations not otherwise credited are from that Report. The illustrations, also, when not otherwise credited or not originally made for this paper, are from my previous writings. Some are taken from Dr. Packard's pamphlet, already mentioned; others, with the permission of Assistant Secretary Willits, from the publications of the Department of Agriculture, while a number have been especially made for the occasion, either from photographs, or from drawings by Miss L. Sullivan or Dr. Geo. Marx or Mr. C. L. Marlatt. When enlarged, the natural size is indicated in hair-line. In the preparation of the pamphlet I have had the assistance of Mr. E. A. Schwarz, and more particularly of Mr. C. L. Marlatt, to both of whom I desire here to express my obligations.

C. V. R.

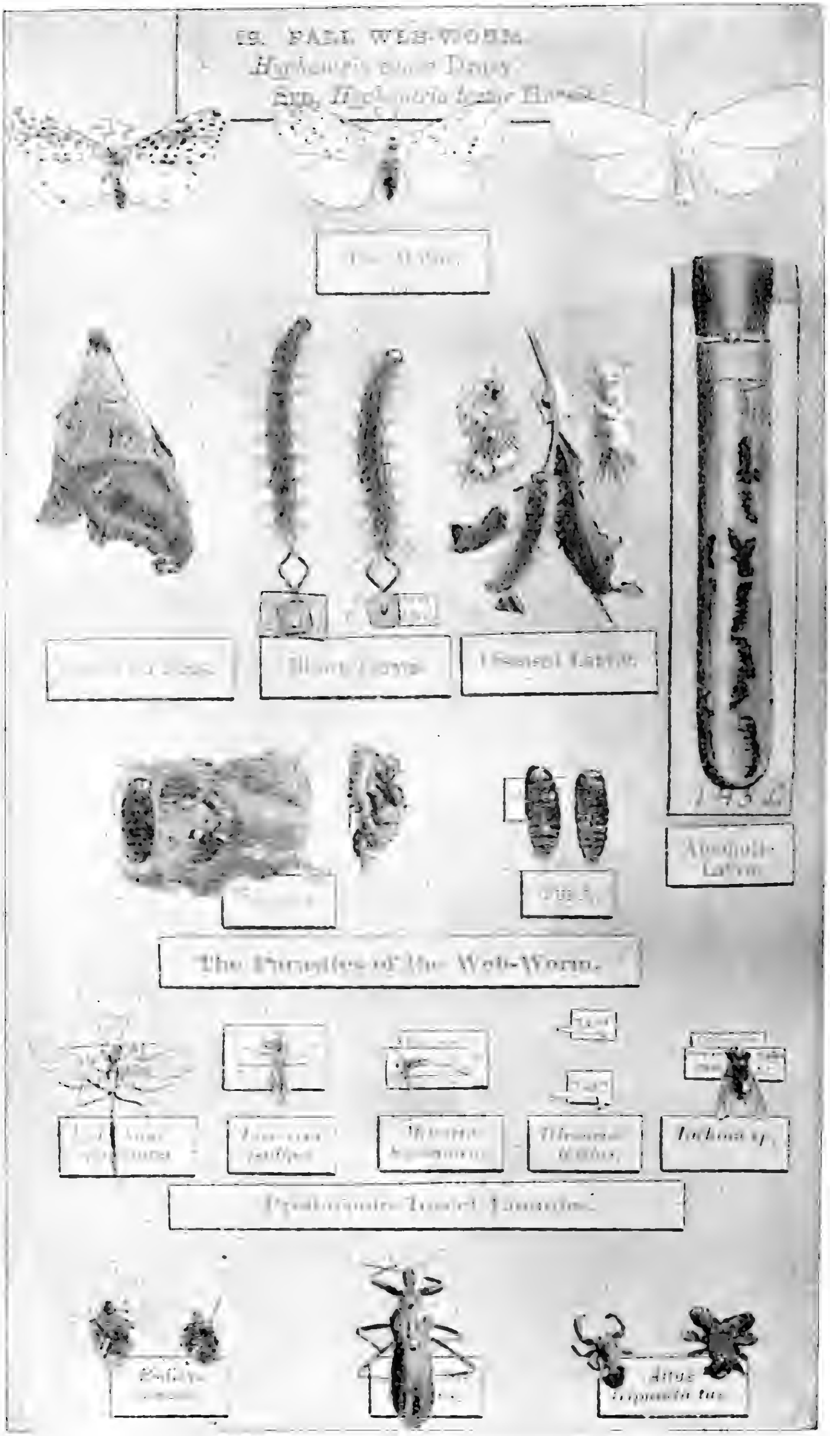


ILLUSTRATION OF BIOLOGIC SERIES.

MANUAL OF INSTRUCTIONS FOR COLLECTING AND PRESERVING INSECTS.

By C. V. Riley,
Honorary Curator of the Department of Insects, U. S. National Museum.

CHARACTERISTICS OF INSECTS.

The term "insect" comes from the Latin *insectum*, and signifies "cut into." It expresses one of the prime characteristics of this class of animals, namely, that of segmentation. This feature of having the body divided into rings or segments by transverse incisions is possessed by other large groups of animals, and was considered of sufficient importance by Cuvier to lead him, in his system of classification, to group with Insects, under the general term Articulata, Worms, Crustacea, Spiders, and Myriopods. Worms differ from the other four groups in having no articulated appendages, and in having a soft body-wall or integument instead of a dense chitinous covering, and are separated as a special class *Vermes*. The other four groups of segmented animals possess in common the feature of jointed appendages and a covering of chitinous plates, and are brought together under the term *Arthropoda*. The division of the body into a series of segments by transverse incisions, characteristic of these animals and these only, justifies the use of Cuvier's old name, Articulates, as this segmented feature represents a definite relationship and a natural division—as much so as the vertebral column in Vertebrates. The Cuvierian name should be retained as a coördinate of Vertebrates, Molluscs, etc., and the terms Vermes and Arthropods may be conveniently used to designate the two natural divisions of the Articulates.

The term "insect" has been employed by authors in two different senses—one to apply to the tracheated animals or those that breathe through a system of air tubes (tracheæ), comprising Spiders, Myriopods, and insects proper or Hexapods,* and the other in its restricted sense as applied to the Hexapods only. To avoid confusion, the latter signification only should be used, and it will be thus used in this article.

* From the Greek ἑξάπους, having 6 feet.

We see, then, that insects share, in common with many other animals, the jointed or articulated structure. Wherein, then, do they differ? *Briefly, in having the body divided into thirteen joints and a subjoint*, including the head as a joint, and in the adult having six true, jointed legs, and usually, though not always, wings. The five classes of Articulates differ from each other in the number of legs they possess in the adult form, as follows: Hexapoda, 6 legs; Arachnida, 8 legs; Crustacea, 10–14 legs; Myriapoda, more than 14 legs; Vermes, none. This system holds for the adult form only, because some mites (Arachnida) when young have only 6 legs, and many true insects in the larva state either have no legs at all, or have additional abdominal legs which are not jointed, but membranous, and are lost in the perfect or adult state. These are called false or prolegs.

It will serve to make these instructions clear if I at once explain that the life of an insect is marked by four distinct states, viz, the egg, the larva, the pupa, and the imago, and that the last three words will constantly recur. We have no English equivalent for the words larva and pupa, for while some authors have written them with the terminal *e*, so as to get the English plural, yet "larves" and "pupes" so shock the ear that the terms have not been (and deserve not to be) generally adopted.

We have seen that an insect in the final state has six true legs. Yet even here many species depart from the rule, as there are many in which the perfect insect, especially in the female sex, is apodous or without legs, just as there are also other cases where they are without wings. Sometimes the legs seem to be reduced in number by the partial or total atrophy of one or the other pair, but in all these exceptional cases there is no difficulty in realizing that we have to deal with a true insect, because of the other characters pertaining to the class, some of which it will be well to allude to.

Insects are further characterized by having usually three distinct divisions of the body, viz.: head, thorax, and abdomen, and by undergoing certain metamorphoses or transformations. Now, while a number of other animals outside of the insect world go through similar transformations, those in the Crustacea being equally remarkable, yet, from the ease with which they are observed and the completeness of the transformations in most insects, the metamorphoses of this class have, from time immemorial, excited the greatest curiosity.

SCOPE AND IMPORTANCE OF ENTOMOLOGY.

But few words are necessary to indicate the importance of entomology, especially to the farming community; for while insects play a most important part in the economy of nature and furnish us some valuable products and otherwise do us a great deal of indirect good, yet they are chiefly known by the annoyances they cause and by the great injury they do to our crops and domestic animals. Hence some knowledge of insects and how to study them becomes important, almost necessary, to every farmer.

The scope of the science may best be indicated by a statement of the number of species existing, as compared with other animals. The omnipresence of insects is known and felt by all; yet few have any accurate idea of the actual numbers existing, so that some figures will not prove uninteresting in this connection. Taking the lists of described species, and the estimates of specialists in the different orders, it is safe to say that about thirty thousand species have already been described from North America, while the number of species already described or to be described in the Biologia Centrali-Americana, i. e., for Central America, foot up just about the same number, Lord Walsingham having estimated them at 30,114 in his address as president of the London Entomological Society two years ago, neither the Orthoptera nor the Neuroptera being included in this estimate. By way of contrast the number of mammals, birds, and reptiles to be described from the same region, is interesting. It foots up 1,937, as follows:

Mammals, 180; birds, 1,600; reptiles, 157.

If we endevor to get some estimate of the number of insects that occur in the whole world, the most satisfactory estimates will be found in the address just alluded to, and in that of Dr. David Sharp before the same society. Linnæus knew nearly 3,000 species, of which more than 2,000 were European and over 800 exotic. The estimate of Dr. John Day, in 1853, of the number of species on the globe, was 250,000. Dr. Sharp's estimate thirty years later was between 500,000 and 1,000,000. Sharp's and Walsingham's estimates in 1889 reached nearly 2,000,000, and the average number of insects annually described since the publication of the Zoölogical Record, deducting 8 per cent for synonyms, is 6,500 species. I think the estimate of 2,000,000 species in the world is extremely low, and if we take into consideration the fact that species have been best worked up in the more temperate portions of the globe, and that in the more tropical portions a vast number of species still remain to be characterized and named, and if we take further into consideration the fact that many portions of the globe are yet unexplored, entomologically, that even in the best worked up regions by far the larger portion of the Micro-Hymenoptera and Micro-Diptera remain absolutely undescribed in our collections, and have been but very partially collected, it will be safe to estimate that not one-fifth of the species extant have yet been characterized or enumerated. In this view of the case the species in our collections, whether described or undescribed, do not represent perhaps more than one-fifth of the whole. In other words, to say that there are 10,000,000 species of insects in the world, would be, in my judgment, a moderate estimate.

CLASSIFICATION OF HEXAPODS.

Seven orders of insects were originally recognized by Linnæus, namely, Neuroptera, Diptera, Hemiptera, Lepidoptera, Coleoptera, Hymenoptera, and Aptera. This classification was based on the organs of flight only, and while in the main resulting in natural divisions which still furnish the basis of more modern classifications, was faulty in several particulars. For instance, the Aptera, which included all wingless insects, was soon found to be a very unnatural assemblage and its components were distributed among the other orders. The establishment of the order Orthoptera by Olivier to include a large and well-defined group of insects associated with the Hemiptera by Linnæus, restored the original seven orders, and this classification has, in the main, been followed by entomologists up to the present time.

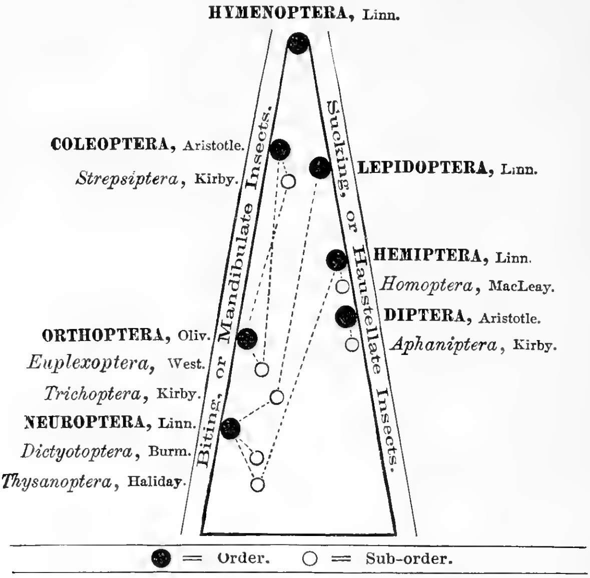


FIG. 1.—Pyramid showing the nature of the mouth, and relative rank of the Orders, and the affinities of the Sub-orders of Insects.

All insects are, in a broad way, referable to one or the other of these seven primary orders by the structure of the wings and the character of the mouth-parts in the imago, and by the nature of their transformations.

Some of these orders are connected by aberrant and osculant families or groups, which have by other authors been variously ranked as independent orders, but which, following Westwood substantially, I have considered, for convenience, as suborders. (*See* Fifth Report, Insects of Missouri, etc., 1872.)

In the article just cited, I made use of the accompanying diagram in the form of a pyramid (Fig. 1), which gives a graphic representation of the distinguishing characters and the relative rank as usually accepted, of the orders and suborders.

Full discussion of the different classifications is unnecessary in this connection. Authors have differed in the past and will differ in the future as to what constitutes a natural system, and it would require many pages to give even a brief survey of the various schemes that have been proposed. As I have elsewhere said, "We must remember that classifications are but a means to an end—appliances to facilitate our thought and study—and that, to use Spencer's words, 'we cannot, by any logical dichotomies, actually express relations which in nature graduate into each other insensibly.'"

The most philosophical, perhaps, of the more modern systems of classification is that of Friedrich Brauer, who has carefully studied the subject, and has given us an arrangement consisting of sixteen orders. This has many merits and has been adopted, with slight modifications, by Packard in his "Entomology for Beginners," and by Hyatt and Arms in their recent and valuable text-book "Insecta." Comstock, in his "Introduction to Entomology" strongly recommends Brauer's classification, but for reasons of simplicity and convenience adheres to a modification of the old classification of Westwood.

For purposes of comparison the classification by Hyatt and Arms, which is substantially that of Brauer, may be introduced.

In linear arrangement it is as follows:

I. Thysanura (*Springtails*, etc.).
II. Ephemeroptera (*Ephemeridæ;* May-flies). (=*Plectoptera* Pack.)
III. Odonata (*Libellulidæ;* Dragon-flies).
IV. Plecoptera (*Perlidæ;* Stone-flies).
V. Platyptera (*Termites*, *Mallophaga*, etc.).
VI. Dermaptera (*Forficulidæ;* Earwigs).
VII. Orthoptera (Locusts, Grasshoppers, etc.).
VIII. Thysanoptera (*Thripidæ;* Fringe-wings).
IX. Hemiptera (Bugs).
X. Coleoptera (Beetles).
XI. Neuroptera (*Sialidæ*, *Hemerobiidæ;* Lace-wings, etc.).
XII. Mecoptera (*Panorpidæ;* Scorpion-flies).
XIII. Trichoptera (*Phryganeidæ;* Caddis-flies).
XIV. Lepidoptera (Butterflies and Moths).
XV. Hymenoptera (Bees, Wasps, etc.).
XVI. Diptera (Two-winged flies).

The relationship of these orders cannot be indicated in a linear arrangement, and is admirably shown by Hyatt and Arms by means of diagrams which I reproduce (Figs. 2, 3.)

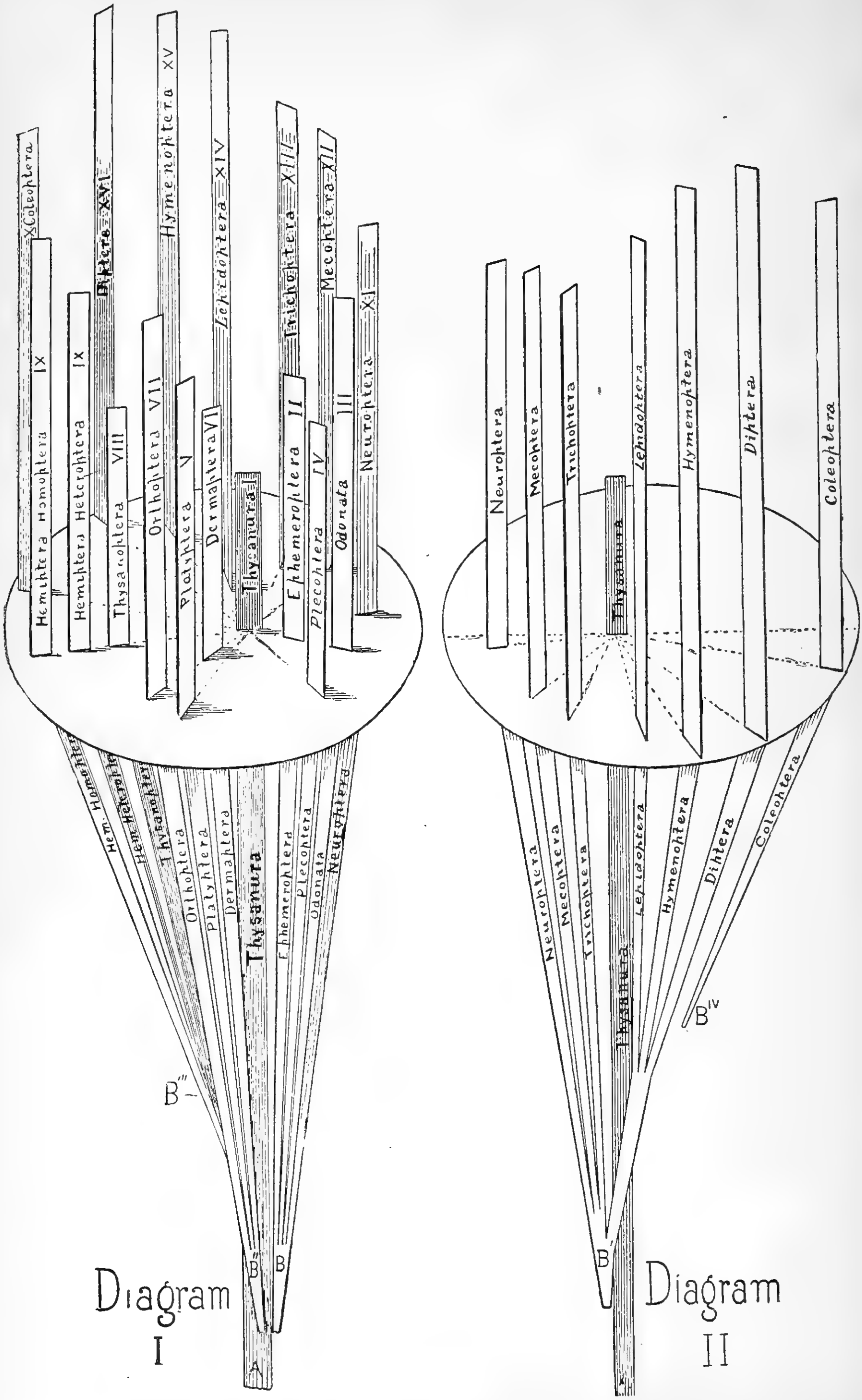


FIG. 2.—Scheme illustrating origin and relationship of Orders. (After Hyatt.)

The relation of these sixteen orders to the older, septenary scheme is shown by the following arrangement:

1. Hymenoptera	Hymenoptera XV.	
2. Coleoptera	Coleoptera X.	
3. Lepidoptera	Lepidoptera XIV.	
4. Hemiptera	Hemiptera IX.	Homoptera. Heteroptera.
	Thysanoptera VIII.	
5. Diptera	Diptera XVI.	Including Aphaniptera or Siphonaptera of some authors.
6. Orthoptera	Orthoptera VII.	
	Dermaptera VI.	
7. Neuroptera	Trichoptera XIII	Neuroptera.
	Mecoptera XII	
	Neuroptera XI	
	Platyptera V	Pseudo-neuroptera.
	Plecoptera IV	
	Odonata III	
	Ephemeroptera II	
	Thysanura I	

It will be seen that the changes are not so great as would at first appear. The three more important orders, namely, the Hymenoptera, Coleoptera, and Lepidoptera, remain substantially the same in all classifications, and so with the three orders next in importance—the Hemiptera, Diptera, and Orthoptera. All that has been done with these

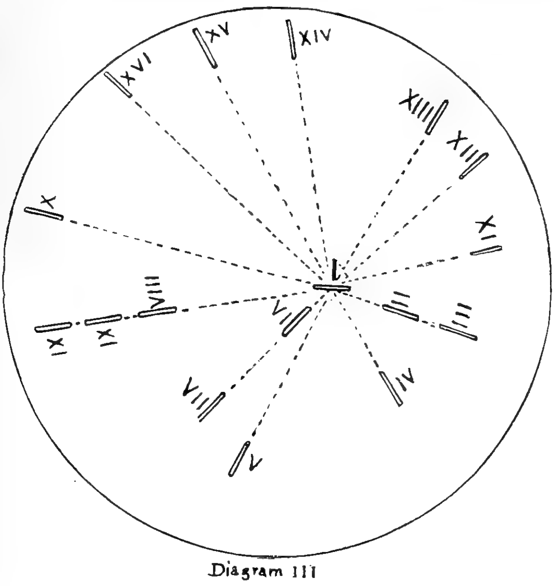


Diagram III

FIG. 3.—Cross section of Fig. 2.

three has been to rank as separate orders what by former authors were preferably considered as either families or suborders. The principal change is in the Neuroptera, of which no less than eight orders have been made. This is not to be wondered at, because the order, as formerly construed, was conceded to be that which represents the lowest forms and more synthetic types of insects, and as such necessarily contained forms which it is difficult to classify definitely.

In the discussion of the characteristics, habits, number of species, and importance of the several groups, I follow, with such changes as the advances in the science of entomology have made necessary, the arrangement shown in Fig. 1.

"Order HYMENOPTERA ('υμήν, a membrane; πτερόν, wing). Clear or Membrane-winged Flies: Bees, Wasps, Ants, Saw-flies, etc. Characterized by having four membranous wings with comparatively few veins, the hind part smallest. The transformations are complete: *i. e.*, the larva bears no resemblance to the perfect insect.

"Some of the insects of this order are highly specialized, and their mouth-parts are fitted both for biting and sucking, and in this respect they connect the mandibulate and haustellate insects. The common Honey-bee has this complex structure of the mouth, and if the editors of our agricultural papers would bear the fact in mind, we should have less of the never-ending discussion as to whether bees are capable of injuring fruit at first hand. The lower lip (*labium*) is modified into a long tongue, sheathed by the lower jaws (*maxillæ*), and they can sip, or, more properly speaking, lap up nectar; while the upper jaws (*mandibulæ*), though not generally used for purposes of manducation, are fitted for biting and cutting. The Hymenoptera are terrestrial, there existing only a very few degraded, swimming forms.

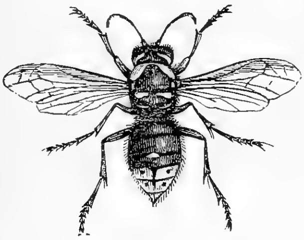


FIG. 4.—Bald-facad Hornet, *Vespa maculata*. (After Sanborn).

"This order is very naturally divided into two sections—the ACULEATA and TEREBRANTIA. The aculeate Hymenoptera, or Stingers, comprise

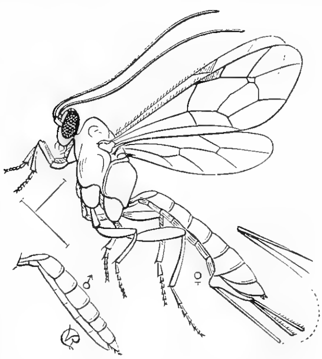


FIG. 5.—An Ichneumon Parasite, *Pimpla annulipes*, showing male and female abdomen.

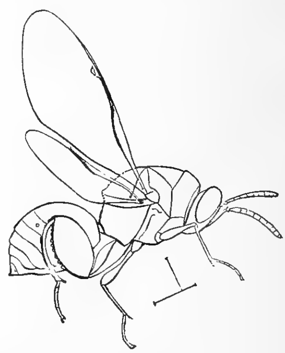


FIG. 6.—A Chalcid Parasite, *Chalcis flavipes*.

all the families in which the abdomen in the female is armed with a sting connected with a poison reservoir, and may be considered the typical form of the order, including all the social and fossorial species. The insects of this section must be considered essentially beneficial to man,

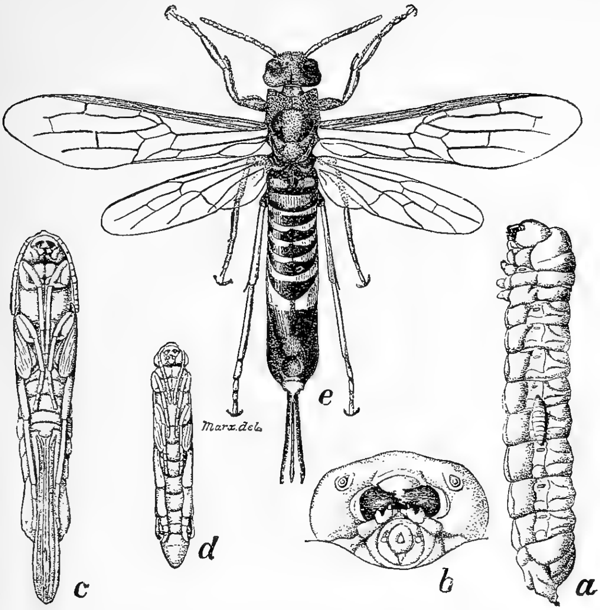


FIG. 7.—A Horn-tail, *Tremex columba*. *a*, larva, showing Thalessa larva attached to its side; *b*, head of larva, front view, enlarged; *c*, female pupa, ventral view; *d*, male pupa, ventral view; *e*, adult female—all slightly enlarged.

notwithstanding the occasional sting of a bee or wasp, the boring of a carpenter bee, or the importunities of the omnipresent ant. Not only do they furnish us with honey and wax, but they play so important a part in the destruction of insects injurious to vegetation that they may be looked upon as God-appointed guards over the vegetal kingdom—carrying the pollen from plant to plant, and insuring the fertilization of diœcious species, and the cross-fertilization of others; and being ever ready to clear them of herbivorous worms which gnaw and destroy. The whole section is well characterized by the uniformly maggot-like nature of the larva. The transformations are complete, but the chitinous larval covering is often so very thin and delicate that the budding of the members, or gradual growth of the pupa underneath, is quite plainly visible, and the skin often peels off in delicate flakes, so that the transition from larva to pupa is not so marked and sudden as in those insects which have thicker skins.

"The terebrantine Hymenoptera, or Piercers, are again divisible into two subsections: first, the ENTOMOPHAGA, which are, likewise, with the exception of a few gall-makers, beneficial to man, and include the parasitic families, and the gall-flies; second, the PHYTOPHAGA, comprising the Horn-tails (*Uroceridæ*), and the Saw-flies (*Tenthredinidæ*), all of which are vegetable feeders in the larval state, those of the first family boring into trees, and those of the second either feeding externally on leaves or inclosed in galls. They are at once distinguished from the other Hymenoptera by the larvæ having true legs, which, however, in the case of the Horn-tails, are very small and exarticulate. The larvæ of many Saw-flies have, besides, prolegs, which are, however, always distinguishable from those of Lepidopterous larvæ by being more numerous and by having no hooks.

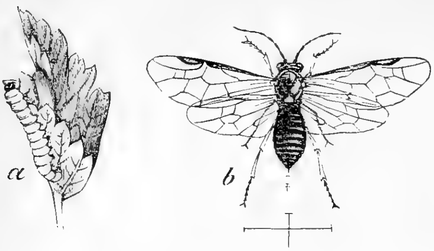


FIG. 8.—Sawfly and Larva. *Pristiphora grossulariæ;* *a*, larva; *b*, imago, Walsh.

"Order COLEOPTERA (κολεός, a sheath; πτερόν, wing). Beetles or or Shield-winged Insects. Characterized by having four wings, the front pair (called *elytra*) horny or leathery, and usually united down the back with a straight suture when at rest, the hind ones membranous and folded up under the elytra when at rest. Transformations complete.

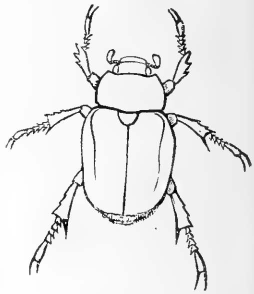


FIG. 9.—A Chafer, *Cotalpa lanigera.* (After Packard.)

"This is an order of great importance, and in the vast number and diversity of the species comprised in it outranks any of the others. The ease with which the insects of this order are obtained and preserved make it one of the most attractive to the amateur, and beetles are, perhaps, of all insects, the best known and understood in the popular mind. For the same reason they have, in the perfect state, received most attention from the entomologists, but their transformations and preparatory forms yet offer a wide and inviting field for the student. The simplest and best-known classification of the beetles is the tarsal system, founded on the number of joints to the tarsi, by which we get four great sections: (1) PENTAMERA, in which

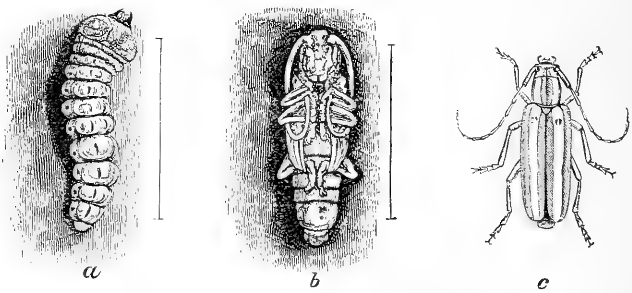


FIG. 10.—A Longicorn, *Saperda candida.* *a*, larva; *b*, pupa; *c*, beetle.

all the tarsi are 5-jointed; (2) HETEROMERA, with the four anterior 5-jointed and the two posterior 4-jointed; (3) PSEUDO-TETRAMERA, with apparently only four joints to all the tarsi, though, in reality, there is a fifth penultimate joint, diminutive and concealed; (4) PSEUDO-TRIMERA, with apparently only three joints to all the tarsi. This system, like most others, is not perfect, as there are numerous species not possessing five joints to the tarsi belonging to the first section; and for practical purposes beetles may be very well arranged according to habit. We thus get, first, the ADEPHAGA, or carnivorous species, including all those which prey on other living insects, and to which, following Mr. Walsh, I have, for obvious reasons, applied the suggestive term 'Cannibal'; second, the NECROPHAGA, comprising those which feed on carrion, dung, fungi, and decaying vegetation; third, the PHYTOPHAGA, embracing all those feeding on living vegetation. This arrangement is by no means perfect, for there are beetles which are carnivorous in the larva and herbivorous in the imago state; while some of the NECROPHAGA are actually parasitic. Yet, it is not more artificial than others which have been proposed. The carnivorous species, broadly speaking, are *Pentamerous*, the only striking exception being the Coccinellidæ (Lady-birds), which are *Pseudo-trimerous*. The carrion-feeders are also *Pentamerous;* but vegetable-feeders are found in all the tarsal divisions, though the *Pseudo-tetramera* are the more essentially herbivorous, and consequently the most injurious."

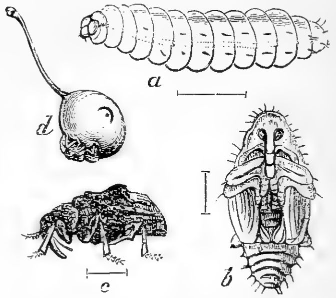


FIG. 11.—The Plum Curculio, *Conotrachelus nenuphar*. *a*, larva; *b*, pupa; *c*, beetle; *d*, plum showing egg-puncture and crescent.

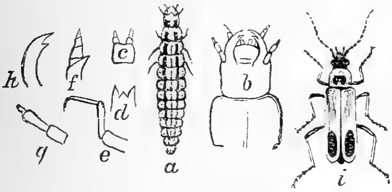


FIG. 12.—A Soldier-beetle, *Chauliognathus pennsylvanicus*. *a*, larva; *b-h*, parts of larva enlarged; *i*, beetle.

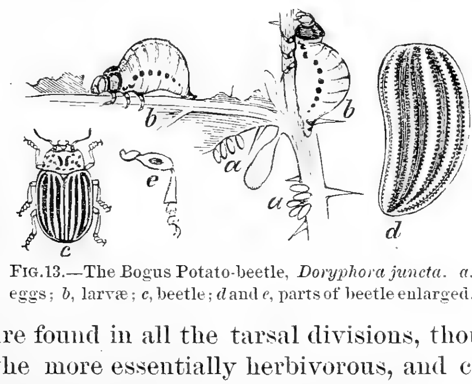


FIG. 13.—The Bogus Potato-beetle, *Doryphora juncta*. *a*, eggs; *b*, larvæ; *c*, beetle; *d* and *e*, parts of beetle enlarged.

"Order LEPIDOPTERA (λεπίς, a scale; πτερόν, wing). Butterflies and Moths, or scaly-winged insects. Characterized by having four branching-veined membranous wings, each more or less densely covered on both sides with minute imbricated scales which are attached by a stalk, but which easily rub off, and appear to the unaided eye like minute particles of glistening dust or powder. Transformations complete.

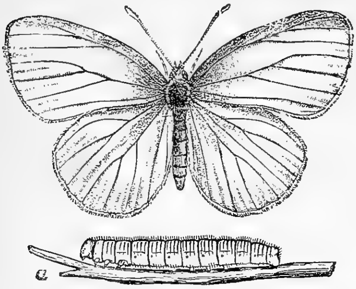


FIG. 14.—A Butterfly, *Pieris oleracea.*

"Next to the Lepidoptera, the Coleoptera are, perhaps, most familiar to the popular mind. Every one admires the beauty of these frail creatures, dressed in every conceivable pattern, and adorned with every conceivable color, so as to rival the delicate hues of the rainbow, and eclipse the most fantastic and elaborate designs of man. When magnified, the scales, to which this beauty of pattern and color is entirely due, present all manner of shapes, according to the particular species or the particular part of the individual from which they are taken. According to Lewenhoeck, there are 400,000 of these scales on the wing of the common silk-worm.

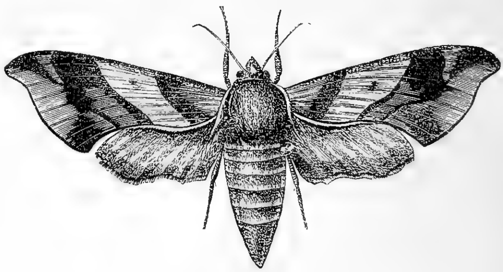


FIG. 15.—A Sphingid, *Ampelophaga myron.*

"The transformations of these insects are complete, and the changes are usually so sudden and striking as to have excited the wonder and admiration of observers from earliest times.

"The more common form of the larva is exampled in the ordinary caterpillar—a cylindrical worm with a head, twelve joints and a sub-joint; six thoracic or true legs, four abdominal and two anal prolegs. But there is a great variety of these larvae, some having no legs whatever, some having only the jointed legs, and others having either four, six, eight, or ten, but never more than ten prolegs. With few exceptions they are all vegetable-feeders, and with still fewer exceptions, terrestrial. The perfect insects make free use of their ample wings, but walk little; and their legs are weak, and not modified in the various ways so noticeable in other orders, while the front pair in some butterflies are impotent.

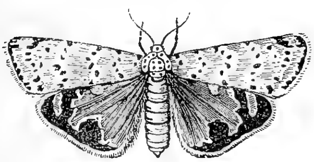


FIG. 16.—A Moth, *Utetheisa bella.*

"As an order this must be considered the most injurious of the seven.

"A convenient system of classification for the Lepidoptera is based on the structure of the antennae. By it we get two great sections: 1st, Butterflies (RHOPALOCERA); 2d, Moths (HETEROCERA), which latter may again be divided into Crepuscular and Nocturnal Moths. Butterflies are at once distinguished from moths by their antennæ being straight, stiff and *knobbed*, and by being day-fliers or diurnal;

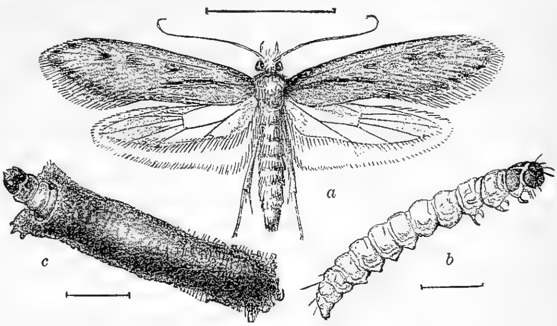


FIG. 17.—A Clothes-moth (*Tinea pellionella*)—enlarged. *a*, adult; *b*, larva; *c*, larva in case.

while moths have the antennæ tapering to a point, and are, for the most part, night-flyers or nocturnal. The crepuscular moths, composed mostly of the Sphinges or Hawk-moths, hover over flowers at eve, and connect the two sections not only in habit, but in the character of the antennæ which first thicken toward the end, and then suddenly terminate in a point or hook.

"Order HEMIPTERA (ἡμι, half; πτερόν, wing), Bugs. The insects of this order are naturally separated into two great sections; 1st, Half-winged Bugs, or HETEROPTERA (ἕτερος different; πτερόν, wing) having the basal half of the front wings (called *hemelytra*) coriaceous or leathery, while the apical part is membranous. The wings cross flatly over the back when at rest; 2d, Whole-winged Bugs, or HOMOPTERA (ὁμός, equal; πτερόν, wing), having all four wings of a uniform membranous nature and folding straight down the back when at rest. The latter, if separated, may be looked upon as a Sub-order.

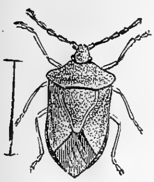


FIG. 18.—A Plant-bug (*Euschistes punctipes*).

"Transformations incomplete; *i. e.*, the larvæ and pupæ have more or less the image of the perfect insect, and differ little from it except in lacking wings.

"The genuine or half-winged Bugs (Figs. 18 and 19) are usually flattened in form, when mature; though more rounded in the adolescent stages. They may be divided into Land Bugs (*Aurocorisa*) and Water Bugs (*Hydrocorisa*). The species of the first division very generally possess the power of emitting, when disturbed or alarmed, a nauseous, bed-buggy odor, which comes from a fluid secreted

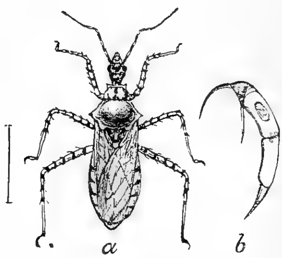


FIG. 19.—A Soldier-bug (*Milyas cinctus*). *b*, beak enlarged.

from two pores, situated on the under side of the metathorax. Such well-known insects as the Bed-bug and Chinch-bug belong here. The habits of the species are varied, and while some are beneficial, others are quite injurious to man.

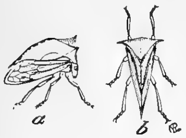


FIG. 20.—A Tree-hopper (*Ceresa bubalus*). *a*, side; *b*, top view.

"The Whole-winged Bugs (Figs. 20 and 21), on the contrary, are all plant-feeders, and with the exception of a few, such as the Cochineal and Lac insects, are injurious. The secretion of a white, or bluish, waxy, or farinose substance from the surface of the body is as characteristic of this section as the nauseous odor is of the first. It forms three natural divisions, arranged according to the number of joints to the tarsi—namely TRIMERA, with three joints; DIMERA, with two joints, and MONOMERA, with one joint to the tarsi."

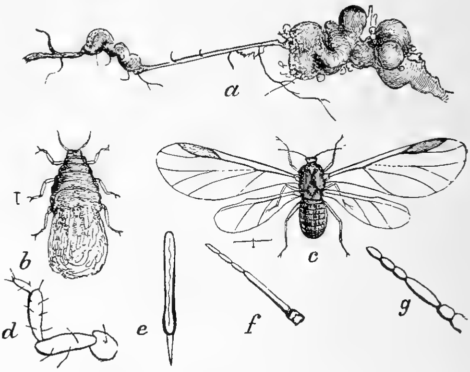


FIG. 21.—A Plant-louse (*Schizoneura lanigera*). *a*, infested root; *b*, larva; *c*, winged insect; *d–g*, parts of perfect insect enlarged.

Suborder THYSANOPTERA (θύςανος, a fringe; πτερόν, wing): This suborder contains the single family *Thripidæ*, which comprises minute insects commonly known as Thrips, and of which a common species, *Thrips striatus*, is shown in the accompanying figure. (See Fig. 22.) They bear strong relations to both the Pseudoneuroptera and the Hemiptera and by later writers are generally associated with the latter order. They feed on plants, puncturing and killing the leaves, or on other plant-feeding species of their own class, and are characterized by having narrow wings crossed on the back when at rest, and beautifully fringed, from which latter feature the name of the suborder is derived.

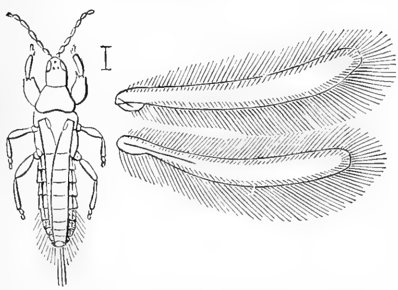


FIG. 22.—*Thrips striatus*, with wings enlarged at side.

The mouth parts are peculiar in that they are intermediate in form between the sucking beak of Hemiptera and the biting mouth parts of other insects.

Their eggs resemble those of Hemiptera; the larvæ and pupæ are active, and in form resemble the adult, except in the absence of wings. Some species, also, are wingless in the adult stage.

The pupæ are somewhat sluggish and the limbs and wings are enclosed in a thin membrane which is expanded about the feet into bulbous enlargements, giving rise to the name "bladder-footed" (Physopoda) applied to these insects by Burmeister.

"Order DIPTERA (δίς, twice; πτερόν, wing) or Two-winged Flies. The only order having but two wings, the hind pair replaced by a pair of small, slender filaments clubbed at tip, and called halteres, poisers, or balancers.

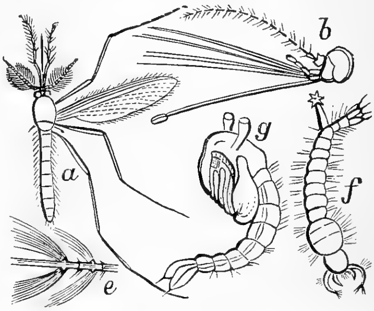


FIG. 23.—A Mosquito (*Culex pipiens*). *a*, adult; *b*, head of same enlarged; *e*, portion of antenna of same; *f*, larva; *g*, pupa. (After Westwood.)

"No order surpasses this in the number of species or in the immense swarms of individuals belonging to the same species which are frequently met with. The wings, which are variously veined, though appearing naked to the unaided eye, are often thickly covered with very minute hairs or hooks. As an order the Diptera are decidedly injurious to man, whether we consider the annoyances to ourselves or our animals of the Mosquito, Buffalo-gnat, Gad-fly, Breeze-fly, Zimb or Stomoxys, or the injury to our crops of the Hessian-fly, Wheat-midge, Cabbage-maggot, Onion-maggot, etc. There are, in fact, but two families, Syrphidæ and Tachinidæ, which can be looked upon as beneficial to the cultivator, though many act the part of scavengers. No insects, not even the Lepidoptera, furnish such a variety of curious larval characters, and none, perhaps, offer a wider or more interesting field of investigation to the biologist. It is difficult to give any very satisfactory arrangement of these Two-winged flies, though they easily fall into two rather artificial sections. These are: 1st, NEMOCERA, or those with long antennæ, having more than six joints, and palpi having four or five joints The pupa is naked, as in the Lepidoptera, with the limbs exposed. This kind of pupa is called *obtected*. 2d, BRACHOCERA, or those with short antennæ, not having more than three distinct joints, and palpi with one or two joints. The pupa is mostly *coarctate*, *i. e.*, is formed within, and more

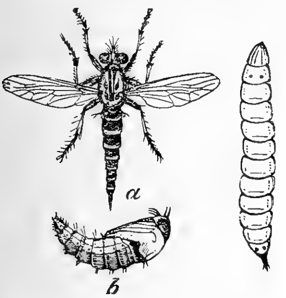


FIG. 24.—A Hawk-fly (*Erax bastardi*). *a* perfect insect; *b*, pupa; larva shown at side.

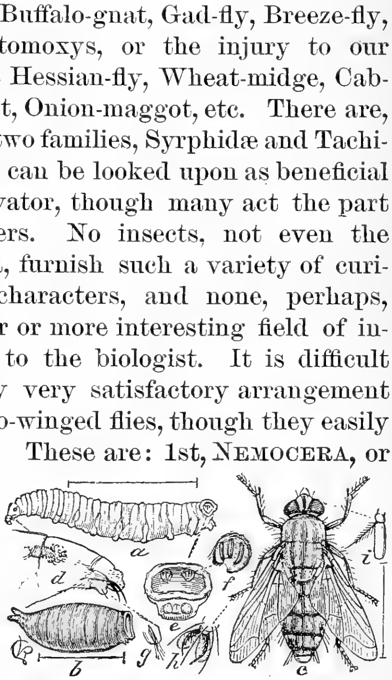


FIG. 25.—A Flesh-fly (*Sarcophaga carnaria*, var. *saracenæ*). *a*, larva; *b*, puparium; *c*, adult insect with enlarged parts.

or less completely connected with, the hardened and shrunken skin of the larva.

"The most anomalous of the Diptera are the Forest-flies and Sheep-ticks (*Hippoboscidæ*). They have a horny and flattened body, and resemble lice in their parasitic habits, living beneath the hair of bats and birds. Their mode of development has always attracted the attention of entomologists. The larvæ are hatched in the abodmen of the female, which is capable of distention. There it remains and, after assuming the pupa state, is deposited in the form of a short, white, egg-like object, without trace of articulation, and nearly as large as the abdomen of the female fly. Closely allied to these are the Bat-ticks (*Nycteribidæ*), which possess neither wings nor balancers, and remind one strongly of spiders.

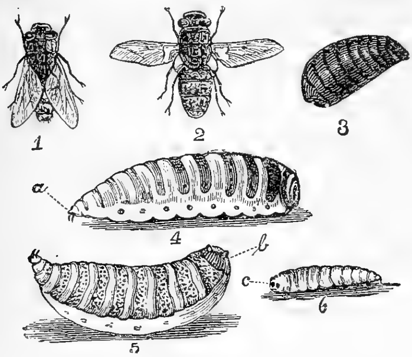


FIG. 26.—The Sheep Bot (*Œstrus ovis*). 1, 2, flies; 3, puparium; 4, 5, and 6, larvæ or bots.

"In this order we may also place certain wingless lice (such as *Braula cœca*, Nitzsch), which infests the Honey-bee in Europe, northern Africa, and western Asia, but which has not yet been detected in this country.

"Suborder APHANIPTERA (ἀφανής, inconspicuous; πτερόν, wing) or Fleas, comprising the single family Pulicidæ, now placed with the Diptera. Everybody is supposed to be familiar with the appearance of the Flea—its bloodthirsty propensities and amazing muscular power; and while everyone may not have the leisure and means to experience the exhilarating influence of the chase after larger animals, there is no one—be he never so humble—who may not indulge in the hunt after this smaller game! In place of wings the flea has four small, scaly plates. The minute eggs—about a dozen to each female—are laid in obscure places, such as the cracks of a floor, the hair of rugs, etc., and the larva is worm-like and feeds upon whatever animal matter—as grease and blood—or decaying vegetable matter it can find.

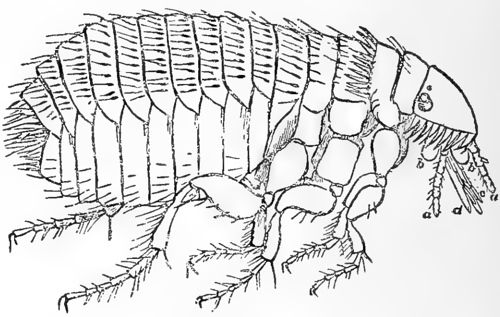


FIG. 27.—A Flea (*Pulex*). (From Packard.)

"Order ORTHOPTERA (ὀρθός, straight; πτερόν, wing), or Straight-winged Insects. Characterized by having the front wings (called

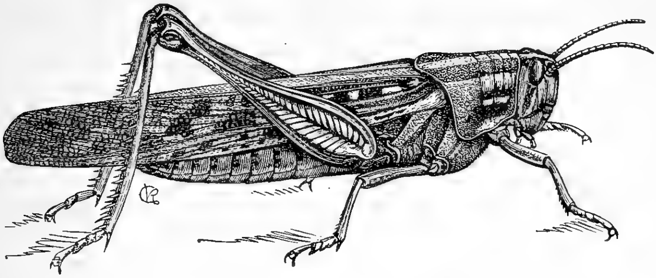


FIG. 28.—A Locust (*Acrideum americanum*).

tegmina) straight and usually narrow, pergameneous or parchment-like, thickly veined, and overlapping at tips when closed; the hind wings large and folding longitudinally like a fan. Transformations incomplete.

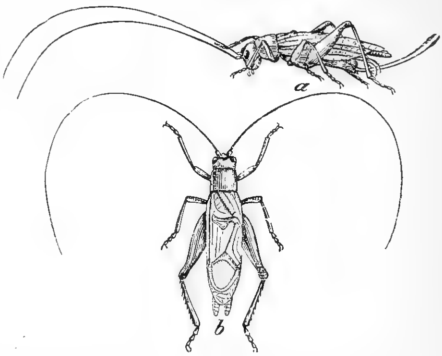


FIG. 29.—A Tree-cricket (*Ocharis saltator*). *a*, female; *b*, male.

"The insects of this order have a lengthened body and very robust jaws, with a correspondingly large head. The legs are strong, and fashioned either for grasping, running, climbing, jumping, or burrowing. As in the other orders, where the transformations are incomplete, the young differ little from the parent, except in the want of wings; and in many instances even this difference does not exist, as

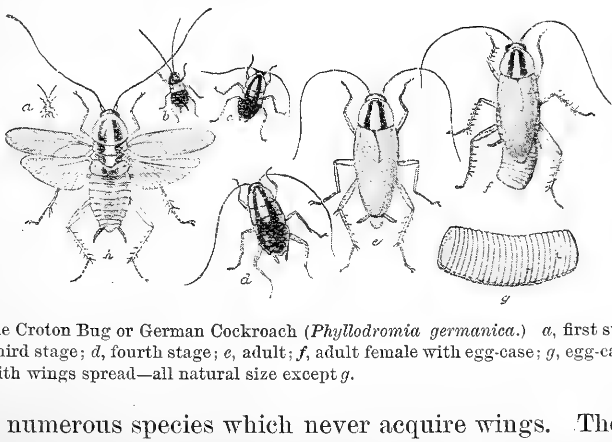


FIG. 30.—The Croton Bug or German Cockroach (*Phyllodromia germanica.*) *a*, first stage; *b*, second stage; *c*, third stage; *d*, fourth stage; *e*, adult; *f*, adult female with egg-case; *g*, egg-case—enlarged; *h*, adult with wings spread—all natural size except *g*.

there are numerous species which never acquire wings. There are no aquatic Orthoptera. Some are omnivorous, others carnivorous, but most of them herbivorous. They form four distinct sections: 1st, CURSORIA, Cockroaches; 2d, RAPTATORIA, Mantes; 3d, AMBULATORIA, Walking-sticks; 4th, SALTATORIA, Crickets, Grasshoppers, and Locusts.

"Suborder DERMAPTERA* (δέρμα, skin; πτερόν, wing), or "Earwigs, consisting of the single family Forficulidæ, which may be placed with the Orthoptera. They are rare insects with us, but very common in Europe, where there prevails a superstition that they get into the ear and cause all sorts of trouble. The front wings are small and leathery; the hind ones have the form of a quadrant, and look like a fan when opened; and the characteristic feature is a pair of forceps-like appendages at the end of the body, best developed in the males. They are nocturnal in habit, hiding during the day in any available recess. The female lays her eggs in the ground, and singularly enough, broods over them and over her young, the latter crowding under her like chicks under a hen."

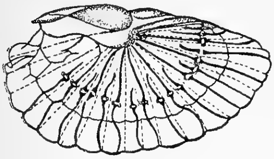


FIG. 31.—Hind wing of Earwig. (From Comstock.)

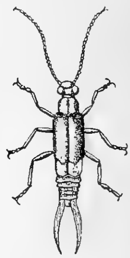


FIG. 32.—An Earwig. (From Packard.)

"Order NEUROPTERA (νεῦρον, nerve; πτερόν, wing), or Nerve-winged insects. Characterized by having the wings reticulate with numerous veins so as to look like net-work. The order forms two natural divisions, the first including all those which undergo a complete, and the second, called Pseudo-neuroptera (Dictyotoptera, Burmeister), those which undergo an incomplete metamorphosis. * * * The insects of this order are, as a whole, more lowly organized, and more generally aquatic, than either of the others. A natural arrangement of them is difficult on account of their degradational character. They present forms which are synthetic and closely approach the other orders, and the evolutionist naturally looks upon them as furnishing an idea of what the archetypal forms of our present insects may have been. They are, as a rule, large and sluggish, with

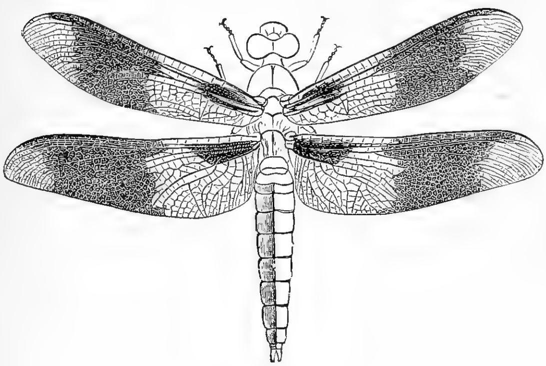


Fig. 33.—A Dragon-fly (*Libellula trimaculata*). (From Packard.)

*Euplexoptera of some authors from ευ, well; πλέχω, folded, referring to the folded wings.

the body parts soft and little specialized, and the muscles weak. Their remains are found in the Devonian and Carboniferous deposits.

"They are mostly carnivorous, and with the exception of the White-ants and certain Book-lice they none of them affect man injuriously, while some are quite beneficial."

The first division of this order, or the Neuroptera proper, characterized by having incomplete metamorphoses, may be considered under the three following suborders:

"Suborder TRICHOPTERA (θρίξ, hair; πτερόν, wing), or Caddis-flies, containing the single family Phryganeidæ, and placed with the Neuroptera, though bearing great affinities with the Lepidoptera. Every good disciple of Walton and lover of the "gentle art" knows the value of the Caddis-fly, or Water-moth, as bait. These flies very much resemble certain small moths, the scales on the wings of the latter being replaced in the former with simple hairs. The larvæ live in the water and inhabit silken cases, which are usually cylindrical and covered with various substances, according to the species, or the material most conveniently obtained by the individual."

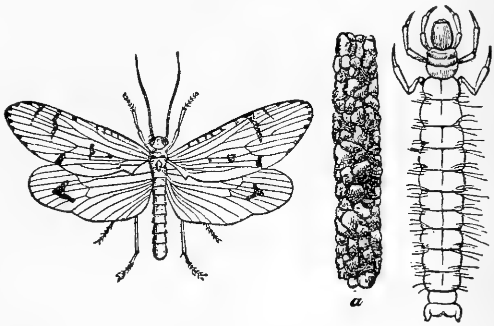


Fig. 34.—Caddis-fly, larva and its case. (From Packard.)

Suborder MECOPTERA (μῆκος, length; πτερόν, wing). This suborder includes a peculiar group of insects, the most striking characteristics of which are the mouth-parts, which are prolonged into a rostrum or beak. The wings are long and narrow, and of nearly equal size. The abdomen of the male is constricted near its posterior end and terminates in long clasping organs from which these insects obtain the common name of Scorpion-flies.

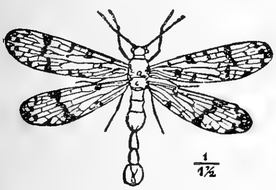


FIG. 35.—Panorpa or Scorpion-fly. (From Packard.)

The larvæ of one genus (*Panorpa*) are remarkable for their great resemblance to the larvæ of Lepidoptera. They have, however, eight pairs of abdominal legs. The habits of these insects are not well known, but they are supposed to be generally predaceous.

Suborder NEUROPTERA. This group as restricted by modern authors is a small one, including the largest species, as in the Hellgrammite, the Lace-wing Flies, the Ant-lions, and the Mantispas representing the families, Sialidæ and Hemerobiidæ, with their subfamilies. The first includes the so-called Hellgrammite Fly (*Corydalus cornutus*), one of our largest and most striking insects, the larvæ of which is known as Dobsons by anglers, and is aquatic and carnivorous in habit. The Hemerobiidæ is a large family, comprising, as a rule, delicate insects with rather ample gauzy wings. The larvæ are predaceous. The common Lace-wing flies are among our most beneficial insects, destroying plant-lice and other soft-bodied species. To the same family belongs the Ant-lion (*Myrmeleon*), the larvæ of which have the curious habit of constructing a funnel-shaped burrow in the sand, in the bottom of which they conceal themselves and wait for any soft-bodied insects which may fall into the trap. This family also includes the peculiar Mantis-like insects belonging to the genus *Mantispa*. As in the true Mantis, the prothorax of these insects is greatly elongated and the first pair of legs are fitted for grasping. The larvæ are parasitic in the egg-sacs of certain large spiders (genera *Licosa*, *Dolomedes*, etc.), and undergo a remarkable change in form after the first molt. In the first stage the larvæ are very agile, with slender bodies and long legs. After molting the body becomes much swollen and the legs are much shortened, as are also the antennæ, the head becoming small and the general appearance reminding one of the larva of a bee.

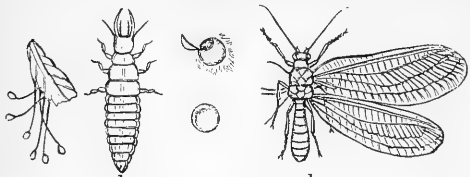


FIG. 36.—Lace-wing fly. *a*, eggs, *b*, larva, *c*, cocoons, *d*, fly with left wings removed.

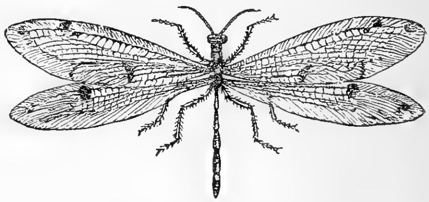


FIG. 37.—An Ant-lion (*Myrmeleon*). (From Packard.)

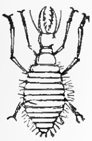


FIG. 38.—Myrmeleon larva.

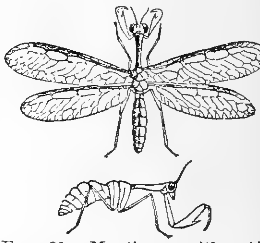


FIG. 39.—*Mantispa* with side view beneath. (From Packard.)

The second section of the Neuroptera, characterized by complete metamorphosis, comprises the following suborders:

Suborder PLATYPTERA (πλατύς, flat; πτερόν, wing). Under this head are grouped the White-ants (*Termitidæ*), the Bird-lice (*Mallophaga*), and the Book-mites (*Psocidæ*). The suborder receives its name from the fact that in the case of the winged forms the wings, when at rest, are usually laid flat upon the back of the insect. The Mallophaga, or Bird-lice, are degraded wingless insects, and are parasitic chiefly on birds, but also on mammals. In shape of body and character of the mouth-parts they are most nearly allied to the Psocidæ. The latter family includes both winged and wingless forms, the Book-mites belonging to the latter category. The winged forms may be illustrated by the common species, *Psocus venosus* (see Fig. 40). The legs and antennæ are long and slender and the wings are folded roof-like over the body when the insect is at rest. They feed on lichens and dry vegetation.

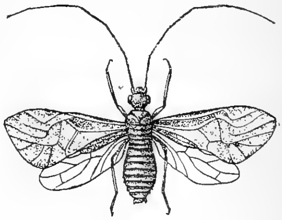


FIG. 40.—*Psocus venosus.* (From Comstock.)

The Termitidæ are represented in this country by the White-ant (*Termes flavipes*), which is frequently so destructive to woodwork, books, etc. The term White-ant applied to these insects is unfortunate, as in structure they are widely separated from ants and resemble them only in general appearance and also in their social habits. Like the ants they live in colonies and have a number of distinct forms, as winged and wingless, males and females, and workers and soldiers.

Suborder PLECOPTERA (πλεκτός, plaited; πτερόν, wing). Closely allied to the latter suborder is the suborder Plecoptera, which includes the single family Perlidæ or Stone-flies. The larvæ and pupæ of these insects are aquatic, being often found under stones in water, whence the name. The adults are long, flattened insects, with long antennæ. The wings are ample and are somewhat folded or plaited, from which character the suborder takes its name.

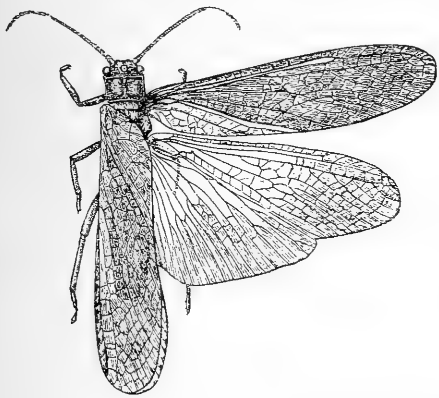


FIG. 41.—A Stone-fly (*Pteronarcys regalis*). (From Comstock.)

Suborder ODONATA (ὀδούς, tooth). This includes the Dragon-flies or Libellulidæ, the most common and the best known of the Neuroptera. The larva and the active pupa or nymph are aquatic and are predaceous, as is also the adult. A common species is represented at Fig. 33.

The Suborder EPHEMEROPTERA (ἐφήμερον, a day-fly; πτερόν, wing) comprises the May-flies, or Ephemeridæ (see Fig. 42). These insects are very fragile and are often attracted in enormous numbers to electric lights. They have large front wings, while the hind wings are small, rudimentary, or wanting. They are furnished with two or three very long, jointed, thread-like caudal appendages. The larval and nymphal stages are passed in the water and aquatic vegetation furnishes the food, although some species may be predaceous. The adults have very rudimentary

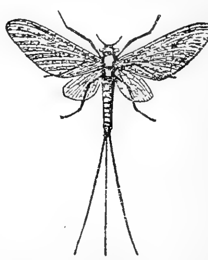


FIG. 42.—A May-fly (*Protamanthus marginatus*). (From Packard.)

mouths and eat nothing; their term of life is also very limited, not exceeding 2–4 days.

Suborder THYSANURA (θύσανος, tassel; οὐρά, tail). This suborder comprises minute, degraded insects commonly known as Spring-tails, Bristle-tails, Fish-moths, Snow-fleas, etc. They occur in damp situations and also infest books, wall-paper, etc., eating the starch paste in the book-bindings, or beneath the wall paper. They comprise very primitive forms and are interesting because they are supposed to represent the original stock from which the higher orders of insects have sprung. They are wingless, usually with simple eyes, and clothed with scales, and undergo no metamorphosis. Some of them, as the Fish-moth (*Lepisma* sp.), run very rapidly and are furnished at the end of the body with a number of long bristles. In other forms these anal bristles or stylets are united at the base and bent under the body and become a powerful jumping organ, giving them the very appropriate name of Spring-tails.

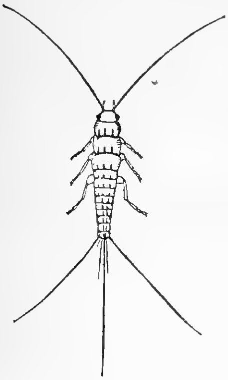


FIG. 43.—(*Lepisma 4-seriata*). (After Packard.)

COLLECTING.

GENERAL CONSIDERATIONS.—"Few departments of natural history offer greater inducements or facilities to the student than Entomology. He need not pass his threshold for material, for it may be found on every hand and at all seasons. The directions for collecting, preserving, and studying insects might be extended indefinitely in detail, as volumes have already been written on the subject; but the more general and important instructions are soon given.

"Beginners are very apt to supply themselves with all sorts of appliances advertised by natural history furnishing stores. Many of these appliances, when it comes to real, practical field-work, are soon abandoned as useless incumbrances; and the greater the experience, the simpler will be the paraphernalia. My own equipment, on a collecting trip, consists chiefly of a cotton umbrella, a strong and narrow steel trowel or digger, a haversack slung across the shoulders, a cigar box lined with sheet cork, and a small knapsack attached to a waistbelt which girts a coat, not of many colors, but of many pockets, so made that in stooping nothing falls out of them. The umbrella is one of the indispensables. It shields, when necessary, from old Sol's scorching rays and from the pelting, drenching storm; brings within reach, by its hooked handle, many a larva-freighted bough which would otherwise remain undisturbed; and forms an excellent receptacle for all insects that may be dislodged from bush or branch. Opened and held inverted under a bough with the left hand, while the right manipulates a beating-stick, cut for the occasion, it will be the recipient of many a choice specimen that would never have been espied amid its protective surroundings. Some collectors use an umbrella painted or lined on the inside with white, to facilitate the detection of any object that drops into it; but as there are fully as many, if not more, pale and white insects as there are dark or black ones, the common dark umbrella is good enough for all ordinary purposes; and if any improvement on the ordinary cotton umbrella is desired, it should be in the way of a joint or knuckle about the middle of the handle, which will facilitate its packing and using. The trowel is valuable for prying off the loosened bark from old trees, whether felled or standing, and for digging into the ground or into decaying stumps and logs. The haversack is for the carriage of different kinds of boxes (those made of tin being best) intended for larval and other forms which it is necessary to bring home alive for breeding purposes; and if made with a partition so that the filled and empty boxes may be separated, all the better; it may also be used for nets and other apparatus to be mentioned, and for such provender as is necessary on the trip. The knapsack may be made on the plan of a cartridge box, of stout canvas or leather, and should be of moderate size and slung onto the belt so as to be slipped to any part of the waist and not hinder free bodily motion. It may be used to carry bottles, phials, and other small appliances, and should be accordingly partitioned and furnished with loops or pockets on the inside. The cigar-box is for the reception of pinned specimens, and may be slipped onto the belt, or buttoned to the trousers by means of leather.

"The greatest requisites in collecting are a pair of sharp eyes and ready hands, with coolness and self-possession; but a few traps will materially aid. One of the most important is the hand-net, which may be made so as to subserve the two purposes of a sweeping and an air-net."

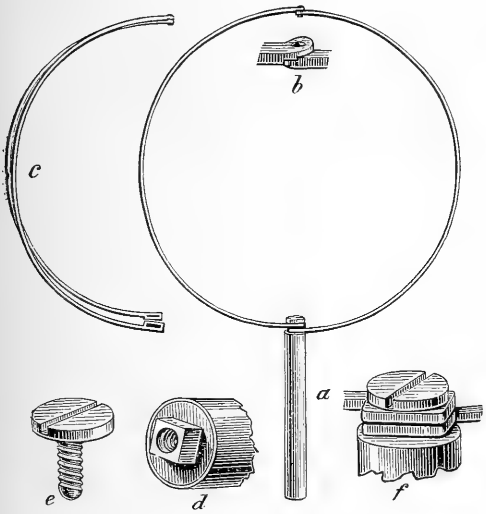


FIG. 44.—The Butterfly net-frame.

"The frame of the net which I use is illustrated herewith (Fig. 44), and will be found strong and serviceable and conveniently portable. It is constructed as follows: Take two pieces of stout brass wire, each about 20 inches long; bend them half-circularly and at one end by a folding hinge having a check on one side, *b*. The other ends are bent and beaten into two square sockets, *f*, which fit to a nut sunk and soldered into one end of a brass tube, *d*. When so fitted, they are secured by a large-headed screw, *e*, threaded to fit into the nut-socket, and with a groove wide enough to receive the back of a common pocket-knife blade. The wire hoop is easily detached and folded, as at *c*, for convenient carriage; and the handle may be made of any desired length by cutting a stick and fitting it into the hollow tube *a*, which should be about 6 inches long. It is well to have two separate hoops, one of lighter wire, furnished with silk gauze or some other light material, for catching flying insects, and one which is stouter and furnished with a net of stronger material for sweeping non-flying specimens.

"Another still more simple, but less convenient frame, is thus described by my friend F. G. Sanborn, of Boston, Mass.:

'Make a loop of strong iron or brass wire, of about 3-16ths of an inch in thickness, so that the diameter of the loop or circle will not exceed 12 inches, leaving an inch to an inch and a half of wire at each end bent at nearly right angles. Bind the two extremities of the wire together with smaller wire (Fig. 45, *a*), and tin them by applying a drop of muriate of zinc, then holding it in the fire or over a gas flame until nearly red hot, when a few grains of block tin or soft solder placed upon them will flow evenly over the whole surface and join them firmly together. Take a Maynard rifle cartridge tube, or other brass tube of similar dimensions; if the former, file off the closed end or perforate it for the admission of the wire, and having tinned it in the same manner on the inside, push a tight-fitting cork half way through (Fig. *c*) and pour into it melted tin or soft solder, and insert the wires; if carefully done, you will have a firmly constructed and very durable foundation for a collecting net. The cork being extracted will leave a convenient socket for inserting a stick or walking cane to serve as a handle.'

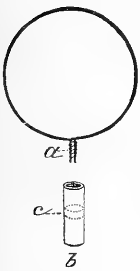


FIG. 45.—The Sanborn net-frame.

"My friend, J. A. Lintner, of Albany, N. Y., makes very good use, in his ordinary promenades, of a telescopic fish-rod, with a head (Fig. 46) screwed on to one end, in which to fasten an elastic brass coil on which the net is drawn, but which when not in use sits snugly inside his silk hat.


FIG. 46.—Clamp of the Lintner net.

"The bag should taper to the bottom, and in any case its length should be fully twice the diameter of the hoop, so that by giving the net a twist, the mouth may be closed and the contents thus secured. The sweeping-net may be protected around the hoop with leather, and in use should be kept in a steady and continued back-and-forth motion, over and touching the plants, until the contents are to be examined; when, by placing the head at the opening and quietly surveying the restless inmates, the desiderata may be secured and the rest turned out. A sudden dash of the air-net will usually lay any flying object at the bottom. A net for aquatic insects may be made on the same principle, but should be stout, with the meshes open enough to allow free passage of water, and the bag not quite as deep as the diameter of the hoop. A forceps net, which consists of two gauze or bobbinet covered frames, having riveted handles, so as to close like a pair of scissors, is employed for small insects; but I find little use for it. A coarse sieve, together with a white towel or sheet, will be found of great service for special occasions, particularly in the spring, when the search for minute insects found under old leaves, or for pupæ around the butts of trees, is contemplated. With the sheet spread on the ground, and a few handfuls of leaves and leafy mold sifted over it, many a minute specimen will be separated from the coarser particles and drop to the sheet, where the eye may readily detect it. Conversely, the earth taken from around trees may be sifted so as to leave in the sieve such larger objects as pupæ, etc. Another favorite plan, with some collectors, of obtaining specimens, especially night-flying moths, is by 'sugaring.' This consists of applying to the trunks of trees or to strips of cloth attached to the trees some sweet, attractive, and stupefying preparation. Diluted molasses or dissolved brown sugar, mixed with rum or beer, is most frequently employed. I have found sugaring of little use till after the blossoming season, and it is almost impossible to so stupefy or intoxicate an insect that it will remain upon the sugared tree till the next morning. I generally sugar at eve, and visit the tree several times between sundown and midnight, armed with wide-mouthed killing-bottles and accompanied by a second person, who carries a dark-lantern. Isolated trees, on the edges of woods, give the best results. Everybody knows how some poor moths will persist in flitting around a light until they singe their wings; and, as many insects are strongly attracted to bright artificial light, it may be employed with good results, especially during warm and damp evenings. The collector should never go unprovided with a small box or tube full of different sized pins (a corked cartridge-tube makes a good box,) a pair or two of forceps, a pair of scissors, a little mucilage, and the killing apparatus to be described."

With these general remarks, it will be well to consider some of the important paraphernalia more in detail.

COLLECTING APPARATUS.

The Sweeping Net.—A multitude of insects of all orders feed or rest on grasses and other low plants. Upon close inspection of these plants a careful observer will be able to secure, without any instruments, not only many mature insects, but also many larvæ in connection with their food-plants. This is laborious and slow work, only necessary on special occasions. The beating net, which is constructed on the same general plan as the butterfly net, is valuable here as a time saver. By holding the handle of the net firmly in one hand and quickly sweeping over the plants first from right to left, and then, after quickly turning the net again, sweeping from left to right, most insects coming within reach of the sweep will fall into the bag and may be easily taken out and put into the collecting-vials. From this mode of operation it is evident that the sweeping net must be stronger in all its parts than the butterfly net, but otherwise it may be made on the same plan.

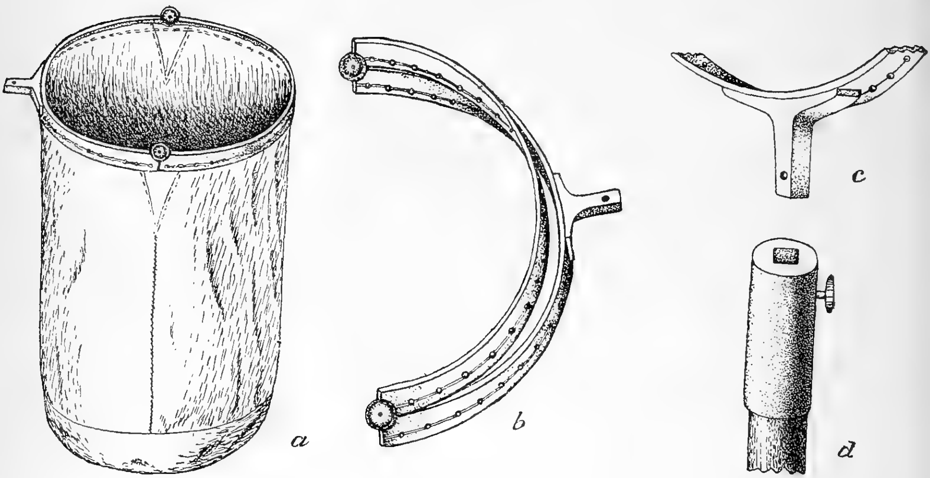


FIG. 47.—The Deyrolle Sweeping Net. *a*, net entire; *b*, frame; *c* and *d*, attachment of frame and handle (original).

The ring should be rigid, made of brass or iron, either of one piece or of two pieces, and fastened to the handle or stick in the same way as the butterfly net. The bag need not be as long as in the butterfly net, about 18 inches being sufficient, but it should be of stout cotton or linen and the bottom should preferably be sewed in as a round piece, so as to avoid corners. Care needs to be bestowed on the fastening of the bag on the ring, for by the use of the net the part of the bag sewed around the ring is soon chafed through. To prevent this a strip of leather is sewed over the cotton along the rim, but since even this must be frequently renewed some other devices are used to give greater durability to the net. In the pattern of a beating-net originally sold by Deyrolle in Paris, the metal ring was flattened, with the narrow edge pointing upwards and the broad side pierced with holes at suitable intervals and grooved on the outer surface between the holes. The bag is sewed on to the inner side of the ring by stout twine, which passes from one hole to the next and is thus prevented from coming in contact with obstructive objects, and only the bottom of the bag wears and will need to be occasionally mended or renewed.

Another method of preventing the tearing of the upper rim of the bag is described and illustrated in Kiesenwetter's useful volume "Der Naturaliensammler" from which I shall frequently have occassion to quote. In this net the main ring is of rounded iron wire on which a number of brass rings are slipped. These must be but little larger than the diameter of the wire. These little brass rings should not be more than 30 mm. or at most 40 mm., distant from each other, and to them the upper rim of the bag is sewed with very strong twine and is thus protected from wear and tear. The handle or stick of the net should be firmly and solidly attached to the ring and should be stout and not liable to break. I prefer a rather short stick, say not longer than two feet.

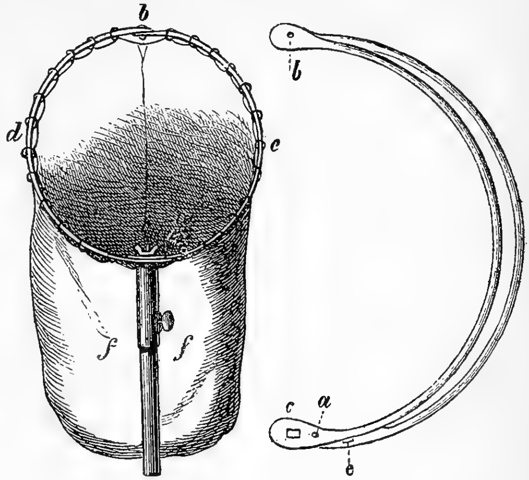


FIG. 48.—Beating net, opened and attached to handle, with frame of same folded. (After Kiesenwetter.)

I figure herewith the ring of a very convenient net for sweeping or beating purposes. It has the advantage of being for sale on the market, and in fact is an ordinary fishing dip net of small size. It is hinged in three places, as shown in the figure, and folds into very small compass. When unfolded and brought together, it screws into a ferrule which may be attached to a cane or a special handle.

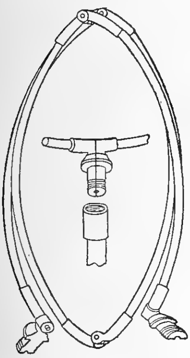


FIG. 49.—Folding ring for beating net (original).

The beating net can be successfully used at almost every season of the year. Even on warm days in winter time many specimens can be swept from the dead grass. So long as the dew is on the plants or in rainy weather no beating should be attempted, as the more delicate species are more or less spoiled by the moisture. After one or two minutes' sweeping the contents should be examined. Those insects which are quick to take wing or which are good runners should first receive attention; the less active can then be examined more at leisure. The desiderata are then disposed of, the rest thrown away, and the beating renewed.

The beating net is an important instrument for collecting all insects excepting mature Lepidoptera, which are apt to get rubbed. Many larvæ, especially of Lepidoptera, are caught by beating and are mostly in good condition, but it is usually difficult to ascertain the food plant.

The Water Net.—The numerous insects or insect larvæ which live in the water can not be conveniently collected without the use of a net, except where they live in small shallow streams or creeks with gravelly or stony bottoms. A suitable water net can readily be made by using the frame of the beating net and attaching to it a rather short bag of some coarse material, *e. g.*, "grass cloth," coarse millinet. The mode of operation with this net is very simple: if some insect is seen swimming in the water, the net is carefully brought beneath the specimen, which is thus lifted out of the water. Most water insects are, however, not seen swimming about freely, but hide amid the various plants, mosses, etc., or in the mud at the base of the plants, and they can best be captured by dragging the net through these plants. When taken from the water the net is more or less filled with mud and parts of plants, and the water must be allowed to run out and the contents of the net spread out on a cloth or on a flat stone, if such be at hand. The insects are at first not readily seen, but after a short while they begin to emerge from the mud and crawl about, and can readily be taken up with a forceps.

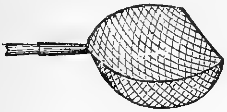


FIG. 50.—The Water Net. (After Packard.)

Water Dip Net.—The small water sieve, shown in the accompanying illustration (Fig. 51), and somewhat resembling in appearance a jockey cap, is frequently of service in collecting the larvæ of aquatic insects, especially where it is necessary to scrape submerged stones or timbers. In use it is fastened on the end of a cane or stick, and can be easily made by any tinsmith.

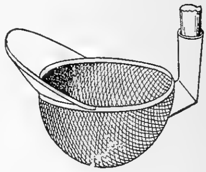


FIG. 51.—Small Water Dip Net (original).

The Umbrella.—The umbrella, as already stated, is one of the most useful instruments of the collector, since it enables him to obtain all those numerous insects which live on the branches of trees, on shrubs, and on other large plants. A common stout cotton umbrella is sufficiently large, but is liable to get out of joint, and moreover the specimens hide themselves under the ribs. It is well, therefore, to have the inside of such umbrella lined along the ribs with muslin, or some other material, preferably of a light color. An umbrella specially constructed for entomological purposes is offered for sale by E. Deyrolle, in Paris. It resembles a stoutly built common umbrella, but has the inside lined with white linen and the handle has a joint near the middle, so that the umbrella can be more conveniently held and more readily packed away. The opened and inverted umbrella is held with the left hand under the branch which the collector intends to relieve of its entomological inhabitants, while the right hand, armed with a heavy stick, is free to properly jar the branch. Care must be taken in the jarring, lest the insects are knocked beyond the circumference of the umbrella. The larger the umbrella the greater are the chances of making rich captures, but the more difficult it becomes to manipulate, especially where the woods are dense or where there are many vines, etc. In the absence of an umbrella the butterfly net or the beating net can be used.

A drawback to collecting with the umbrella is that many insects take wing and escape before being secured. This can hardly be avoided,

FIG. 52.—The Umbrella and its mode of use. (After Kiesenwetter.)

and experienced collectors, in southern countries more particularly, have found it advisable to discard the umbrella and to use in its stead a very large butterfly net, 2 feet or more in diameter.

The Beating Cloth.—A very simple substitute for the umbrella, and one which can always be carried without inconvenience, may here be described. It consists of a piece of common unbleached cotton cloth (1 yard square), to each corner of which a loop of stout twine is sewed. Upon reaching the woods, two straight sticks, each about 5 feet in length and not too heavy, but also not so small as to be liable to break or to bend too easily, are cut from a convenient bush. The sticks are placed crosswise over the cloth and fastened to the loops at the four ends. This is easily and quickly done by making sliding loops of the simple loops. The cloth is thus kept spread out between the sticks, and forms a very good substitute for an umbrella. In beating, the sticks are held at their intersecting points. When not in use one of the loops is detached from the stick and the instrument can be rolled up and carried under one arm without seriously interfering with other operations of the collector. When laid on the ground, with the sticks on the underside, this simple instrument may be advantageously used as a cloth on which to sift or examine fungi, moss, pieces of bark, etc., and since the cloth is always tightly expanded, it offers a smooth and level surface, where examination of various objects can be made with ease and accuracy.

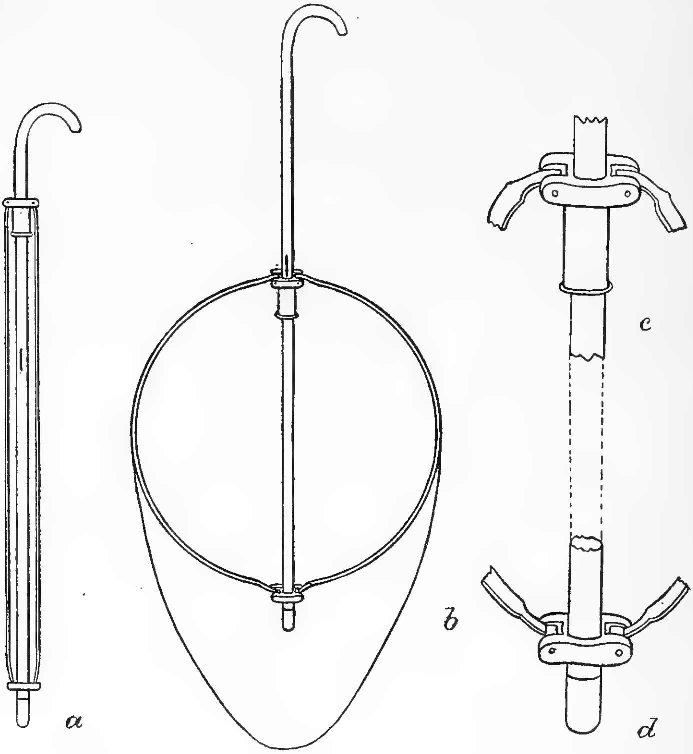


FIG. 53.—The umbrella beating and sweeping net (original).

The Umbrella Net.—A very convenient form of net for both sweeping and for use in place of an umbrella for beating has been devised by Dr. George Marx. (See Fig. 53.) It is constructed from an old umbrella, as follows: To the handle of the umbrella are attached two steel rods working on hinges at the apex of the umbrella, as do the ordinary umbrella ribs, and attached to the sliding piece of the umbrella in the same manner, as shown at *a*. These rods should be about $2\frac{1}{2}$ feet long. When the sliding piece is pushed up and caught behind the spring clip, as shown at *b*, a circular loop is formed giving the framework for the net. The latter, which should be comparatively shallow, is made of stout muslin and sewed to the frame, as in the ordinary sweeping net. The enlarged drawings *c* and *d* illustrate clearly the manner of constructing the frame. The advantage of this net is its convenience in carrying and its general usefulness, taking the place of both the umbrella and the sweeping net. When not in use the frame is allowed to assume the position shown at A, and the net may be wrapped about the frame and the whole inserted in an ordinary umbrella cover.

The Sieve.—This useful aid to good collecting has not been generally employed by American entomologists. It facilitates the finding of small insects living under old leaves, in moss, in decayed trees, in fungi, in ants' nests, or in the ground. Any ordinary sieve about a foot in diameter and with meshes of about one-fifth of an inch will answer, though for durability and convenience of carriage one made of two wire or brass rings and muslin (Fig. 54), as follows, is the best. The ends of the wire netting should be bent around the ring so as not to project. A piece of common muslin about 1 foot wide and long enough to go around the circumference of one of the rings is then sewed together so as to form a kind of cylinder or bag without bottom, and the upper and lower rims of this bag are then sewed on around the two rings. The whole instrument thus forms a bag, the top of which is kept open by the simple wire ring, and the bottom is closed by the second ring covered with the wire netting. After choosing a suitable locality a white cloth is spread as evenly as possible on the ground; the collector then takes the sieve, places therein two or three handfuls of the material to be sifted, returns to his cloth, and, holding with his right hand the lower ring and with the left hand the upper ring, shakes the sieve over the cloth. The larger particles and specimens are retained in the sieve while the smaller fall through the meshes on to the cloth. Care must be taken that the siftings form an even and thin layer on the surface of the cloth, so as to be easily examined from time to time. If the locality is favorable many insects will be seen at the first glance crawling or running about, and these can easily be picked up by means of a moistened brush, or with the forceps. Many other insects, however, either feign death or, at any rate, do not move until after the lapse of several minutes, and the proper investigation of a single sifting often requires much time, and patience will be more fully rewarded here than in any other mode of collecting.

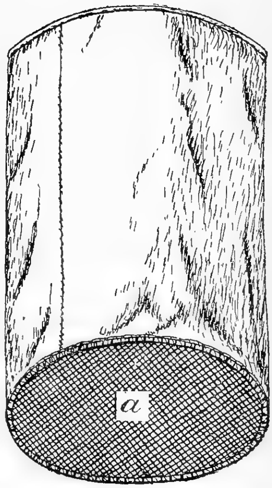


FIG. 54.—The sieve. *a*, wire netting (original).

The size of the wire meshes given above is best adapted for sifting the fragments of old decayed trees, which furnish the most frequent material for the use of the sieve, but for sifting ants' nests, soil, etc., a sieve with smaller meshes is desirable.

The sieve is indispensable to the Coleopterist, the Arachnologist, and to the specialist in the smaller Hemiptera and Hymenoptera, but it is also useful for most other orders, many interesting species existing which can be secured in numbers only by this mode of collecting. Many

Tineidæ and even Noctuidæ hide under old leaves, but the specimens are usually rubbed and rendered useless in the process of sifting. Many larvæ and pupæ can, however, thus be obtained.

If the locality chosen for sifting prove to be a good one, it pays to put the sifted material in a small sack and to carry it home where it can be investigated at leisure, and with a greater thoroughness than is usually possible outdoors. This sack can be easily arranged to be attached to or drawn over the lower ring of the sieve, so that the sifting can be done directly into the sack.

As a rule it may be said that very dry places are least productive, while more or less moist places are apt to furnish a rich harvest. Old wet leaves lying immediately along the edges of swamps, or wet moss, harbor many interesting insects, but such wet material is sifted with difficulty.

The sieve can be used with great advantage at all seasons of the year, but more especially late in fall or early in spring, when so many species are still hibernating.

The Chisel.—For securing the many insects living or hiding under bark of dying or dead trees an instrument of some sort is indispensable, as, in most cases, the bark so firmly adheres to the wood that it cannot be torn off with the hand. A stout pocket-knife will do good service, but far better is a common chisel of medium size and with a short handle. This chisel is also useful as an instrument for digging in the ground or for investigating the interior of partly decayed logs.

The Trowel.—Aside from the fact that many insects enter the ground for the purpose of hibernation in various stages, there is a rich subterranean life to be found during the summer. There are many burrowing Coleoptera; many, if not most, ants construct subterranean nests; the number of other fossorial Hymenoptera is very large, and there are also various burrowing Orthoptera and many Lepidopterous larvæ which hide in the ground during the day. Some instrument for digging in the ground is therefore of great importance, and while, as stated above, the chisel will answer this purpose if nothing else be at hand, yet there are other instruments which perform the work much quicker and more thoroughly. The most available instrument is a rather small steel trowel, such as can be had at the hardware stores in a great variety of patterns, and which can be carried on excursions without much inconvenience. One with a long and narrow blade, made very stout, I have found very useful, though somewhat awkward to carry.

FIG. 55.—The collecting tweezers.

The collecting Tweezers.—In the picking up of specimens and transferring them into the various bottles, vials, or boxes, the trained collector will gather by hand the most delicate specimens without injuring them. Yet this labor will be greatly facilitated by the use of the

FIG. 56.—Pinning forceps.

tweezers or the brush. The former is a small, light pair of forceps, made of steel or brass. It should be as pliable as possible, and the tip should be narrow and rounded off and not pointed. It may be either straight or curved at tip, according to individual preference.

Suitable tweezers may be obtained at the larger hardware stores or of watchmakers. Excellent tweezers made of steel (see Fig. 55) are

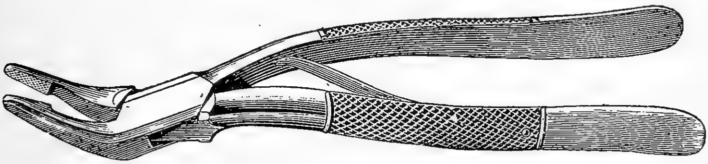


FIG. 57.—Pinning forceps.

sold for about 40 cents a pair by Codman, Shurtleff & Co., Tremont street, Boston, Mass. Aside from their utility in picking up specimens from the collecting cloth or the umbrella, the tweezers are indispensable for extracting insects from cracks, or holes in timber, or from their burrows in branches and stems of plants, or from places whence it is impossible to dislodge them by hand. The larger "collecting forceps," sold by various dealers, do good service in certain emergencies, as when large scorpions or other very large and ferocious insects are to be secured.

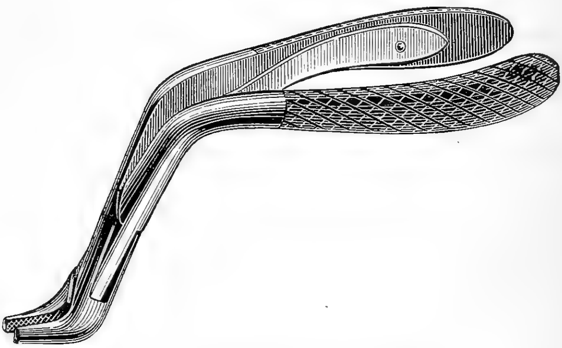


FIG. 58.—Pinning forceps for Lepidoptera.

For the handling of mounted insects various special forceps are employed, a number of styles of which are shown at Figs. 56–8.

The Brush.—A common camel's hair brush, of smaller or larger size according to individual preference, is useful for picking up very small or soft-bodied insects. For this purpose the brush is slightly moistened with saliva, and the tip brought in contact with the specimen, which then adheres to the brush, so that it can readily and without injury be transferred to the collecting bottle or box. The brush is indispensable also for preparing small specimens for the cabinet. If taken into the field the handle of the brush should be of a bright color, otherwise the brush is often lost.

The Fumigator.—This is not used by American collectors, but there are several patterns sold by European dealers. It is intended to smoke out specimens that hide in otherwise inaccessible places, *e. g.*, cracks in the ground, holes in hard wood, etc. The accompanying figure and the following description of a fumigator are taken from Kiesenwetter. A common smoking-pipe mouthpiece (Fig. 59, *a*) with flexible rubber joint (*b*) is attached to the cover (*c*) of a very large smoking-pipe head (*d*). To the mouth (*e*) of the latter a rubber hose (*f*) is attached, which has a convenient discharge at its end (*g*). The pipe is then filled with tobacco, and the latter ignited by means of a piece of burning tinder placed on top; the cover is then screwed on, and the smoke can be directed to any desired point by blowing air through the mouthpiece. The smoke from a common pipe or cigar is often useful. In sifting in cold weather a puff of tobacco smoke gently blown over the débris on the collecting cloth will induce many specimens to move, which otherwise "play possum" and could not be observed; and, further, tobacco smoke blown into holes and cracks in timber by means of an improvised funnel made of a piece of paper will be the means of securing many rare specimens.

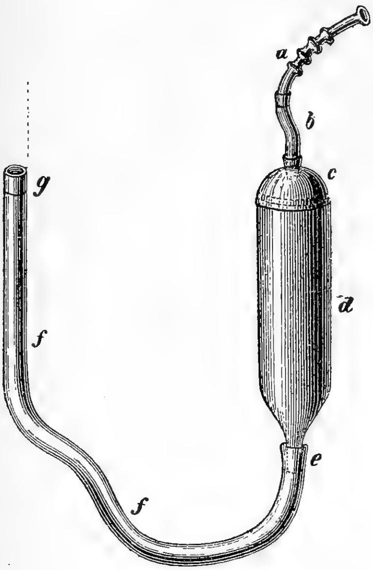


FIG. 59.—The Fumigator. (After Kiesenwetter).

The Haversack.—In order that the above-mentioned instruments and the various bottles, vials, and boxes which are needed for the preservation of specimens may most conveniently and with the least impediment to the collector be carried along on excursions, a haversack is indispensable. This is made either of leather or, still better, of some waterproof cloth, and should contain various compartments of different sizes; one for stowing away the nets, the sieve, and the larger instruments, and several smaller ones for boxes and vials—the whole so arranged that each desired object can readily be taken out and that nothing will drop out and get lost. The haversack is slung across the shoulders by means of a leather strap, and a full field outfit need not be very heavy nor seriously interfere with free bodily movements.

Many of the smaller objects are most conveniently carried in the pockets of the coat, which acquires, therefore, some importance to the collector. The coat should be of some durable stuff and provided with many pockets, so arranged that in stooping nothing falls out of them.

The Lens and Microscope.—In the examination of the minuter forms of insect life the naked eye is not sufficient, and a hand-lens, or, for more delicate work, the compound microscope will be found necessary. I had, in my early experience, some difficulty in getting a satisfactory hand-lens, and the use of a poor hand-lens in time injures the eyesight, as I know by a year's rather disagreeable experience. For a hand-lens the achromatic lenses formerly manufactured by A. K. Eaton, of Brooklyn, N. Y., and now made by John Green, 35 Liverpool street, East Boston, Mass., are most excellent in workmanship and are satisfactory in every respect. A very good lens can also be purchased of any of the leading manufacturers of microscopical apparatus in this country. The kind of compound microscope to be purchased will depend upon the nature of the work of the investigator. Very serviceable instruments are made by J. W. Queen & Co., Philadelphia, Pa., and by the Bausch & Lomb Optical Company, of Rochester, N. Y., and others. The German microscopes are in many respects superior to those of American make, and if one has sufficient means, I would recommend the purchase of one of the better instruments of Zeiss's manufacture, which may be obtained either direct from the manufacturers or through Queen & Co., or from the Boston Educational Supply Company. Microscopic material, including slides, cover glasses, instruments for mounting, mounting media, staining fluids, etc., may be obtained of either of the firms named above.

Having thus indicated somewhat fully the general methods of collecting, and the paraphernalia most desirable in collecting, it will be well to go still further into detail, and in connection with the different orders give some more specific information that will be valuable as a guide not only to the general collector, but to the specialist.

COLLECTING HYMENOPTERA.

The insects of this order, including Bees, Wasps, Ants, Ichneumon-flies, Gall-flies, Saw-flies, and allied insects have always been of unusual interest both to entomologists and non-entomologists on account of their diversified and peculiar habits. In abundance of species they exceed perhaps even the Coleoptera. In general they are day fliers and always to be found in abundance on bright days about flowers. The best season for collecting is in early spring, on the bloom of the Willow, Alder, and other trees. They may also be found at any season of the year, but the males of many species are only to be taken in fall. In this order, species of many groups can be most easily obtained by breeding. This includes the gall-making family, Cynipidæ, and the parasitic families Chalcididæ, Proctotrypidæ, Ichneumonidæ and Braconidæ. The Chrysididæ and certain other less important families are also parasitic, but are more easily obtained by general collecting. The implements necessary for collecting Hymenoptera are the sweeping-net and the beating-net. Many rare forms of the smaller parasitic families may be obtained by sweeping the grass and foliage of all sorts. The

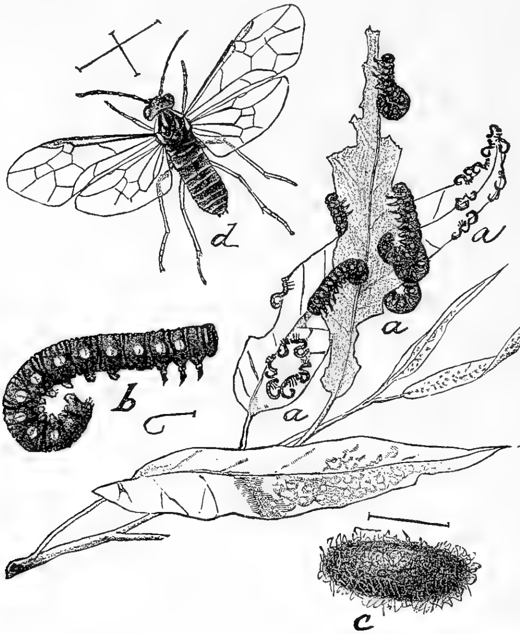


FIG. 60.—A Saw-fly (*Nematus ventralis*). *a*, *a*, *a*, young larvæ; *b*, full-grown larva; *c*, cocoon; *d*, adult; all slightly enlarged.

Proctotrypidæ may be collected in quantity by sifting leaves and rubbish collected in the woods. Mr. William H. Ashmead, who has made an especial study of this group, finds winter sifting profitable. Dried leaves and rubbish are sifted, the finer portion being retained and transferred to a bag. When a sufficient quantity is collected it is removed to a warm room. Many hibernating species are taken in this way, and, revived by the warmth, are easily noticed when the material is spread on white paper.

On account of the interest attaching to a knowledge of the various hosts of parasitic insects the collector should always aim to obtain the latter by breeding as much as possible. This can easily be done by keeping a lookout for larvæ of all sorts which give evidence of being parasitized. The larvæ of Lepidoptera found late in the fall are very apt to be parasitized, and should be collected and kept over the winter. The parasites will emerge throughout the winter season and in the early spring. Such larvæ will be found on the trunks of trees, in the crevices of the bark, and the cocoons of parasites will also be found in similar situations.

The Tenthredinidæ (Saw-flies) are not so often found about flowers but usually remain in the vicinity of the food-plant of the larva, and may many of them be collected by sweeping. The larvæ of this family are in many cases difficult to breed, as most of them are single-brooded, and it becomes necessary to carry the larvæ over the winter.

The Gall-flies, Cynipidæ, are the easiest of the families to collect, because of their abundance and because of the ease with which they may be reared. Their galls occur in enormous variety on oaks of various species and also upon brambles and certain common weeds. These should be collected when mature and be kept in glass jars. The Gall flies and inquilinous and parasitic species may thus be easily obtained, the former appearing at particular seasons and the latter emerging from the galls at all seasons of the year, and sometimes continuing to escape for a period exceeding two years.

One of the most interesting families in this order is the Formicidæ, which comprises the true ants. In the case of these insects isolated specimens should not ordinarily be collected, and it is especially desirable to collect the species from colonies so that the three forms (males, females, and workers) may be obtained together. This holds also in the case of the social wasps and bees, but the different sexes of the latter may be collected in a season's collecting about flowers, the females and workers in early spring and the males in the fall.

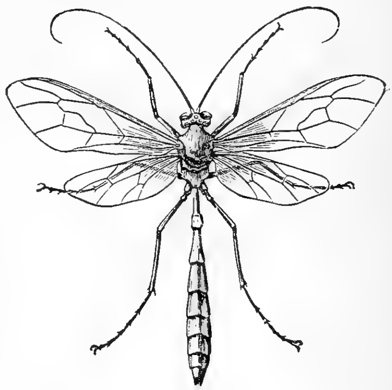


Fig. 61.—An Ichneumon (*Ophion*).

The Uroceridæ or woodborers are to be found only about trees in which the larvæ breed. They may frequently be taken about tree trunks, or burrowing with their long gimlet-like ovipositors into the trunks of trees to oviposit. Breeding is also a satisfactory method of obtaining these insects.

Some special methods of collecting Hymenoptera may be briefly outlined. In the case of the social bees, particularly bumble-bees, and also the smaller wasps and yellow-jackets, a very satisfactory method of collecting consists in first stupefying the insects in the nest by introducing a small amount of chloroform, benzine, or bisulphide of carbon. This should preferably be done in the late evening, after all the insects have come in for the night. The nest may then be opened and examined without any danger of being stung, and the different forms may thus easily be obtained, together with any rare parasitic or inquilinous insects. In the case of the nests of Bombi this is the best method of obtaining the inquilinous Apathus species.

On account of the danger of being stung, and also on account of the extremely quick flight of these insects, the removing of Hymenoptera from the net is not always an easy task, and in many cases rare specimens escape. One method of avoiding the danger of being stung is to have the collecting net constructed with an opening at the bottom which, during the sweeping, is tied with a string. When a sufficient quantity of insects is obtained they are, by a few quick motions, driven to the bottom of the net, and the net is then seized just above the insects with the hand, the folds of cloth preventing the insects from getting to the hand, so that there is little danger of being stung. The lower end is then carefully untied and inserted into a wide-mouthed bottle, and the contents of the net shaken out into the bottle. After the catch is stupefied the vial may be turned out and the undesirable material discarded. A second method consists in the use of an ordinary sweeping-net of light material. A quantity of Hymenoptera are collected from flowers and driven to the bottom of the net, and secured as in the preceding method. The portion of the net containing the insects is then, by means of a pair of forceps, thrust bodily into a large collecting bottle. After a few minutes the insects are stupefied and may be readily examined.

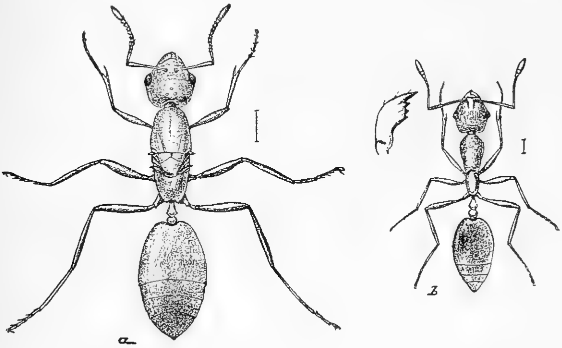


FIG. 62.—The Little Red Ant (*Monomorium pharaonis*). *a*, female; *b*, worker enlarged.

COLLECTING COLEOPTERA.

GENERAL DIRECTIONS.—Owing to their hard outer skeleton, Coleoptera can be collected, handled, and preserved with greater safety and with less trouble than most other orders of insects. From this fact, and from their very great diversity in form, Coleoptera have, next to the Lepidoptera, always been favorites. As a consequence, there are now more species described in this than in any other order, and in the large museums they are much better represented than other insects. This rich material has been studied by numerous and competent specialists, and the classification of Coleoptera is at present more advanced and more accessible than that of the other orders. This fact gives stimulus to neophytes, and though the literature of our North American fauna is much scattered and we are still in want of comprehensive works (with the exception of the general "Classification" by Drs. Le Conte and Horn), yet, except in a few hitherto neglected families and smaller groups, the species are fairly well worked up.

On the other hand, our knowledge of the earlier states of Coleoptera is yet very imperfect as compared with the Lepidoptera. Coleopterous larvæ are, with few exceptions (notably Coccinellidæ and some Chrysomelidæ), much more difficult to find and rear, and their distinguishing characters are more difficult to study. The few comprehensive works on Coleopterous larvæ that have been published are based on rather scant material and none of them deal with the North American fauna.

Coleoptera occur in all climates and in all localities. Species are known from the highest northern latitudes ever reached by man, and in the tropics they occur in an embarrassing richness of forms. They are found in the most arid desert lands, in the depths of our subterranean caves, and on our highest mountains up to the line of eternal snow. The open ocean and the open water of our Great Lakes are the only regions free from them. As a rule, the number of species gradually increases from the Arctic regions toward the tropics, but it would be difficult to decide, speaking of North America, whether or not the fauna of the Middle States is poorer in the number of species than that of the Southern States; or whether the beetles of the Atlantic slope outnumber those of the Pacific States or those of the Central region. On the Pacific slope the influence of the seasons on insect life is greater than on the Atlantic slope. While in the latter region a number of species may be found the whole year round, there is, in the more arid regions of the West, an abundance of insect life during and shortly after the rainy season, with great scarcity during the dry season, except, perhaps, on the high mountains.

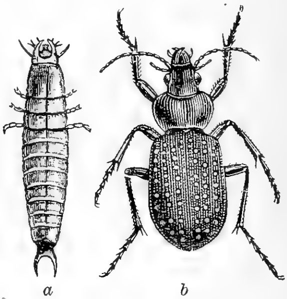


FIG. 63.—A Ground-beetle (*Calosoma calidum*). *a*, larva; *b*, adult.

Few persons have had a more extended experience in collecting Coleoptera than Mr. E. A. Schwarz, one of my assistants, and the following account has been prepared by him at my request and is given *in extenso*.

WINTER COLLECTING.—There are more species of Coleoptera hibernating in the imago state* than in any other order and winter collecting is therefore most profitable in many respects. For instance, great swampy tracts which are inaccessible in the summer season harbor an abundance of rare Coleoptera, which either can not be found in summer time or are found at that season with the greatest difficulty. At the approach of winter, however, all or most of these species will leave the swamp and seek drier ground, where they hibernate under old leaves, under bark of trees, or in rotten stumps near the edge of the swamp. Such places will, therefore, give a rich harvest to the Coleopterist late in the fall, during warm spells in midwinter, and in very early spring. If the temperature is below the freezing point, or if the ground is frozen hard, no winter collecting should be attempted, first, on account of sanitary

*There are a few species of Coleoptera known in Europe which belong to the true "winter insects," *i. e.* such as appear in the imago state only during winter time, but whether or not we have such species in our own fauna has not yet been ascertained.

considerations, and also because the Coleoptera then retreat more deeply into the ground and can not be found so easily as when the ground is free from frost. Other good collecting places in winter are the accumulated old leaves along the edges of forests or under the shrubbery along water courses, thick layers of moss, and the loose bark of dead or dying trees, and, finally, also under the bark of certain living trees, *e. g.* Pines, Sycamore, Shellbark Hickory. Digging in the ground at the base of large trees or rocks also yields good returns. The only instruments necessary for winter collecting are the sieve, the chisel, and the trowel.

SPRING COLLECTING.—With the first days of spring, collecting becomes a little more varied. The methods used for winter collecting can still be continued with good success. Certain spring flowers, notably Willow blossoms, will furnish many valuable species, which are not seen again during the rest of the season.

Myrmecophilous and Termitophilous species.—The early spring is also the best time for collecting the Myrmecophilous and Termitophilous Coleoptera. Termitophilous species have in North America hitherto been found only in connection with the White-ants (*Termes flavipes*), and the inquilinous beetles are found running among the White-ants in the colonies under stones, loose bark of trees, and more numerously in the interior of old infested trees. Myrmecophilous Coleoptera are by far more numerous in species than the Termitophilous species and are found among many species of ants which have their nests either under stones or loose bark of trees, in stumps or logs, or which construct larger or smaller hills. Upon uncovering a colony of ants under a stone, the underside of the latter as well as the galleries of the ants in the ground should be carefully examined for inquilines, which from their greater or slighter resemblance to the ants are liable to be overlooked by an inexperienced collector. If such colony of ants harbors a rare beetle the subterranean part of the colony itself should be dug out and sifted, but since from the stony nature of the ground this is not always practicable it is to be recommended to carefully replace the stone under which the colony has been found. Upon revisiting the spot again the next day or even a few hours after the first visit additional specimens of the inquilines are usually to be obtained on the stone or in the superficial galleries of the ants. Ant colonies in hollow trees and in rotten logs should be sifted and there is no particular difficulty connected with this operation. Owing to the pugnacious character of the hill-constructing ants it would seem to be a rather unpleasant task to examine a strong and vigorous colony for inquilinous beetles, but the collector must not mind being bitten and stung by the infuriated ants, and after a little experience he will find that it is not such a difficult thing after all to attack even the largest ant-hill. The only thorough way of investigating such ant-hills is to sieve the same, which can be easily done if the hill is composed of sticks and other vegetable débris. If it is built of earth or sand the process of sifting is more difficult and tedious. Another method of securing specimens of these inquilinous beetles is to place flat stones or similar objects on the surface of the ant-hill and to examine them occasionally, when the beetles will be found on the underside of the traps.

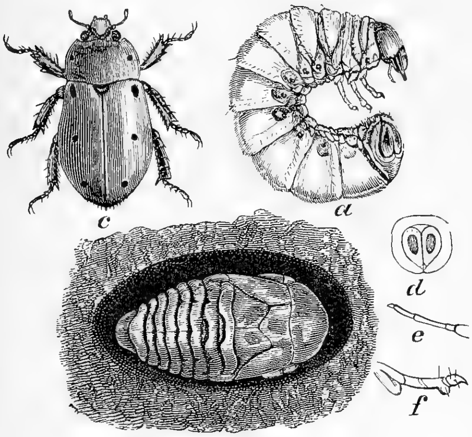


FIG. 64.—A Lamellicorn (*Pelidnota punctata*). *a*, larva; *b*, pupa; *c*, beetle; *d*, *e*, *f*, enlarged parts.

Spring Flights of Coleoptera.—On the first really warm days of spring commences the "swarming" season of Coleoptera, when all winged species are flying about, especially toward evening. On favorable days the number of specimens and species that can thus be found is astonishingly great, and this is one of the few occasions when the Coleopterist can advantageously use a light butterfly net. The flying beetles preferably alight and rest on the top of wooden fences (especially newly made ones), on the railings of bridges, etc., where they can be easily seen and secured, or they are attracted in great numbers by the white-painted surface of buildings. This flying season lasts in the latitude of Washington from the end of April to the middle of June, but favorable days are not of frequent occurrence, since a peculiar combination of atmospheric conditions appears to be necessary to induce the Coleoptera to fly about in great numbers.

Beach collecting.—Along the shores of the ocean and the Great Lakes untold numbers of Coleoptera and other insects fall at this season into the water, and, if the tides, the currents, and the winds be favorable, they are washed ashore by the waves on the sandy beaches, where they often form windrows several inches in height and width. If the collector is happy enough to be at the right place on the right day he has then the opportunity to pick up hundreds of rare species within a very short time and without any trouble. Many of the specimens thus washed ashore are dead and decayed, but the majority are alive and in excellent condition. This "beach collecting" affords also an excellent opportunity for the Hymenopterist and Hemipterist to secure large numbers of rare species, but favorable days are also here of rare occurrence.

Attracting by Lights.—On the beaches, day and night flying insects can thus be captured. Away from the beach night-flying Coleoptera can best be collected at the electric lights of our cities; but, as in the Lepidoptera, not all night-flying species are attracted by the light. Gas and other lights also attract Coleoptera, and the various "light traps" that have been devised and described can advantageously be used for collecting these insects.

Traps.—The method of "sugaring," so important to the Lepidopterist, is by far less favorable for collecting Coleoptera. Still, certain rare Carabidæ, Elateridæ, and Cerambycidæ are attracted by this bait, and the Coleopterist should not entirely ignore this mode of collecting. There are a few other methods of trapping certain Coleoptera. By laying out dead mammals, birds, fishes, snakes, etc., on suitable places and so that they are protected from dogs, rats, etc., the carrion-feeding Coleoptera can be found in great abundance, but a cleaner and less disagreeable method of obtaining them is to bury in the ground tin cans or glass jars so that the top is even with the surrounding ground and to bait them with pieces of meat, fried fish, boiled eggs, etc. Many Curculionidæ, Scolytidæ, and numerous other wood-inhabiting species can be successfully trapped in the following way: A number of branches, preferably of only one kind of tree, are cut and tied up into bundles of convenient size. The bundles are then laid on the ground in a shady place or firmly fastened on trunks of trees. When the cut branches begin to get dry they will attract many of these Coleoptera, which can then be readily collected by shaking the bundles out over the collecting cloth.

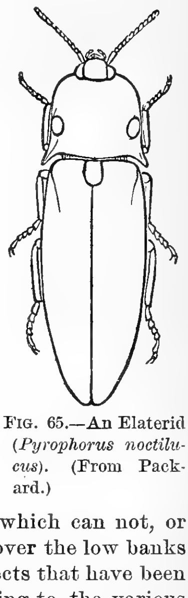


FIG. 65.—An Elaterid (*Pyrophorus noctilucus*). (From Packard.)

Freshets.—Freshets usually take place in springtime in most of our rivers and creeks, and furnish the means of obtaining a multitude of Coleoptera, among which there will be many species which can not, or only accidentally, be found otherwise. These freshets, sweeping over the low banks or inundating wide stretches of low land, carry with them all insects that have been caught by the inundation. Intermingled with, and usually clinging to, the various floating débris, these insects are eventually washed ashore by the current at various points and the Coleopterist should not miss this rare opportunity, but go out to the river bank at a time when the water is still rising, or at least when it has attained its highest point. Among, or on the washed up débris, a multitude of Coleoptera of various families can be found, and the specimens can either be gathered up on the spot or a quantity of the débris be put in sacks and taken home, where it can be examined more thoroughly and with greater leisure than out of doors. A day or so after the floods have receded the washed up specimens will have dispersed and only a few will remain in the débris for a longer period. Still more profitable than the spring floods are the summer freshets, because a larger and more diversified lot of Coleoptera is then brought down by the water. A similar opportunity for collecting is offered near the seashore if unusually high tides inundate the low marshes along the bayous and inlets.

SUMMER COLLECTING.—During the latter part of spring and throughout the whole summer, when the vegetation is fully developed, every possible collecting method can be carried on with success, so that the beginner hardly knows what particular method to use. There are stones to be turned over; old logs, stumps, and hollow trees to be investigated; newly felled or wounded trees to be carefully inspected; here a spot favorable for sifting claims attention; promising meadows and low herbage in the woods invite the use of the sweeping net; living or dead branches of all sorts of trees and shrubs to be worked with the umbrella; the mud or gravel banks of ponds, lakes, rivers, and creeks afford excellent collecting places; the numerous aquatic beetles are to be collected in the water itself; the dung beetles to be extracted from their unsavory habitations; in the evening the electric and other lights are to be visited, the lightning beetles chased on meadows and in the woods, or the wingless but luminous females of some species of this family to be looked for on the ground, and the trees and shrubs are to be beaten after dark in search of May beetles and other nocturnal leaf-feeding species which can not be obtained at daytime; and, finally, some of the rarest Scarabæidæ and some other species fly only late at night or again only before sunrise.

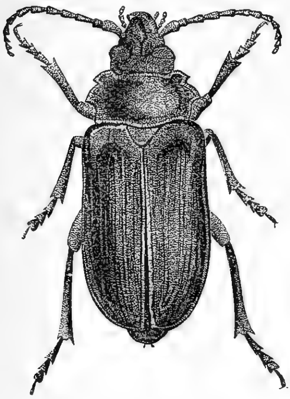


FIG. 66.—A Longicorn (*Prionus laticollis*).

In view of this embarrassing multitude of collecting opportunities in a good locality, the beginner is apt to be at a loss what course to pursue. Experience alone can teach here, and only an expert collector is able to decide, at a glance at the locality before him, what collecting method is likely to produce the best results, and his judgment will rarely be at fault.

It is impossible to go into details regarding the various collecting methods, just mentioned, and only a few general directions can be given regarding those methods which have not previously been alluded to.

Collecting under Stones.—Turning over stones is a favorite method among beginners and yields chiefly Carabidæ, the larger Staphylinidæ, certain Curculionidæ, and a multitude of species of other families. Stones on very dry ground are productive, only early in spring or in the fall, while those on moist ground, in the shade of woods, are good at all seasons. In the Alpine regions of our mountainous districts, especially above the timber line, collecting under stones becomes the most important method, and is especially favorable along the edges of snow fields. In often frequented localities the collector should carefully replace the stones, especially those under which he has found rare specimens. The neglect of this rule is one of the principal causes for certain rare species having become extinct in the vicinity of our cities.

Collecting in rotten Stumps and Logs.—Success in collecting in rotten stumps depends much upon the more or less advanced stage of decay as well as upon the situation of the log and upon the particular kind of wood. If the decay is very much advanced neither the loose bark nor the interior of the log will harbor many Coleoptera excepting a multitude of *Passalus cornutus* and its larvæ. If the decay is less advanced, but if such log is exposed to the scorching rays of the sun, it will be far less productive than a log in a shady situation. The investigation of the bark of a favorably situated log in the right stage of decay does not need any special instruction, but the decayed wood itself should be pried off with a chisel or trowel, put in the seive and sifted on tue collecting cloth. This is the best way of obtaining the numerous species of rare Micro-coleoptera of various families that inhabit such places. A "red rotten" oak or beech log is more favorable for this mode of collecting than a "white rotten" of the same or other kinds of trees.

Collecting in dying or dead Trees.—Dying or dead trees almost always harbor a large number of Coleoptera and offer an excellent collecting opportunity until the wood becomes thoroughly dry, which usually takes place in large trees two or three years after the death of the tree, and in less time with smaller ones. The bark of such trees is the best collecting place for Cucujidæ, Colydiidæ, Scolytidæ, Histeridæ, etc., and it will be found that the shady side of the tree is more profitable than the side exposed to the sun. The numerous Buprestidæ, Elateridæ, Ptinidæ, Cerambycidæ, Melandryidæ, etc., which breed in the wood can be obtained only with difficulty. Some specimens may be cut out from their holes by a skillful use of the knife or hatchet; others (especially the Buprestidæ) may be found resting on or crawling over the trunk in the bright sunshine, while the more nocturnal species may be found on the tree toward evening or after dark, when, of course, a lantern must be used. A large proportion of the species living in the trunks of dead trees also breed in the dead branches of otherwise healthy trees from which they can be beaten into the umbrella, or where the use of the knife is more practicable than in the large trunks. The trunks of freshly felled trees attract numbers of Cerambycidæ and Buprestidæ and have to be carefully looked over, while the drying foliage of such trees affords an excellent opportunity for the use of the umbrella.

Beating living Trees, Shrubs, and Vines.—The success of beating into the umbrella branches of living trees and shrubs depends on the particular kind of tree or shrub, on the condition and situation of these, and largely also upon the season. Pine trees are very productive from early in the spring to early in the summer, but much less so in midsummer and later on. Young Oak trees or Oak shrubs are much more preferred by the leaf-eating Coleoptera peculiar to this tree than the older trees. The Beech, which, next to the Oak, is the best tree for wood-boring species, harbors but few leaf-eating species. The leaves of the Chestnut are also generally not attacked by Coleoptera; still a surprising number of species can be beaten from this tree when it is in blossom. There is not a single species of Coleoptera known to live in the wood or to feed on the leaves of the Holly (*Ilex glabra*); still it will pay the Coleopterist to beat this tree when it is in bloom. Trees, shrubs, and vines in the interior of unbroken forest districts are, as a rule, unproductive, while the edges of the woods, narrow strips of hedges, and especially solitary trees are excellent collecting places. In the Rocky Mountains, especially in the more southern sections, long stretches of mountain slopes are occasionally perfectly bare of vegetation with the exception of a few solitary, sickly-looking, and dwarfed trees, but every one of these is a veritable gold mine to the Coleopterist with his umbrella.

Sweeping.—The use of the beating net continues profitable from spring till fall, a different set of species appearing with each season. Low and swampy meadows, meadows on the slopes of mountains or surrounded by woods, low underbrush, and herbage in smaller patches of woods are very good beating grounds. Dry and sandy meadows are less productive, but harbor usually a different set of species on account of the difference in the flora. Pastures and meadows much frequented by cattle and horses are much less productive, and where a large number of sheep are kept there is usually no chance for using the beating net, since neither grass nor specimens are left. The lawns in our parks and gardens are usually poor collecting ground on account of the limited variety of plants in such places; but the few species found there occur in enormous number of specimens. The endless stretches of our western prairies swarm at the right season (in June) with numerous Coleoptera (mostly Ma-

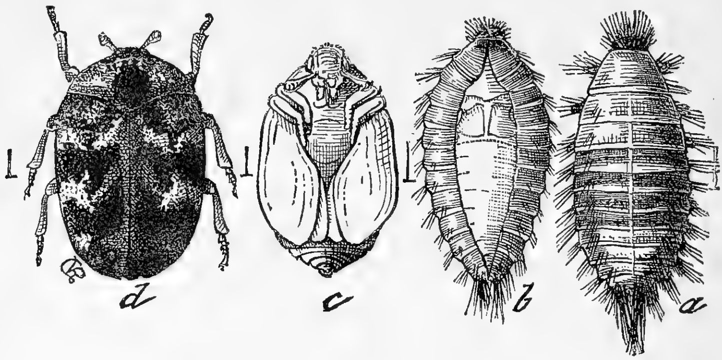


FIG. 67.—A Dermestid (*Anthrenus scrophulariæ*). *a*, larva, dorsal view; *b*, larva, ventral view; *c*, pupa; *d*, adult—all enlarged.

lachiidæ, Chrysomelidæ, Mordellidæ, Curculionidæ, etc.), provided prairie fires have not swept too frequently over the place. Fires and cattle produce a remarkable change in the flora and fauna of the prairies; many indigenous species disappear or become scarce and are replaced by a much smaller number of imported species.

Sweeping may commence in the forenoon as soon as the dew has disappeared; it is less profitable in the heat of the midday, but produces the best results late in the afternoon and more especially in the short interval from just before sunset until dark. At this time many rare Pselaphidæ and Scydmænidæ, species of the genera *Colon* and *Anisotoma*, and other small Silphidæ can be beaten from the tips of grasses, all being species which can not, or only accidentally, be found during daytime, when they hide between the roots of plants.

Collecting on mud and gravel Banks.—The mud or gravel banks of rivers, creeks, and stagnant bodies of water are inhabited, especially early in summer, with an astonishing multitude of Coleoptera. Countless specimens of smaller Carabidæ (*Dyschirius, Clivina, Bembidium, Tachys*, etc.) and Staphylinidæ (*Tachyusa, Philonthus, Actobius, Stenus, Lathrobium, Trogophlœus* and many other genera) will be seen actively running over the mud or sand; many other specimens are hiding under the pebbles in company with other species (*Cryptohypnus, Georyssus*, etc.) or in little subterranean galleries (*Dyschirius, Bledius, Heterocerus*). All these beetles must be collected by picking them up with the fingers, an operation which, owing to the activity of the specimens, requires some little practice. The beginner will at first crush or otherwise injure many of the delicate specimens, the capture of which is moreover by no means facilitated by the rapidity with which most of them are able to take wing. The collector must necessarily kneel down and he must not mind getting covered with mud. A good device for driving these species out of their galleries or from their hiding places under stones or in cracks of the ground is to pour water over the banks, and this can in most cases be done with the hand. Larger stones and pieces of wood or bark lying on the bank are favorite hiding places of certain larger Carabidæ (*Nebria, Chlænius, Platynus*, etc.), and should of course be turned over. Finally, the moss growing on rocks and logs close to the water's edge, and in which, besides other beetles, some rare Staphylinidæ and the Byrrhid genus *Limnichus* can be found, should be scraped off and investigated on the collecting cloth or on the surface of a flat rock, if such be conveniently at hand.

Collecting aquatic Beetles.—The fishing for water beetles in deeper water by means of the water net has already been alluded to (p. [32]), but many species live in shallow brooks with stony or gravelly bottom, where the water net can not be used. The Dytiscidæ and Hydrophilidæ living in such places usually hide under stones, and can in most cases be easily picked up with the hand, or a little tin dipper or a spoon will be found convenient for catching them. The species of the family Parnidæ are found on the underside of rough stones or logs which are either partially or entirely submerged. They are more numerous, however, in the moss or among the roots of other plants that grow in the water. Such plants have to be pulled out and examined over the collecting cloth.

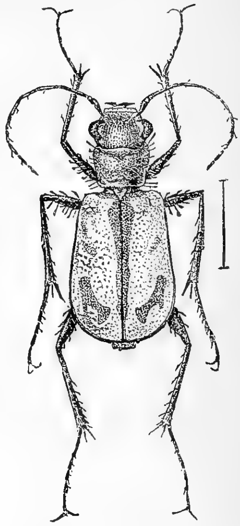


Fig. 68.—A Tiger Beetle (*Cicindela limbata*), drawn by Miss Sullivan—enlarged.

Collecting at the Seashore and on sandy Places.—A large number of species belonging to various families live exclusively in the vicinity of the ocean, some on the open beach, others along the inlets, bayous, or salt marshes, and still others on the dry sand dunes. The Cicindelæ are actively running or flying about close to the water's edge and have to be captured with the butterfly net. The remaining maritime species live hidden under the seaweed and other débris cast up by the waves, or in the sand (sometimes quite deep below the surface) beneath the débris or between the roots of the plants growing on the dunes. The majority of the maritime species do not appear before June (in the Middle States), but the collecting remains good until September.

In dry sandy places away from the seashore, the collecting at the roots of plants is especially to be recommended, and the plants, and more especially the bunches of coarse grasses usually growing in such places, should be pulled up and shaken out over the collecting cloth. This mode of collecting acquires a great importance in the arid regions of the West and Southwest, where, in the warm season, nearly all Coleoptera are hiding during daytime in the ground at the roots of plants.

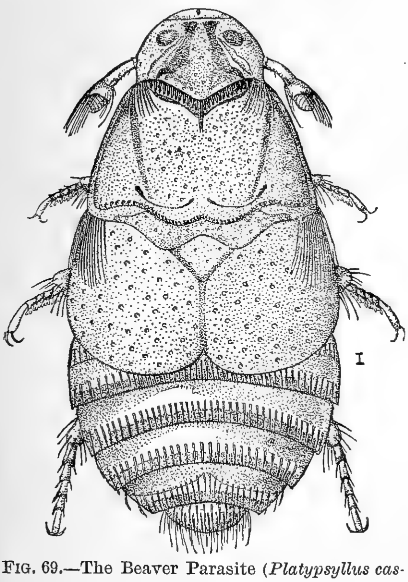


Fig. 69.—The Beaver Parasite (*Platypsyllus castoris*), adult—greatly enlarged.

Collecting Dung-beetles.—The collecting of the numerous species (*Hydrophilidæ, Staphylinidæ, Histeridæ, Scarabæidæ,* etc.) which live in the droppings of various animals is by no means an agreeable task. The collector should provide himself with a pointed stick and collecting tweezers, and must manage to pick up the specimens as best he can. The larger specimens are best collected in alcohol, while the more delicate species can be collected in a cleaner condition by removing the droppings and sifting the ground beneath the same. Some species hide deep in the ground beneath the droppings and have to be dug out. Summer freshets, when pasture lands are inundated, offer an excellent opportunity for collecting the dung-inhabiting species in a clean condition.

Night Collecting.—The beating of trees and shrubs after dark is a good method of obtaining Lachnosternas and other species, and here the collector will do well to secure the assistance of a companion, who takes charge of the lantern and the collecting bottles, while the collector himself works the umbrella.

FALL COLLECTING.—From the first of August the number of species gradually diminishes, but late in the summer or early in fall quite a number of other species make their appearance, *e. g.*, some Chrysomelidæ, Cerambycidæ, and many Meloidæ. Many of these frequent the blossoms of Golden-rods, umbelliferous and other late-flowering plants. The fall is also the best season for collecting Coleoptera living in fungi. Although puff-balls, toadstools, and the numerous fungi and moulds growing on old trees, etc., furnish many species of Coleoptera also earlier in the season, yet most fungi, and more especially the toadstools, flourish best in the fall, and consequently there is then the greatest abundance of certain species of Coleoptera. Decaying toadstools are especially rich, and should be sifted, and the collector should also not omit to examine the soil beneath them.

During the "Indian summer" there is usually a repetition of the "spring flight" of Coleoptera, though on a smaller scale, and collecting on the tops of fence posts and on whitewashed walls again becomes good. The first really sharp frost causes these late species to disappear, and winter collecting commences again.

COLLECTING LEPIDOPTERA.

In this order the importance of collecting the early states and of rearing the adult insects rather than of catching the latter should, if the collector has the advancement of knowledge and the greatest pleasure in mind, be insisted upon. Collected specimens, in the majority of cases, will be more or less rubbed or damaged and unfit for permanent keeping, and will always be far inferior to freshly reared specimens. All Lepidopterists, therefore, rely to a great extent upon breeding rather than upon field collecting. There are, however, many species of which the early states are still unknown, and these can only be taken by field collecting, and by attracting to various lights or traps. This subject, therefore, naturally falls into two categories—(1) the general collecting of the adult, and (2) collecting the early stages and rearing the perfect insects.

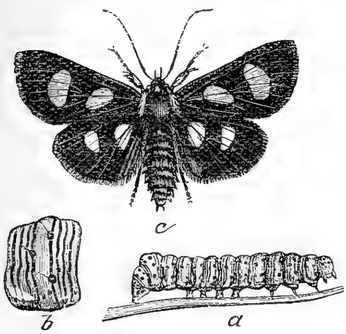


FIG. 70.—The Eight-spotted Forester (*Alypia octomaculata*). *a*, larva; *b*, enlarged segment of same; *c*, moth.

Collecting the Adult.—The implements for the general collecting of butterflies comprise the collecting net, and in some cases the beating net, although the use of the latter will not often be called for. The Rhopalocera or Diurnals may be taken about flowers, and the best season is in the early spring. Most of them are double-brooded, and the second brood will be in the greatest abundance during July and August. They are, however, to be found throughout the summer. They are also to be looked for in the neighborhood of the food-plants of their larvæ, and in the case of many species, examination of such plants affords the most satisfactory means of collecting. The food of butterflies is almost exclusively the nectar of flowers, but strangely enough they are also attracted to decaying animal matter, and many species, including rare forms, may be taken about decaying animal matter or resting on spots where dead animals have lain, or beneath which they have been buried. Moist spots of earth are also frequented by them, especially in dry seasons. Many of the larger butterflies, whose larvæ feed on the taller shrubs and the foliage of trees, will be found fluttering about the open spaces in forests, but by far the larger number, as the Browns, the Blues, the Yellows, and the Whites, which develop on the lower herbaceous and succulent plants, will be found flying over fields, prairies, and gardens. Crepuscular and nocturnal Lepidoptera, comprising most of the Heterocera, the Sphingidæ, Bombycids, Noctuids, etc., have different habits. The Sphingidæ or Hawk Moths fly in early evening, and may be collected in quantity about such plants as the Honeysuckle, Thistle, Verbena, Petunia, etc. The Bombycids and many Noctuids also fly in the early evening, but mostly at night. The former, however, do not frequent flowers, except such as are the food-plants of their larvæ, as their mouthparts are rudimentary, and they take no nourishment.

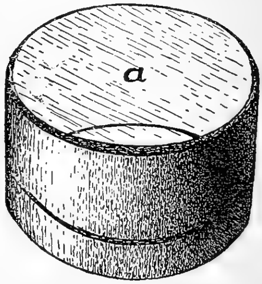


FIG. 71.—Collecting Pill-box. *a*, glass bottom (original).

Collecting by the aid of strong light is a favorite means for moths as well as other insects, and nowadays the electric lights in all large cities furnish the best collecting places, and hundreds of species may be taken in almost any desired quantity. In woods or in other situations they may be attracted to a lantern or to a light placed in an open window. Various traps have been devised, which comprise a lamp with apparatus for retaining and stupefying the insects attracted to the light. The common form is made by providing a lantern with a strong reflector. Under the light a funnel several inches larger than the lantern reaches down into a box or bottle containing the fumes of chloroform, ether, or benzine.

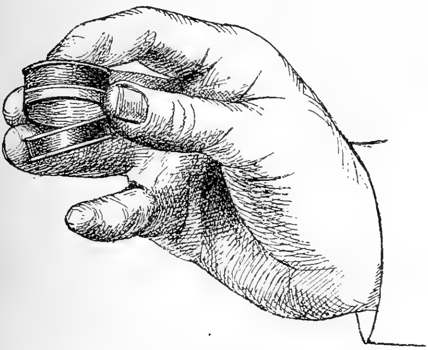


FIG. 72.—Method of holding and manipulating collecting pill-box in capturing (original).

Mr. Jerome McNeill describes at length and figures in the *American Naturalist*, Vol. XXIII, p. 268–270, an insect trap to be used in connection with electric lights. It consists of a tin pail or can charged with cyanide after the manner of a collecting bottle, which is attached beneath the globe of the electric light.

The insects attracted by the light strike against a vertical tin screen fixed above the can and fall into a tin funnel the small end of which enters and closes the mouth of the can, and they are thus conducted into the last. A support or post in the center of the can bears a hollow tin cone, the apex of which is pierced with a number of small holes to admit light, and enters and partly closes the lower end of the funnel. The entire interior of the can is painted black and the chief light comes through the holes in the apex of the interior cone. The entrapped insects endeavor to escape by crawling up the central post towards the light coming through the small holes in the end of the cone rather than by the entrance slit about the latter and fall back repeatedly until overcome by the cyanide.

Many of the Lepidoptera will be ruined by the beetles and other insects or by their own ineffectual attempts to escape, but Coleoptera, Hymenoptera, Neuroptera, and Hemiptera are secured in satisfactory condition.

Many of the devices are very complicated and can not be described in this connection. The nocturnal species, also, fly into our houses, and this is especially the case in the country, and an open window, with a strong light reflected onto a table covered with either a white paper or a white cloth will keep one busy, on favorable nights, in properly taking care of the specimens thus attracted.

Another favorite method of collecting moths early in the evening, or as late as or later than midnight, is by sugaring. This consists in smearing a mixture of sugar and vinegar, or some similar compound, on the bark of trees or on the boards of fences, and visiting the spot from time to time to collect the moths attracted to the bait. It has been found that the use of beer or some other alcoholic liquor, as rum or brandy, with the sugar or molasses water, greatly adds to its efficiency in attracting the moths. This method of collecting moths will be found especially efficient on warm, moist, cloudy nights. The collector should be provided with a dark lantern and a good net, and a number of wide-mouthed cyanide collecting bottles. The smearing should be done just before dark, and I have always found that better success attends this method of collecting when two are engaged in it—one to hold a bull's eye lantern while the other bottles the specimens. Experience will soon teach the surest way of approaching and capturing the specimens.

For collecting Microlepidoptera, in addition to the ordinary net, some special apparatus will be found very essential. Lord Walsingham makes use of a special glass-bottomed pill-box, with which to capture specimens, and the satisfactory nature of the work done with this box, and the dexterity acquired by practice with it, I can vouch for by personal experience. These glass pill-boxes are useful, also, in admitting of the examination of specimens, so that worthless or common species can be discarded and only desired forms kept. The method of holding these boxes is illustrated in the accompanying illustrations. (Figs.

72, 73.) A drop of chloroform on the bottom of the box at once stupefies the capture so that it can be taken out and otherwiise dsposed of.

The necessity of rearing to obtain perfect specimens is even more important in the case of the Microlepidoptera than with the larger forms, and many species are very easily reared and can thus be obtained in quantity. The Micros are abundant from early spring to late fall about shrubbery, in open fields, and along the edges of woods. They are, for the most part, day fliers, being on the wing chiefly in the latter part of the day and early evening. As soon as collected they should be transferred to pill-boxes and the greatest care should be exercised to avoid mutilating them, as the slightest touch will denude them of a portion of their scales or break their limbs or antennæ. Lord Walsingham thus gives his experience in collecting Micros:

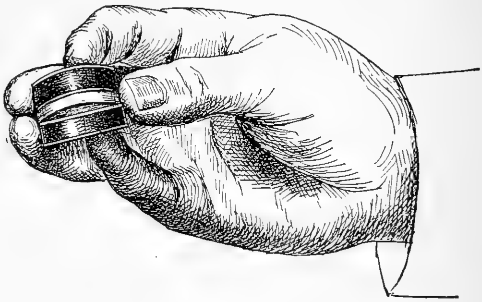


FIG. 73.—Same, showing method of closing pill-box after the specimen is secured (original).

I go out with a coat provided with large pockets inside and out, containing an assortment of pill-boxes, generally of three sizes, glass-bottomed pill-boxes preferred, a bag slung over my shoulder, and a net. Unless searching for particular day-flying species, I prefer the last three hours before dark. As the sun goes down many species move which do not stir at other times. I watch the tops of the grass, the stems of the flowers, the twigs of the trees; I disturb leaves and low-growing plants with a short switch and secure each little moth that moves, taking each out of the net in a separate pill-box, selected according to the size of the insect, as he runs up the net to escape. Transferriug the full boxes to the bag I continue the process until moths cease flying or night sets in. Many species can be taken with a lamp after dark.

Collecting the early States.—The careful entomologist who prides himself on the appearance of his specimens, will, as stated above, rely largely on collecting the early states and on rearing the insects, for his material. The Macrolepidoptera have either a single or two broods, or more, in a season, and the collection of the early states will be greatly facilitated if a knowledge of the insect's life-habits is first obtained. The eggs are often found on the food plants of the species, and where they are deposited in masses they afford a very easy method of getting the larvæ in numbers. In many cases, however, the eggs are deposited singly and their discovery then becomes a difficult matter.

More satisfactory in some respects is the method of obtaining the eggs from captured gravid females, and the general collector should always be on the lookout for females of rare species from which he may be able to obtain eggs. A single battered female may, in this way, be the source of large numbers of excellent reared specimens. Many rare Lepidopterous larvæ may be obtained by the use of the beating net and by beating foliage over an umbrella. A very satisfactory method consists in collecting pupæ, which may frequently be found in numbers about the bases of the trees on which the larvæ feed. Many larvæ of the large family of Owlet Moths (*Noctuidæ*) are found either on the surface of the ground or under various substances, while others burrow into the stems of the different herbaceous plants, some being subaquatic and feeding on the underside of leaves or in the stems of aquatic plants. In the case of Microlepidoptera, their habit as larvæ, of mining leaves or tying or webbing them together, affords an easy means of detecting their presence in most cases. The miners are easily noticed by the discolored spots on the leaves or the wavy, pale, or brown lines marking their burrows. The presence of others is indicated by the leaves being drawn together and united with webs, or withered and brown from being skeletonized by the larvæ. Many species are case-bearers, and live upon the leaves and branches of trees and plants, dragging their cases along with them. Others burrow in grasses or in the stems of plants or the trunks of trees, or in fungi. In the case of the leaf-miners and leaf-tiers, little difficulty is experienced in rearing the imagoes.

The care of the larvæ, the outfit required, and the methods of breeding will be described in later sections.

COLLECTING HEMIPTERA.

For the most part the directions for collecting Coleoptera will apply to this order of insects equally well, especially so far as concerns the first section of the order (Heteroptera), and the higher families of the second section (Homoptera). A few directions may be given for the lower forms, including the Aphididæ, Coccidæ, Aleurodidæ, and Psyllidæ, and the suborder Parasita, including the degraded forms which infest man and the lower animals. The Plant-lice or Aphides should always be collected in connection with their food-plants, and it is very essential also to collect the same species at different seasons of the year to obtain the different forms or generations, which frequently present very marked differences. It is also very necessary to secure the winged forms, which are usually produced toward autumn, and without which the species are not easily identified. The Bark-lice or Scale-insects should also be collected in connection with the leaves or twigs which they infest. The males of these insects are minute and, as a rule, two-winged, resembling small gnats, and may be bred from the male scales. The females are for

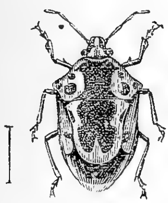
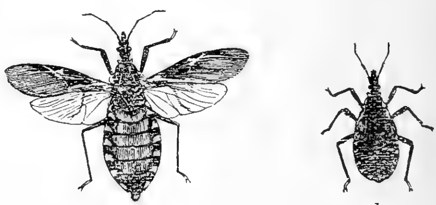


FIG. 74.—A Pentatomid (*Stiretrus anchoraga*).



a b

FIG. 75.—The Blood-sucking Cone-nose (*Conorhinus sanguisuga*). *a*, mature bug; *b*, pupa.

the most part stationary, being fixed to the plant by the protecting, waxy, excretion or scale. The Flea-lice (*Psyllidæ*) frequently produce galls, and these should always be collected with the insect architects. Some species do not produce galls, and may be collected by sweeping. The Hackberry is infested by large numbers of species of Psyllids, and these produce a great variety of interesting galls. The Aleurodidæ (Fringe-scales) are delicate insects, and easily injured in the taking; they are therefore best reared from their stationary and fringed larvæ and pupæ, which occur on the leaves of many plants. Leaves bearing the latter should also be collected and pinned or preserved in alcohol. The Parasita, the lowest representatives of the order, may be obtained from the domestic and wild animals which they infest.

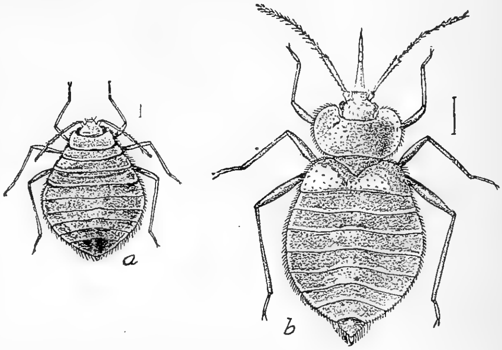


FIG. 76.—The Bed-bug (*Acanthia lectularia*). *a*, young; *b*, adult—enlarged.

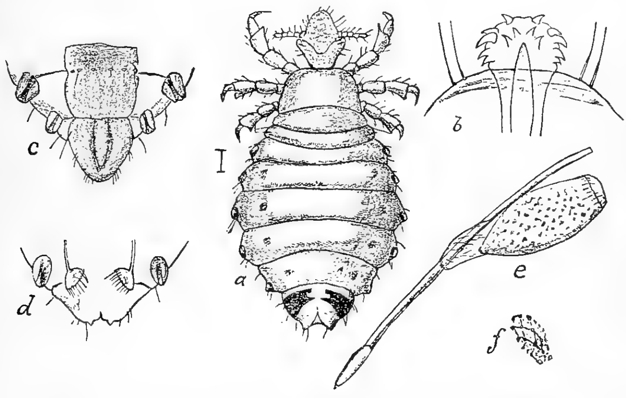


FIG. 77.—The Short-nosed Ox-louse (*Hæmatopinus eurysternus*). *a*, female; *b*, rostrum; *c*, ventral surface, last segments of male; *d*, female; *e*, egg; *f*, surface of egg greatly enlarged.

COLLECTING DIPTERA.

Most Diptera frequent flowers and may be collected with a sweeping net without much difficulty. The best season is from April to June, and the bloom of the Willow, Alder, Plum, Cherry, Dogwood, Blackberry, etc., will ordinarily yield a bountiful supply of specimens and species. Parasitic and saprophytic forms may also readily be obtained by breeding, the former as in the case of the parasitic Hymenoptera, and the latter from decaying vegetable matter and fungi. The Diptera require the most delicate treatment, and the greatest care must be exercised both in collecting and handling. A light sweep net is the best implement for collecting and the contents of the net should frequently be emptied into bottles provided with blotting paper to absorb the excess of moisture. Very small Diptera should not be killed when they can not be immediately pinned, and hairy flies should never be taken from the net with the hand, but should be handled with fine forceps. A pair of special collecting shears has been used by Lord Walsingham very successfully. It is represented in the accompanying figure, and consists of a pair of screen-covered disks, between which the fly is caught. The insect is at once pinned through the screen and may be removed and transferred to a box containing a sponge soaked in chloroform. The use of this implement is especially advisable in the case of the Bee-flies *(Bombiliidæ)* and other hairy forms which are liable to be rubbed when

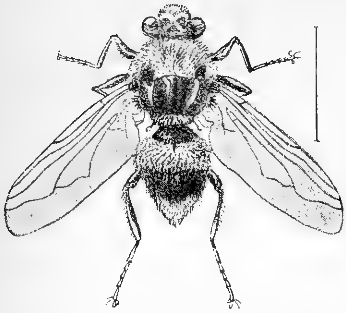


FIG. 78.—Ox Bot-fly (*Hypoderma bovis*) enlarged. (After Brauer.)

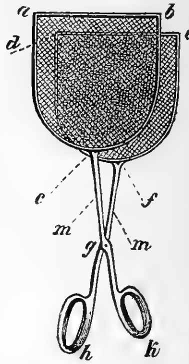


FIG. 79.—The Collecting Shears. (After Kiesenwetter.)

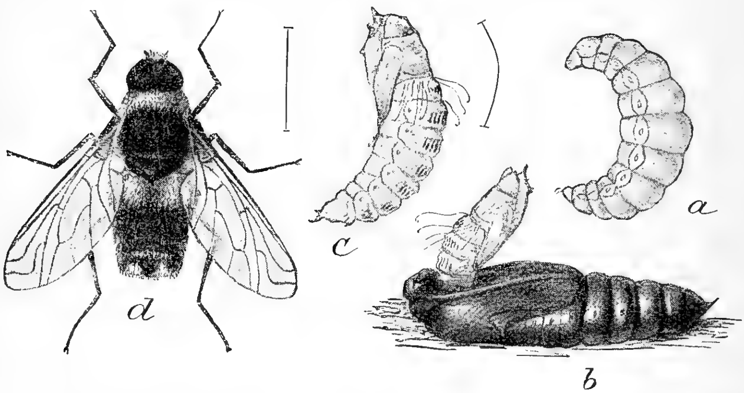


FIG. 80.—A Bee-fly (*Anthrax hypomelas*). *a*, larva from side; *b*, pupal skin protruding from cutworm chrysalis; *c*, pupa; *d*, imago—all enlarged).

collected in the ordinary net. The Gall-making Diptera *(Cecidomyidæ)* are of little value unless accompanied with their galls, and the aim should always be to collect the galls and rear the insects rather than the keeping of specimens taken in the course of general collecting with a sweep net. The rearing of Cecidomyidæ is, however, a delicate task, and requires considerable experience. Some knowledge of the habits of the species is very essential to success. From immature galls no rearings need be expected. A good plan is to examine the galls from time to time and collect them when it is found that the larvæ are beginning to abandon them. In the case of species like the common Cone Gall-gnat of the Willow, the larvæ of which do not leave the gall to undergo transformation in the earth, it is advisable not to gather the galls until the transformation to the pupa state takes place, which, in this species, occurs in early spring. The various leaf-mining and seed-inhabiting species can be treated as in the case of the Microlepidoptera.

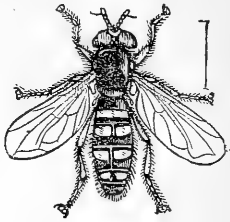


FIG. 81.—A Syrphus-fly.

COLLECTING ORTHOPTERA.

The insects of this order may all be collected by the use of the sweeping net. Some of the families are attracted to light, as certain of the roaches and green locusts, or Katydids (*Locustidæ*). Our common roaches (*Blattidæ*) are cosmopolitan insects, and infest dwellings. Certain species are also found about ponds, under rotten logs, the bark of trees, and particularly in decaying vegetable matter. In the tropics the species are very abundant, but aside from the domestic forms, they occur rarely in northern latitudes. The collection of the egg-cases (oötheca) is important as they furnish many interesting characters. The Mantidæ, of which the Preying Mantis (*Phasmomantis carolina*) is

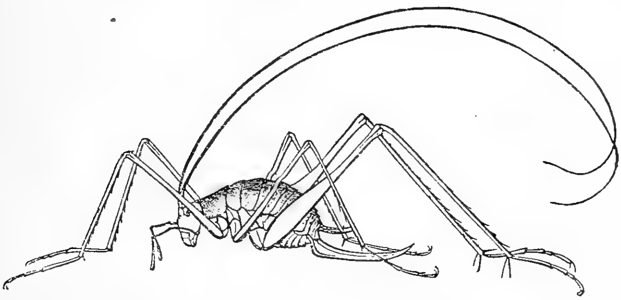


FIG. 82.—A blind Cricket (*Hadenalcus*) from Mammoth Cave. (From Packard.)

a type, are sluggish, carnivorous insects frequently found about houses and may best be collected by general sweeping of vegetation. The Phasmidæ or Walking-sticks are herbivorous and may be collected in the midst of vegetation by sweeping or by the hand. The crickets (*Gryllidæ*) frequent, for the most part, moist situations. Certain forms, like the Mole-cricket and the Jumping Water-crickets (*Trydactylus* spp.), burrow in moist soil and occur in numbers near the edges of ponds and water courses. The katydids and locusts are abundant on low shrubs or trees and in pasture and meadow land, but are most numerous in the somewhat dry, arid regions of the West. Most of these insects mature in late summer and fall and should be collected at this season. The Forficulidæ or Earwigs are very odd-looking insects, resembling somewhat the Rove-beetles (*Staphilinidæ*), and are provided with a prominent anal forceps. They are very rare in the United States, are nocturnal in habit; and, flying about at dusk, may be attracted to light or may be secured by sweeping after nightfall. They feed on flowers and fruit.

COLLECTING NEUROPTERA.

As indicated in the preliminary outline of classification, this large order has been divided into many orders by later entomologists. It has also been divided, as indicated, into two grand divisions, the Pseudoneuroptera, comprising those insects with incomplete transformations, and the Neuroptera proper, comprising those insects whose metamorphoses are complete. It will be convenient to discuss these insects under these two heads.

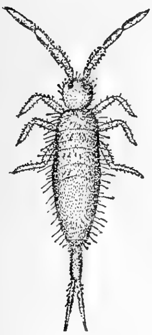


FIG. 83. A Spring-tail (*Degeeria lanuginosa*).

Pseudoneuroptera.—Spring-tails, Bird-lice, Stone-flies, White-ants, Dragon-flies, May-flies.

The Spring-tails, Fish-moths, etc., representing the primitive stock from which the higher forms have developed, have a varied habit and hence are to be found in divers situations. The Spring-tails (*Collembola*, etc.), occur in damp and moist places, usually in immense numbers. The Fish-moths and Book-mites are common household pests, but also occur outdoors under logs, boards, bricks, and rubbish of all sorts. In houses they feed on the starch paste beneath wall-paper and also on the starch in bookbindings and other domestic articles. They may be collected at all seasons and a sieve is the only implement necessary.

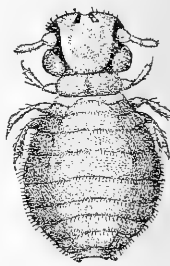


FIG. 84.—A Mallophagan (*Trichodectes latus*). (After Denny.)

The Bird-lice or Mallophaga may be collected at all seasons on birds and mammals. A number of species infest domestic animals, horses, cattle, etc., but the majority of them can be found only by the examination of domestic fowls and wild birds. The Stone-flies (*Perlidæ*) are found in the neighborhood of water courses and ponds, are very sluggish in flight, and easily captured with the sweep-net. They are also attracted to light. The Psocidæ are a small family of certain degraded wingless forms, comprising the Book-lice, which, as the name implies, infest books, feeding on the starch of the binding. Others have ample wings and closely resemble large Aphides. They occur on the trunks of trees and on foliage, and feed on lichens and other dried vegetable matter. They are gregarious in habit and frequently occur in immense numbers together. In the case of the Termitidæ or White-ants, their abundance renders their collection an easy matter. Effort, however, should be made to discover the different forms, the females and soldiers as well as the workers. The former may be found in rotten tree trunks, but are very rarely met with. In the tropics many species occur and construct curious nests, either attaching them to the boughs of trees or building them in the form of pyramids on the ground. The Dragon-flies (*Libellulidæ*,) are collected in the same way as the Diurnal Lepidoptera. They are very swift flyers, and are practically always on the wing. Their collection requires some degree of skill in the use of the net. A good method consists in visiting, in the early morning, water courses in which the larval and pupal states are passed, and capturing the adults just as they issue from their pupal skins at the edges of the pond or stream. In cold weather they are less active and may frequently be found clinging to trees and plants, particularly in the vicinity of their breeding places. May-flies (*Ephemeridæ*) occur in immense numbers near their breeding places in ponds and streams and are also attracted in large quantities to electric lights. Their collection is therefore an easy matter, but on account of the very fragile nature of these insects the utmost care must be employed in handling them. The early states of all the aquatic forms mentioned above may be obtained for breeding by the use of the dip net by dragging it forcibly against water plants.

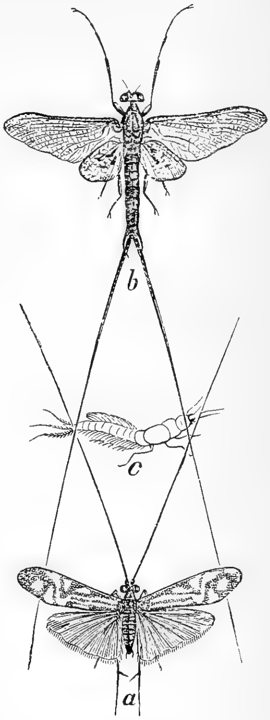


FIG. 85.—*b*, a May-fly (*Palingenia bilneata*); *c*, its larva; *a*, a Caddis-fly (*Macronema zebratum*).

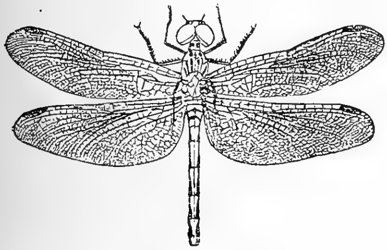


FIG. 86.—A Dragon-fly (*Libellula*). (From Packard.)

Neuroptera proper (Hellgrammites, Lace-wings, Ant-lions, Caddis-flies, etc.)—Among the largest insects of this order are the Sialidæ, which includes the enormous Hellgrammite Fly, *Corydalus cornutus*. The larvæ of this insect are carnivorous and occur in streams, under stones, etc. The adults may be collected in neighboring situations and are also attracted to light. The Lace-wing flies (*Chrysopa*), Ant-lions, etc., are carnivorous as larvæ, and occur, the former among the Aphides which infest various plants and the latter

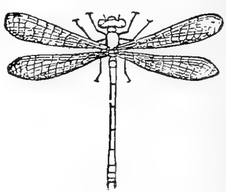


FIG. 87.—A Dragon-fly (*Agrion*). (From Packard.)

at the bottom of pits in loose, sandy soil. The adults may be obtained by general sweeping and are also attracted to light. The most interesting insects of this order are the Caddis-flies, on account of the peculiar and frequently very beautiful cases constructed by their larvæ, which it is important to collect. The Caddis-flies breed in ponds and lakes and the adults may be collected in such situations or at light. The larvæ may easily be reared, and should be collected for this purpose. Most of the insects named in this order are extremely delicate and require great care in handling.

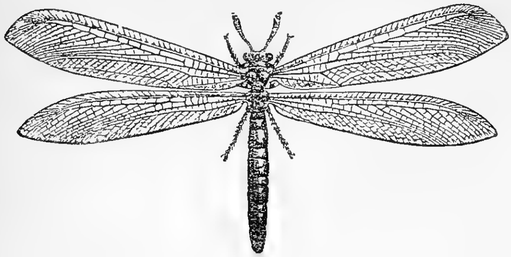


FIG. 88.—An Ant-lion, adult (*Myrmeleon*). (From Packard.)

KILLING AND PRESERVING INSECTS.

Between the collecting of the specimens and their final disposition in a well-arranged cabinet, a good deal of mechanical work is necessary, involving a skill and dexterity which can be thoroughly acquired only by practice.

FIRST PRESERVATION OF LIVING SPECIMENS.—Larvæ, pupæ, or imagoes, intended for rearing purposes, must be kept alive, and are best placed, after capture, in tin boxes of various sizes, according to the number of specimens to be put in each and according to the size or nature of the food plant, etc., on or in which the specimens are found, and of which a quantity must always be taken home. For larger tin boxes those known as "Seidlitz powder boxes," described and figured below, which can be made to order at any tinner's shop, are well adapted, and smaller tin boxes of a convenient round form can be obtained of the watchmaker. The collector will find it advisable to take with him on his longer jaunts a larger tin collecting box as well as the smaller boxes, and for this purpose nothing is better than a good botanist's collecting can or vasculum. All tin boxes used for entomological purposes should be tight, and the cover should so fit that it neither drops off too readily nor closes too tightly. Larvæ of Lepidoptera and Tenthredinidæ should be placed in a box with a quantity of the leaves of the plant on which they were found. Larvæ, especially of Coleoptera, found in the earth or in decayed wood, should be placed in a box filled with such earth or wood, so as to prevent shaking or rattling about. Larvæ found in roots or stems of living plants can generally be reared to maturity only if the whole plant with a quantity of the surrounding soil is taken home, and for this purpose the large collecting box, just mentioned, is very useful. Most Coleopterous or other larvæ found under bark or in solid wood can be reared only if large sections of the wood are obtained and the larvæ are full grown or nearly so. This holds true, also, of species breeding in seeds and with most leaf-mining species. The greatest difficulty is experienced with carnivorous Coleopterous larvæ, and care should be taken with such not to inclose two or more specimens in one box. Most larvæ die quickly if placed in an empty box, and this is especially true of predaceous species; so that it is always advisable to pack the box with moist soil, decaying wood, leaves or other similar substance. Aquatic larvæ should be carried in tin boxes filled with wet moss or some water plant, for, if placed in corked vials with water, they die quickly.

Killing Specimens.—Specimens not intended for rearing should be killed immediately after capture unless for each specimen a separate vial or box can be provided. If a number of miscellaneous insects are put in the same vial the stronger specimens will, in a short time, crush or otherwise injure the more delicate ones or the predaceous species will devour any others they can master. But even where the specimens are killed immediately the following rule should be observed: Do not put large and small specimens in the same vial, but provide a larger bottle for the larger specimens, and one, or still better, several, smaller vials for the medium-sized and very small specimens. The importance of this rule is recognized by all experienced collectors.

There are several methods of killing insects, each having its own peculiar advantages and drawbacks.

Alcohol.—The use of alcohol will, on the whole, prove the most satisfactory method of killing Coleoptera, many Hemiptera, some Neuroptera, and larvæ of all sorts. Only the best quality of alcohol should be used, but it should be diluted with from 30 to 40 per cent of pure water, the greatest care being taken to keep the alcohol as clean as possible. During the collecting a mass of débris and dirt is apt to be thrown into the bottle, and when this is the case the alcohol should be changed even during short excursions. At any rate, upon the return from the excursion, the specimens should be at once taken from the bottle and washed in pure alcohol in a shallow vessel. The larvæ and other material intended for permanent preservation in alcohol should be transferred to suitable vials and the material to be mounted cleansed with chloroform or acetic ether and then prepared for the cabinet. If it is inconvenient or impossible to mount the Coleoptera, etc., soon after the return from the excursion they should be washed, dried, and placed in pill boxes between layers of soft paper, or they may be replaced in a vial with pure alcohol. On longer collecting trips, lasting several days or weeks, specimens will keep thus very well, provided they are not shaken up, and this can be prevented by filling the empty space in the vial with cotton or soft paper. If the bottle is a large one and contains many large specimens the alcohol should be renewed three or four times at intervals of eight or ten days; otherwise the specimens are liable to decompose. Small and delicate specimens, if they are to be kept in alcohol, should be treated with still greater care. Upon the return from the excursion they should also be cleaned in pure alcohol and placed in small vials into which a very few drops of alcohol, just sufficient to keep the contents moist, are poured. The vial should be corked as tightly as possible and the specimens will keep pretty well for an indefinite time.

The drawbacks to the use of alcohol are: 1st, that all hairy specimens are liable to spoil; 2ndly, that all Coleoptera with soft integuments spread the wing-cases apart if kept too long in it. The advantage of the alcohol is that it is the simplest and least troublesome fluid for naturalists traveling in distant countries who are not specialists in entomology. Specimens killed in alcohol are also less liable to be attacked by verdigris when pinned than those killed by some other method. Rum, whisky, or similar strong alcoholic liquors may be used as substitutes where no pure alcohol can be obtained, but are not especially to be recommended.

Chloroform and Ether.—Killing with the fumes of *chloroform* or *ether* (sulphuric or acetic) or *benzine*, or some other etheric oil, is often practiced and advocated by those who, for any reason, dislike the use of alcohol or object, on account of its poisonous nature, to the use of cyanide of potassium, and they are of especial value in the case of butterflies and moths, Hymenoptera and Diptera. "A small and stout bottle of chloroform or ether, with a brush securely inserted into the cork (Fig. 89), will be found very serviceable. A slight moistening through the air net will stupefy most insects caught in it, and facilitate their removal to the cyanide bottle; while a touch or two with the wet brush under the head and thorax, will kill the more delicate specimens outright, without in the least injuring them. Another way of using chloroform is by means of a small, hollow tube passed through the cork, what is called jeweler's hollow wire answering the purpose. The liquid evaporates more readily in such a bottle, and I altogether prefer the first mentioned. Some large insects, and especially female moths, whose size prevents the use of the ordinary cyanide bottles, are difficult to kill. With these, fluttering may be prevented by the use of chloroform, or they may be killed by puncturing the thorax or piercing the body longitudinally, with a needle dipped in liquid cyanide, or oxalic acid. A long bottle with a needle thrust into the cork may be kept for this purpose; but the needle must be of ivory or bone, as those of metal are corroded and eaten by the liquids. * * *

FIG. 89.—Chloroform bottle with brush.

"For killing small and delicate moths which have been bred, I find nothing more handy than chloroform. They may be caught in turned wooden boxes which are kept by every druggist; and a touch of the chloroform on the outside of the box immediately stupefies them. It has a tendency to stiffen them, however, and they are best set immediately after death."

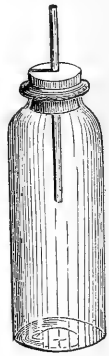


FIG. 90.—Bottle with liquid cyanide.

A piece of heavy blotting paper or heavy cloth soaked with chloroform or ether or benzine and placed at the bottom of a jar or bottle makes an excellent killing bottle for large-sized insects. For smaller specimens the collecting vial should be half filled loosely with narrow strips of soft paper, upon which a few drops of the liquid are poured, not so much, however, as to wet the paper. While collecting, the vial must be kept closed as much as possible. Some collectors prefer chloroform, others ether. If this method of killing is practiced with the necessary care, there is no objection whatever to it; the specimens are not wetted as they are in alcohol, and remain cleaner than those killed by any other method. The drawback is that the substances mentioned evaporate very rapidly and have to be renewed even on short excursions. On account of this great volatility, one can never be certain that all the specimens in the collecting bottle are dead after a given time and there is always some danger that one or the other of the hardier insects may regain activity. What mischief such revived specimens are capable of doing, many collectors have experienced to their sorrow. Another disadvantage of these volatile substances is that if used in too large quantities they will, in delicate specimens, especially beetles, cause an extension of the soft ligaments between the head and prothorax or between the latter and the mesothorax, and thus bring the specimen into an unnatural position, or cause the head, or head and thorax to drop off.

FIG. 91.—The Cyanide bottle with paper strips to give support to the insects.

Cyanide of Potassium.—The method of killing which, of late years, has found most favor with collectors, is the use of cyanide of potassium. For killing large sized specimens they are simply put in what is now universally known as the "cyanide bottle." This may be constructed as follows:

Take a 2-ounce quinine bottle, or still better a shorter bottle with a wide mouth; break up a quantity of cyanide of potassium into pieces of convenient size (about a cubic centimeter); put these pieces in the bottle so that they form an even layer at the bottom; mix in a convenient vessel a quantity of plaster of Paris with water just sufficient to make the mixture semifluid and then pour it over the cyanide so as to cover this last to a depth of about 5 millimeters. The bottle is then left open for an hour or two until the plaster is thoroughly dry. The walls of the bottle are then cleansed from particles of the plaster which may have splashed on them, and the bottle is ready for use. If not used too frequently, especially in warm weather, it will last for an entire year or longer. Bottles or vials of different sizes can be prepared in the same way, and a very small cyanide vial which can be carried in the vest pocket will be found most convenient for use on all occasions. Fig. 92 represents a medium-sized chemist's test tube, converted into a very convenient cyanide bottle, in which, however, a cotton wad has been used to keep the poison in place. When the collected specimens have been removed from the bottle the latter should be carefully wiped clean with a piece of cloth or paper. The surface of the plaster soon becomes dirty and, on account of the hygroscopic property of the cyanide, more or less moist, especially during warm weather. The cyanide bottle is, therefore, not well adapted for the killing and temporary preservation of small and delicate specimens. This difficulty can be altogether obviated by placing a circular piece of blotting paper, cut to neatly fit the interior of the bottle, on the surface of the plaster. This can be renewed once a week or so, or oftener if it becomes necessary. It will frequently be advisable, also, especially in the collection of Diptera, Hymenoptera, and other delicate insects, to put a strip of blotting paper partially round the inner side of the bottle. This will absorb any moisture which may gather on the inside of the bottle and which would otherwise wet and injure the specimens. The accompanying figure (Fig. 93) illustrates a bottle arranged as described above. A similar result is attained by some collectors by partially filling the bottle with narrow strips of bibulous paper to support and separate the insects as shown at Fig. 91.

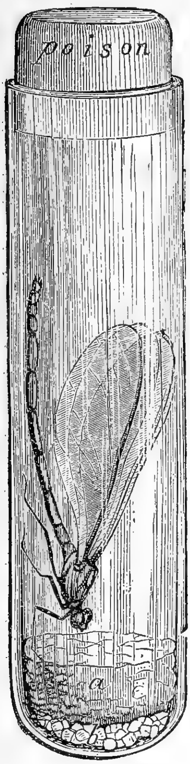


FIG. 92.—Pocket cyanide bottle.

For delicate specimens, also, the collecting bottle may consist of a test-tube of about the size of Fig. 92. This is half filled with loose, thin strips of soft white paper. A piece of cyanide about the size of a pea is then wrapped carefully in paper and so placed in the middle of the strips that it can not come in contact with the sides of the glass.

Some prefer to pin the paper containing the cyanide to the lower surface of the cork. The latter should be rather short and tapering toward its lower end. It is longitudinally perforated through its center by a round hole just large enough to insert a goose-quill, which is cut straight at the lower end and obliquely at its upper end. By means of this goose-quill the specimens may be introduced into the bottle without taking off the cork. This form of cyanide bottle lasts for only one day's collecting, except in cold weather, and in very warm weather it is advisable to take two prepared bottles along, so that the first used can be stowed away as soon as the cyanide begins to moisten the paper strips. Most insects are quickly killed in such a bottle, but some Coleoptera must be left in for five or six hours, while others resist death for a still longer time. This is especially true of the Coleopterous families Curculionidæ, Trogositidæ, and Tenebrionidæ.

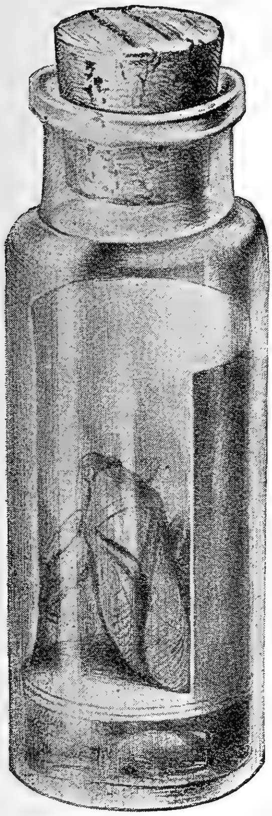


FIG. 93.—The cyanide bottle with blotting-paper lining (original).

Submersion in alcohol will prove a satisfactory method of killing these or other beetles with similar vitality.

Other Agents.—Prof. E. W. Claypole has found the use of benzine or gasoline very cheap and satisfactory for killing Lepidoptera, as the largest are at once killed thereby without injury to their scales. (*Can. Ent.*, XIX, p. 136.) He squirts it onto the specimen within the net or in the open air by means of a druggist's dropping tube. Hot water kills rapidly and leaves the specimens in good flexible condition for mounting. The heads of large insects may be held for a few moments in the water, while smaller specimens should first be thrown into a corked bottle and the bottle submitted to heat. Where the laurel grows its bruised leaves may be used in place of cyanide; they kill less quickly. The leaves of the Laurel-cherry (*Prunus laurocerasus*), a plant commonly grown in England for screens and hedges, are also used for this purpose.

Some collectors, with indifferent olfactory sense, moisten the cork of their boxes with creosote. Its killing power lasts for several days. A few whiffs from a cigar, when nothing else is at hand, will also kill many of the more tender insects.

SPECIAL DIRECTIONS FOR DIFFERENT ORDERS.—A few brief directions for the special treatment of different orders may be given. Certain Coleoptera, notably those of the Curculionid genus Lixus, are covered with a yellowish pruinosity resembling pollen, which is of an evanescent nature, so that if the specimens are collected and killed by the ordinary methods, the pruinosity is completely lost. To preserve the natural beauty of such species it is necessary to put each specimen alive in a small vial and to kill it at once by means of a lighted match held under the vial for a few seconds. In pinning or otherwise mounting the specimen it should not be handled between the fingers.

Many Hymenoptera and Lepidoptera, especially species with yellow markings, if kept for any length of time in a cyanide bottle, will become discolored, the yellow changing to reddish, and hence such insects should not be left longer than necessary in the bottle. If care is exercised in this respect, no danger of discoloration need ordinarily be feared. The chloroform collecting bottle may be used with these insects if discoloration is anticipated. All the more delicate insects, including Hymenoptera, Diptera, the smaller Lepidoptera, and the Neuroptera, require special care in killing. Large numbers should not be thrown into a killing bottle together, and plenty of bibulous paper should be kept in the bottle to prevent moisture from accumulating and wetting and ruining the specimens. It is frequently advisable to pin Diptera, especially the hairy forms (as the Bee-flies), in the net and transfer them at once to a cigar box containing a sponge moistened with chloroform. When the collecting shears are used, the insects are always thus pinned at once, which is, in fact, the only method of securing them. This is also necessary in the case of many Lepidoptera. Delicate Neuroptera may be killed by the use of the cyanide bottle, or, preferably, placed at once in a vial of alcohol, as these insects, in many instances, cannot be kept securely if pinned or mounted. Large Lepidoptera, as the Bombycids, may be killed by pouring benzine, naphtha, or chloroform over the thorax and abdomen. These substances evaporate rapidly and do not appreciably injure the vestiture of the insects. Some collectors, in the case of butterflies, seize them dexterously between the thumb and finger, and give a sharp pinch on the sides of the thorax. This will prevent the fluttering of the insect when transferred to the cyanide bottle, and, if carefully done, the scales need not be rubbed off. It is objectionable, however, because the thorax is distorted and subsequent anatomical study interfered with, and, in the case of moths, should never be practiced, as the thorax affords important characters used in classification. Orthoptera may be killed by the use of the cyanide bottle but should be transferred at once to the vials of alcohol. If placed in a cyanide bottle, especially in the case of Locusts (*Acrididæ*), they are apt to exude colored juices from the mouth, so that the specimens become soiled. Hence the use of vials of alcohol is preferable, and these insects should never be thrown into vials containing delicate insects of other orders. Plant-lice, together with the plant which they infest, should be placed at once in vials of alcohol, and specimens of the Aphides, representing all the forms present, should be mounted on slides for microscopic examination. The fixed forms of Coccids, comprising the majority of the species, require no special treatment, and the leaves, twigs, or bark on which they occur may be pinned at once and placed in the collection. The free forms are treated as in the case of plant-lice.

ENTOMOTAXY.

Under this term may be considered the preparation of insects for the cabinet.

CARE OF PINNED AND MOUNTED SPECIMENS.

Insect Pins.—In mounting insects for the cabinet, expressly made entomological pins should be used. These come from three different sources: Kläger pins, made by Hermann Kläger, Berlin, Germany; Karlsbad pins, made by one or several firms in Karlsbad, Bohemia, Austria; and Vienna pins, made by Miller, Vienna, Austria.* These three kinds of pins have each their own slight advantages and disadvantages, so that it is difficult to say which is the best. All have the disadvantage that the pinned specimens are liable to be ruined by verdigris, and to obviate this japanned ("black") insect pins are made by Kläger and Miller. These black pins are, however, much softer than the "white" pins, and therefore more difficult to handle. A pin of 35 millimeters in length will be found most convenient for pinning all insects excepting the larger Lepidoptera and other heavy-bodied insects, for which a longer pin may advantageously be used. According to the different degrees of fineness, the pins are numbered from No. 00 (the finest in the trade) to No. 7 or 8, but the numbers used by the different manufacturers do not correspond with each other. In experience, pins of Nos. 1, 2, 3, and 4 (Kläger numbers) are more often needed than the others. The long pins of the finer numbers (Nos. 0 and 00) are difficult to handle in the collection and, for this reason, not to be recommended.

For many small insects, especially Microlepidoptera and Microdiptera, which *must* be pinned, even the finest ordinary insect-pins are too large, and two special makes of pins are in use for this purpose. The "elbow pin" (formerly made and sold by Dr. Kuenow, of Königsberg, Prussia, Germany) consists of a piece of fine silver wire, pointed at one end, and with a coil loop at the other end, into which a longer pin (No. 3 or No. 4) is thrust. This pin is illustrated in Fig. 94. Still more satisfactory are the "Minutien-Nadeln" (pins for minute insects) manufactured by Mr. Miller, of Vienna, Austria, and which consist of a straight piece (about 14^{mm}. long) of extremely fine steel wire which is pointed at

* In North America, Kläger pins and Karlsbad pins can be obtained through Mr. John Ackhurst, 78 Ashland Place, Brooklyn, N. Y., and possibly also through Messrs. Blake & Co., 55 North Seventh street, Philadelphia, Pa. The Vienna pins and the Minutien-Nadeln have to be ordered direct through the manufacturer, Mr. Miller.

one end, and which is used in connection with a piece of pith or cork. The mode of using this pin is shown in Fig. 101. These fine and elbow pins may be obtained either "white" or japanned.

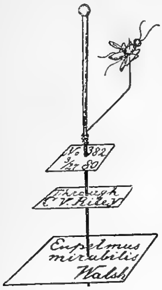


FIG. 94.—Insect mounted on "elbow-pin."

"Many English entomologists use short pins, very much like those of ordinary make, and my late friend Walsh never gave up the custom, and most vehemently opposed the use of what he ridiculed as 'long German skewers.' But the only advantage that can possibly be claimed for the short pins is that they are less apt to bend, consequently more easily stuck into the bottoms of boxes, and require less room; while, compared with the long pins, they have numerous disadvantages. Long pins admit of the very important advantage of attaching notes and labels to the specimen; render it more secure from injury when handled, and from museum pests in the cabinet; and on them several rows of carded duplicates may be fastened, one under the other, so as to economize room."

I have seen few old collections in better condition than that of the late E. Mulsant, of Lyons, France; and he used iron wire, cut slantingly, of the requisite length—a common custom in France. These wires bend so easily and have such dull points that they require much more careful manipulation than the pins, and the claim made for them that they do not verdigris would, perhaps, be offset by their rusting in moist climates or near the sea. Silver wire or silver-plated wire is also used.

Preparation of Specimens.—Upon the return from an excursion the specimens should be prepared for the collection as soon as practicable. If they have been collected in the forenoon they should be mounted the same evening, and those collected during an afternoon or evening excursion should be mounted the following morning, or, at any rate, before they get dry and brittle. Even specimens collected in alcohol should be attended to as soon as possible.

Specimens are taken from the collecting bottle, spread out on a sheet of white blotting paper and cleaned from adhering impurities either with a soft dry brush, or, in the case of species with hard covering, by washing them with chloroform or ether or benzine where necessary. Theoretically the best way of mounting would be to pin all specimens, since the under side with its important characters then remains free for examination. Pins adapted for pinning even the smallest insects have been described above, but this pinning is such a delicate operation and requires so much time that considering the large number of small specimens that may be collected on a single short excursion it is next to impossible to carry out this method, and therefore only the larger specimens need be pinned and the smaller may be glued onto the paper points described later. If the work is done with proper care all insects can be prepared for the cabinet so that both the upper and under surface of the specimen may be examined without further manipulation.

Pinning.—"Insects should be pinned through the middle of the thorax, when, as is more generally the case, this portion (the mesothorax) is largely developed. Beetles (*Coleoptera*) and Bugs (*Hemiptera*), should, however, be pinned, the former through the right elytron or wing-cover (Fig. 95), and the latter through the scutel or triangular piece behind the thorax, the pin issuing between the middle and hind legs (Fig. 96). The specimens look very pretty with all the legs neatly spread out, but for practical purposes it is better to let them dry in the natural, partly bent position. It is a saving of time and space, and the limbs are not so apt to break. The legs must also not reach too far downward or they will interfere with the proper labeling and the secure pinning of the specimen in the cabinet Moreover, the antennæ and legs must be brought into such position that they will not obstruct the view of any important part of the undersurface. The pin should always project about half an inch above the insect to facilitate handling, and uniformity in this regard will have much to do with the neat appearance of the collection. In pinning very large and heavy insects on a No. 4 or No. 5 pin, it is a good plan to first flatten the pin by a few blows of a hammer, in order to prevent the specimen from subsequently turning round on the pin."

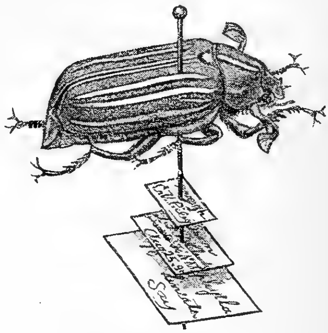


FIG. 95.—Method of pinning and labeling Coleoptera (original).

FIG. 96.—Method of pinning Hemiptera (original).

In pinning specimens which have a flat or nearly flat undersurface and short legs (as in many Coleoptera and Hemiptera and some Hymenoptera, *e. g.* the Saw-flies) the specimens are laid on a piece of cork and held in place there with the fingers or with a forceps. The pin is then pushed through the insect at the proper point, care being taken not to strike one of the legs or coxæ, and that the pin passes through the specimen in a vertical direction.

After the pin has been pushed through the specimen it is taken out of the cork and the specimen is pushed up to its proper height. This can be done either by holding the specimen between the fingers or by placing it on the upper edge of a thick book. A piece of card-board provided with a small hole may also be used for this purpose. The perforations in ordinary sheet-cork, or the lapel of one's coat, will answer the same purpose. In pinning Lepidoptera or Hymenoptera the specimen should lie lightly in the angle formed by the thumb and first two fingers of the left hand and the pin be carefully thrust through at the proper angle. In pinning all insects the pin should be so inserted that the insect is nearly at right angles with the pin, the posterior end being slightly depressed.

Moanting on Points.—Most insects which are too small to be pinned on a No. 2 pin may be fastened to cardboard by means of gum tragacanth, gum shellac, or any good glue. It is not always easy to determine whether to pin a medium specimen or to glue it to a triangle. Pinned specimens are more secure, and not so apt to fall or be knocked off, but they are liable to become corroded by verdigris and ultimately lost, especially in families the larvæ of which are endophytous or internal feeders. It is better to glue wherever there is doubt. A drop of corrosive sublimate added to the water in which the gum tragacanth is dissolved will indefinitely prevent its souring, but should not be used where the gum is to come in contact with the pin, as it inclines the latter to verdigris. In such cases a little spirits of camphor mixed with the gum tragacanth is best. Shellac should be dissolved in alcohol and this requires some time. This glue is not affected by moisture, and if it is desired to remove the specimens, they must be immersed in alcohol until the shellac is again dissolved.

A number of different kinds of glue are used by entomologists. The requirements of a good glue are that it be colorless, and, what is of greater importance, that the specimens adhere firmly to the paper points so that there is little or no danger of their being jarred off. Those glues which are readily soluble in cold or lukewarm water are perhaps more convenient than those which require alcohol or chloroform for dissolving. Gum arabic and gum tragacanth have the disadvantage that they are more liable to attract mites and are more brittle, so that they do not hold specimens as well as some of the liquid glues that are on the market. Spalding's glue answers a very good purpose, as also the preparation known to European entomologists as Léprieur's gum. White bleached shellac, while requiring alcohol to dissolve it, has the advantage that a very minute quantity suffices. In olden times the method employed was simply to glue the specimen by the ventral side to the middle of a quadrangular piece of cardboard, which was then pinned on a No. 3 or No. 4 insect pin. This method is still in vogue with English entomologists, but can not be recommended except for mounting duplicates. Much better are the small isosceles triangles which, before mounting the specimen, are pinned through near the base on a No. 2 or No. 3 insect pin. Only the best and finest cardboard should be used for this purpose, since that of poor quality is liable to be broken while passing the pin through it and will yellow with age. "Reynolds's Superfine Board," which may be ordered through any dealer in artist's supplies of Devoe & Co., Fulton street, New York City, is perhaps the best for this purpose. Some of the neatest mounting which I have had done by any of my agents or assistants is by Mr.

Albert Koebele, who has used mica or gelatine instead of cardboard, the object being not only to show the whole of the under side of the specimen, but to obscure less of the light from the labels and to render the triangles less conspicuous in the cabinet. These have been in use in the museum collection only for the last two or three years, and whether they will eventually tend to corrode the pins is not yet settled. Mica and isinglass are also used for the same purpose. The points used in mounting may easily be cut by hand to a convenient size, say one-fourth of an inch (6–8^{mm}) long by one-sixteenth or less at the base, and tapering to a point. The point may be narrower or wider to accommodate insects of different sizes.

For cutting these triangles or points, various forms of punches similar to the appended figure (Fig. 97) known to the trade as conductor's punches may be used, and points thus cut are to be preferred to those made by other means, on account of the greater uniformity secured. An experienced hand, however, will cut these points very rapidly and accurately with a pair of shears, and most collectors use no special instrument for this purpose.

The punches mentioned may be obtained of the manufacturers* of such instruments at from $2 to $3. Care should be observed in ordering to state explicitly the length, width at base and point, or, what is better, to inclose sample of the size of point it is desired to cut; but above all, to state that the block of paper to be cut out is the result desired, and that the instrument should cut clean and even, with no ragged edges.

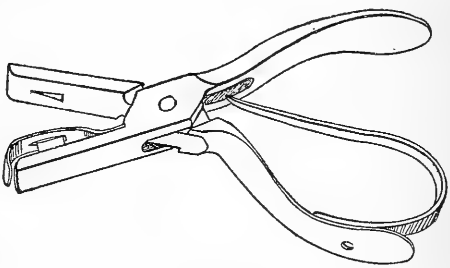


FIG. 97.—Insect punch for cutting triangles or points (original).

For mounting different forms and sizes the fastidious collector uses four or five sizes of points, but for all practical purposes one to cut a card point not less than 1.3^{mm} at the base and prolonged as nearly as possible to a point, and another a trifle wider at the base, say $1\frac{1}{2}$ or $1\frac{2}{3}^{mm}$ and with a point about $1\frac{1}{2}^{mm}$ in width will suffice.

For mounting most long-bodied insects, *e. g.*, Staphylinidæ and Elateridæ, an oblong card say $1\frac{1}{2}^{mm}$ in width is desirable. With a little care these may be cut with sufficient uniformity with scissors. Seven and one-half millimeters may be taken as a standard of length, as this is about the size used by the majority of our best collectors. Shorter points, say 6^{mm} or one-quarter inch long, are sometimes preferred, where economy of space is a desideratum.

FIG. 98.—Points for mounting insects (original).

*Montgomery & Co., 105 Fulton street, New York City.

A series of four points of different sizes for mounting insects is shown in the accompanying illustration. The sharp-pointed one, *a*, is designed for the minutest forms and the larger points for large insects. The largest should be mounted on points of a nearly rectangular shape, shown at *d*. The dimensions of these points as adopted by most entomologists, are as follows:—

	Length.	Breadth.	Point.
a	7.5 mm.	1.5 mm.	.0 mm.
b	7.5	1.5	.4
c	7.5	1.5	.6
d	7.5	1.6	1.6

The point or triangle should be mounted on the pin and directed to the left, the height from the top of the pin varying somewhat with the specimen, but averaging about one-half an inch. The insect is then glued to the point with the head pointed forward. In the case of Coleoptera and Hymenoptera, and in fact of most insects, the specimen is mounted with the back uppermost, but in the case of the smaller Hymenoptera it is advisable to mount some of the specimens, at least, on the left side (see Fig. 99). This directs the legs toward the pin, as a matter of safety, prevents their being broken in handling, and also gives opportunity for subsequent examination of the back, side, and venter of the specimen. Coleopterists always mount specimens on the venter, and in the case of a correctly mounted specimen the whole underside of the body should be available for examination except the right half of the metasternum, as shown in figure 100.

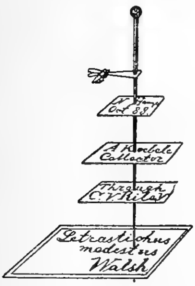


FIG. 99.—Insect mounted on cardboard triangle.

In mounting minute insects a few precautions are necessary. The beginner usually uses too much glue or shell-lac, and the result is that the mounted specimens are more or less covered with the fluid, so as to render them unfit for examination. If, on the other hand, too little of the glue is used, the specimens are not securely fastened to the paper point, and are liable to be jolted off by the slightest jar. Before mounting specimens the legs and antennæ must be brought into the proper position by means of a brush or with a dissecting needle, so that they may easily be seen. A supply of paper points should always be at hand, and after selecting one of the proper size for the specimen, with an acute tip for a very small specimen and with a more obtuse point for a larger one, a small quantity of glue is applied to the tip by means of a pointed stick, such as a toothpick, the amount varying with the size of the specimen. The tip of a moistened brush may be used to transfer the

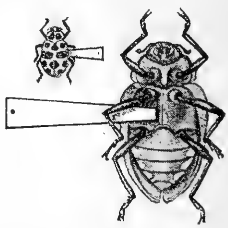


FIG. 100.—Method of gluing beetle on paper point (original).

specimen to the point, or one will soon become dextrous enough to do this without the aid of the brush. The specimens are then allowed to dry in a horizontally placed box. If the drying box is placed in a vertical position the specimens, especially long-bodied ones, are liable to topple over before the glue has become firm.

Delicate flies and Microlepidoptera, which it will not do to fasten with mucilage, may first be mounted on the fine pins described above and these thrust into oblong or triangular bits of pith or cork, which are mounted on larger pins as shown in Figures 101 and 102. This affords a very satisfactory method of mounting, particularly as the different sexes may be brought together on the same bit of pith, or the adult and puparium in Diptera, as shown at Figure 101. Strips of stout cardboard with the pins run through the narrow edge may also be used. The method of mounting minute Hymenoptera and Diptera and other insects on a bent wire, mentioned above, is illustrated at Figure 94. This method has not proved so satisfactory, as the wires are apt to become loose on the pin.

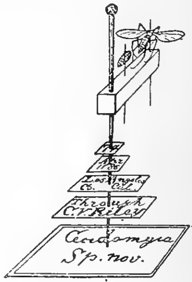


FIG. 101.—Cecidomyiid mounted on pith (original).

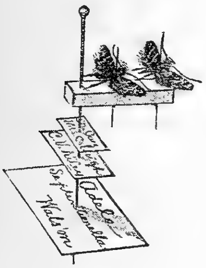


FIG. 102.—Microlepidoptera mounted on pith (original).

Mounting Duplicates.—If the collector finds more specimens of a rare species than he cares to have in his collection, the excess may be mounted as duplicates. If the species happens to be of a large size the specimens are pinned in the ordinary way, but if small enough to be gummed, there is a most convenient method of rapidly mounting the specimens so that they may be sent through the mail with much less risk of getting broken or knocked off than if glued on paper points, and will also take up very little room in the duplicate boxes. It consists in gluing the specimens in a transverse row on a strip of white card paper with one of the glues soluble in water, care being taken that between the individual specimens some space be left, and further that the heads and antennæ do not project beyond the edge of the paper. The width of the paper strip must be somewhat greater than the length of the specimen, so that below the latter there is sufficient room for inserting a pin through the paper. After the glue has become dry the row of specimens is cut with scissors into several smaller rows of convenient size, so that on each of these rows there are two or three or more specimens, according to the size of the species. A locality label is pushed high up on a No. 3 or No. 4 pin, and one of the mounted rows of specimens is then pinned and pushed up

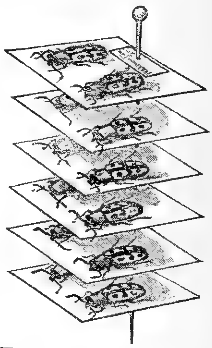


FIG. 103.—Method of mounting duplicates (original).

near the locality label; a second row is then pinned and pushed near the first row, and the same process continued with the third row and so on. A single pin will thus bear five or six rows, and in giving away or sending away specimens the lowest row is taken from the pin and repinned for mailing. The accompanying figure (Fig. 103) illustrates the mounting of a moderate-sized species in rows of two specimens each. This method of mounting duplicates may be adopted not only for Coleoptera, but also for Heteroptera, Homoptera (excepting Aphididæ and allied families), smaller Orthoptera, and Hymenoptera. It is, however, impracticable for Lepidoptera, Diptera, and most Neuroptera.

Temporary Storage of Specimens.—If the entomologist is prevented from mounting his captures soon after returning from an expedition, or if, on extended collecting trips, time does not offer for this purpose, specimens of almost all orders except the Lepidoptera, Orthoptera, and Neuroptera may be placed in a small, tightly closing pill box, care being taken to keep the larger specimens apart from the small ones. In this way specimens will keep for an indefinite period, provided they are properly packed. In the case of the traveling collector, where the material is to be carried from point to point at great risk of breaking, specimens should be packed very carefully to prevent any shaking or rattling about in the boxes. This may be done by placing a round piece of soft paper on the top of the specimens in the pill box. This paper should be gently pressed down and the empty space above filled with other layers of paper or with cotton. The packing of specimens between cotton is not recommended, as it is a difficult and tedious task to afterwards free them from the adhering fibers. Layers of soft paper or, yet better, velvet, are preferable.

Envelopes for Lepidoptera, etc.—On an extended trip, it will be found impracticable to mount and prepare insects requiring cumbersome apparatus for spreading, as Lepidoptera or Neuroptera, and a very excellent plan consists in folding the wings of the insect so that the lower surfaces come together and then placing it in a triangular envelope, as shown in the accompaying illustration. The collector should be provided with a quantity of paper of the requisite dimensions for making these envelopes, and specimens, as they are taken from the collecting bottle, may be rapidly inclosed in them, labeled, and packed away in a tight wooden (not tin) box containing a supply of naphthaline, the specimens thus occupying the minimum of space. Specimens secured in this way may be kept without further manipulation indefinitely or until time is found to relax and set them.

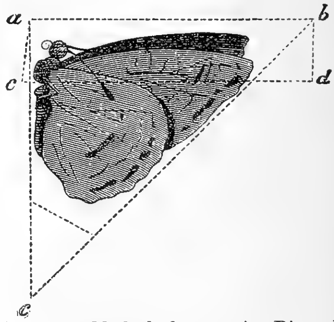


FIG. 104.—Method of preserving Diurnal Lepidoptera in paper envelopes. (After Kiesenvetter.)

This is also an excellent method of sending diurnal Lepidoptera and Dragon-flies through the mails and is preferable in some respects to mailing spread specimens.

Directions for Spreading Insects.—"For the proper spreading of insects with broad and flattened wings, such as butterflies and moths, a spreading board or stretcher is necessary. One that is simple and answers every purpose is shown at Fig. 105. It may be made of two pieces of thin whitewood or pine board, fastened together by braces at the ends, but left wide enough apart to admit the bodies of the insects to be spread; strips of cork or pith, in which to fasten the pins, may then be tacked or glued below so as to cover the intervening space. The braces must be deep enough to prevent the pins from touching anything the stretcher may be laid on, and by attaching a ring or loop to one of them the stretcher may be hung against a wall, out of the way. For ordinary-sized specimens I use boards 2 feet long, 3 inches wide, and $\frac{1}{3}$ inch thick, with three braces (one in the middle and one at each end) $1\frac{1}{2}$ inches deep at the ends, but narrowing from each end to $1\frac{1}{6}$ inches at the middle. This slight rising from the middle is to counteract the tendency of the wings, however well dried, to drop a little after the insect is placed in the cabinet. The wings are held in position by means of strips of paper (Fig. 105) until dry. For stretching the wings and for many other purposes, a handled needle will be found useful. Split off, with the grain, a piece of pine wood 3 or 4 inches long; hold it in the right hand; take a medium-sized needle in the left hand; hold it upright with the point touching a walnut table, or other hard-grained wood, and bring a steady pressure to bear on the pine. The head of the needle will sink to any required distance into the pine, which may then be whittled off, and you have just the thing you want (Fig. 106). To obtain uniformity in the position of the wings, a good rule is to have the inner margins of the front wings as nearly as possible on a straight line. When the specimens are thoroughly stiff and dry, they should be taken from the stretcher and kept for several weeks in the drying box before being permanently placed in the cabinet. The drying box is simply a box of any required dimensions, containing a series of shelves on which to pin the specimens, and without a solid back or front. The back is covered on the inside with fine gauze and on the outside with coarser wire, and the door in front consists of a close-fitting frame of the same material, the object being to allow free passage of air, but at the same time to keep out dust and prevent the gnawings of mice and other animals. The shelves should

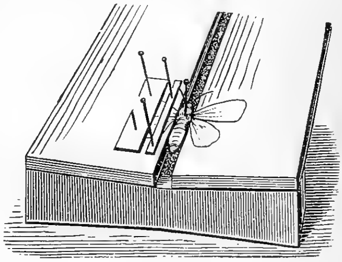


Fig. 105. Spreading board for Lepidoptera.

Fig. 106. Needle for spreading insects.

be not less than 2 inches deep, and if made in the form of a quadrangular frame, braced with two cross-pieces on which to tack sheet cork, they will serve for the double purpose of drying spread specimens and for the spreading of others, as there are many insects with long legs which are more conveniently spread on such a board, by means of triangular pieces of stiff cardboard braces or 'saddles,' than on the stretcher already described. Two of these braces are fixed on the setting board, by means of stout pins, at sufficient distances apart to receive the body between them. The wings are then spread upon them and kept in place until dry by means of additional braces. In the case of bees, wasps, etc., the pin may be thrust well into the cork or pith so that the wings may be arranged in the proper position and braced and supported by strips of stout cardboard. This method is especially recommended in the case of the Fossorial wasps, the legs of which, if mounted in an ordinary spreading board, can not be properly arranged.

In spreading Lepidoptera I have used, in the place of a number of paper strips pinned across the wings, blocks of glass of various sizes to hold the wings in position. My method of mounting, with a large amount of material on hand to be attended to, consists in pinning a row on the spreading-board and fixing the wings in position with spreading needles, fastening them with a single narrow strip of paper placed next the body. The entire spreading-board is filled with specimens in this way, a single long strip of paper on either side answering to keep the wings of all the specimens in position. Then, instead of pinning additional strips to hold the wings flat and securely in position, the pieces of glass referred to are used, placing them on the wings of the insect. With the use of glass the spreading-board must always be kept in a horizontal position and must never be disturbed. The advantage of the glass is that the wings can be seen through it and more truly adjusted.

Spreading-boards may be made as described above, or it may be of advantage, when a good deal of work is to be done, to adopt a somewhat different method. Five or six spreading-boards may be made together, forming a sort of shelf. A number of these shelves may be constructed and the whole combined in a case with a screen cover to exclude insects. The individual shelves may be arranged with grooves to slide on tongues in the side of the case. A screen-covered case for spreading-boards is always desirable, as the insects are otherwise very liable to be eaten by roaches or other insects. A spreading-case of the form described is shown at Fig. 107.

A new Apparatus for Spreading Microlepidoptera.—For the spreading of Microlepidoptera my assistant, Mr. Theo. Pergande, has devised an apparatus, represented in the accompanying illustration, which he finds very convenient. It consists of a small spreading-block represented at

B and the support with attachment shown at *A*. The former is made in a long strip of the shape shown in the illustration, having a square groove, *c*, cut in the top. Over this is glued a thin strip of wood, *b*, say $\frac{1}{8}$ inch thick, and a narrow slit is sawed in the center of this above, cutting through into the groove *c*. This is then sawed up into pieces of uniform length, say $1\frac{1}{2}$ to 2 inches, and the block is completed by the insertion of a rectangular strip of pith or cork into the groove. The Micro is pinned on a short black pin, and the pin is thrust down into the narrow opening made by the saw and is held firmly by the pith or cork. This block is then slid into the groove in the setting-board *A*, which narrows slightly from *e*, and pushed along until firmly secured (*d*). The operator can then rest his hands and arms on either side of the support, and, if necessary, bring a large hand lens over the object by means of a support with ball-and-socket joint shown at *e*. The wings may thus be easily and accurately arranged and fixed in position with pins or strips of paper, as in the ordinary mounting of such insects. Two or three specimens may be mounted on each of these blocks. The construction of the support is indicated in the annexed drawing. One side is attached by clamps, shown enlarged at *f*, which afford means of adjusting the width of the slit in which the small sawed blocks slide and correct the shrinking or swelling which may take place in moist or dry seasons. The advantage of the apparatus is that the operator has the setting block firmly fixed before him and has both hands free to manipulate the wings of the insect in addition to having the lens in a convenient position, the use of which is necessary in the preparation of the very minute forms.

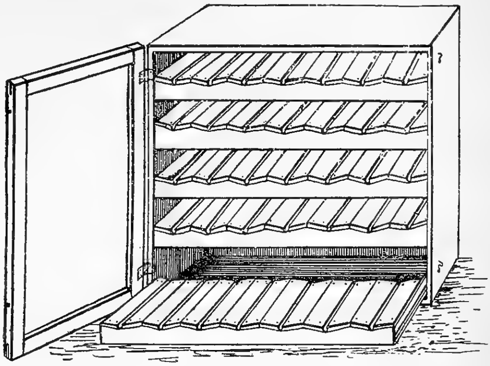


FIG. 107.—Spreading-case (original).

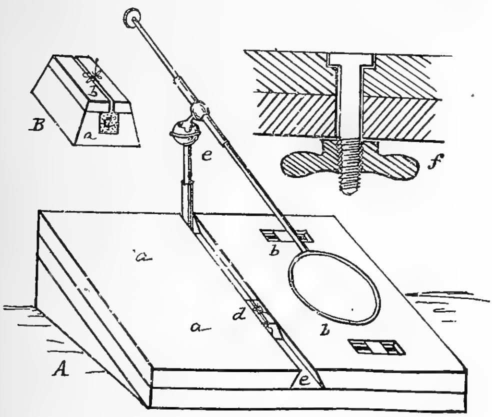


FIG. 108.—Spreading apparatus for Microlepidoptera (original).

Spreading Microlepidoptera.—The mounting of Microlepidoptera is about the most delicate work in entomotaxy, and I can not do better than quote the explicit directions given by Lord Walsingham on the subject.

Returning to camp I put a few drops of liquid ammonia on a small piece of sponge and place it in a tin canister with such of the boxes as do not contain the smallest species, and put these and the remainder away until morning in a cool place. In the morning I prepare for work by getting out a pair of scissors, a pair of forceps, my drying-box containing setting-boards, a sheet of white paper, and some pins.

First, I cut two or three narrow pieces of paper from 3 to 6 lines wide, or rather wider, according to the size of the largest and smallest specimens I have to set. I then double each of these strips and cut it up into braces by a number of oblique cuts. Now I turn out the contents of the canister and damp the sponge with a few drops of fresh ammonia, refilling with boxes containing live insects. Those which have been taken out will be found to be all dead and in a beautifully relaxed condition for setting. Had the smallest specimens been placed in the canister over night there would have been some fear of their drying up, owing to the small amount of moisture in their bodies.

If the weather is very hot there is some danger of killed insects becoming stiff while others are being set, in which case it is better to pin at once into a damp cork box all that have been taken out of the canister, but under ordinary circumstances I prefer to pin them one by one as I set them.

Taking the lid off a box, and taking the box between the finger and thumb of the right hand, I roll out the insect on the top of the left thumb, supporting it with the top of the forefinger and so manipulating it as to bring the head pointing toward my right hand and the thorax uppermost. Now I take a pin in the right hand and resting the first joint of the middle finger of the right against the projecting point of the middle finger of the left hand to avoid unsteadiness, I pin the insect obliquely through the thickest part of the thorax, so that the head of the pin leans very slightly forward over the head of the insect. After passing the pin far enough through to bring about one-fourth of an inch out below,* I pin the insect into the middle of the groove of a setting board so that the edge of the groove will just support the under sides of the wings close up to the body when they are raised upon it. The board should be chosen of such a size as will permit of the extension of the wings nearly to its outer edge. The position of the pin should still be slanting a little forward. The wings should now be raised into the position in which they are intended to rest, with especial care in doing so not to remove any scales from the surface or cilia of the wings. Each wing should be fastened with a brace long enough to extend across both, the braces being pinned at the thick end, so that the head of the pin slopes away from the point of the brace; this causes the braces to press more firmly down on the wing when fixed. The insect should be braced thus: The two braces next the body should have the points upwards, the two outer ones pointing downwards and slightly inwards towards the body, and covering the main portion of the wings beyond the middle. Antennæ should be carefully laid back above the wings, and braces should lie flat, exercising an even pressure at all points of their surface. The fore wings should slope slightly forwards so that a line drawn from the point of one to the point of the other will just miss the head and palpi. The hind wings should be close up, leaving no intervening space, but just showing the upper angle of the wing evenly on each side. I can give no more precise directions as to how this desirable result may most simply and speedily be attained; no two people set alike. Speed is an object; for I have often had to set twelve dozen insects before breakfast. A simple process is essential, for a man who is always pinning and moving pins, and rearranging wings and legs, is sure to remove a certain number of scales and spoil the appearance of the insect, besides utterly destroy-

* This applies to the use of short pins, which should subsequently be connected through strips of pith with longer pins. For some of the larger micros the long pins may be used directly and a different spreading board employed.

ing its value. I raise each of the fore wings with a pin, and fix the pin against the inner margin so as to keep them in position while I apply the braces. Half the battle is really in the pinning. When an insect is pinned through the exact center of the thorax, with the pin properly sloped forward, the body appears to fall naturally into its position on the setting board, and the muscles of the wings being left free are easily directed and secured; but if the pin is not put exactly in the middle it interferes with the play of the wings. Legs must be placed close against the body or they will project and interfere with the set of the wings. Practice, care, and a steady hand will succeed. When all the insects that have been killed are set the contents of the canister will be found again ready, twenty minutes being amply sufficient to expose to the fumes of ammonia. Very bright green or pale pink insects should be killed by some other process, say chloroform, as ammonia will affect their colors.

Insects should be left on the setting boards a full week to dry; then the braces may be carefully removed and they may be transferred to the store box.

In my own experience I have found that a touch or two of the chloroform brush on the pill-box containing small moths is sufficient to either kill or so asphyxiate them that they can easily be mounted. I have also found that strips of corn pith or even of soft cork, with grooves cut into them, are very handy for the pinning and spreading, and that by means of a small, broad-tipped, and pliable forceps the smallest specimens can be deftly arranged in the groove and kept in place until pinned. In fact, for all persons who have not very great experience and dexterity this method is perhaps more to be recommended than that of holding them between the thumb and fingers. Where chloroform is used either to kill or deaden specimens, it is important that after they are once spread and in the drying box they should be subjected to an additional asphyxiation, as the larger species may revive and are apt to pull away from the holding strips, and thus rub off their scales.

Microlepidoptera, together with Microhymenoptera and Diptera may be conveniently pinned on fine, short pins, and these thrust into an oblong bit of cork or pith. This form of mounting has already been described and is represented in figure 102. The neatest mounting of Microlepidoptera which I have seen is the work of my assistant, Mr. Albert Koebele, who mounts these insects on an oblong strip of pith. This is very light and presents no difficulty in pinning. The strips may be made of considerable length and both sexes may be pinned on the same block (see Fig. 103). Most Lepidoptera present on the under surface an entirely different aspect from that on the upper surface, and, in such cases, it is a good plan to mount a number of specimens obversely.

Relaxing.—It will frequently be desirable to re-spread insects which have been incorrectly mounted, or to spread specimens which have been collected and stored in papers, or pinned and allowed to dry without being prepared for the cabinet. Such specimens may be relaxed by placing them in a tight tin vessel half filled with moist sand to which a little carbolic acid has been added to prevent molding. Small specimens will be sufficiently relaxed to spread in twenty-four hours. Larger specimens require from two to three days. More rapid relaxing may be caused by the use of steam, and a flat piece of cork with the specimens laid or pinned thereon and floated on the top of hot water in a closed vessel constitutes an excellent relaxing arrangement.

Inflation of the Larvæ of Lepidoptera.—The larvæ of Lepidoptera preserved in alcohol are excellent for anatomical and general study, but are not very suitable for use in economic displays. This means of preservation also has the disadvantage of not generally preserving the natural color and appearance of the specimens. These objections may be avoided, however, by the dry method of preserving larvæ, viz, by blowing or inflation. The process may be described as follows: The larva may be operated upon alive, but should preferably be first killed by dipping in chloroform or alcohol, or in the cyanide bottle. It is then placed on a piece of blotting paper and the alimentary canal caused to protrude from one-eighth to one-fourth of an inch, by rolling a pencil over the larva from the head to the posterior extremity. The protruding tip is then severed with a sharp knife or pair of dissecting scissors, and the contents of the abdomen are forced out by passing a pencil, as before, a number of times over the larva. Great care should be exercised in expressing the fluids not to press the pencil too strongly against the larva or to continue the operation too long, as this will, especially in delicate larvæ, remove the pigment from the skin, and the specimen when dried will show discolored spots and be more or less distorted. The larva should be moved from place to place on the blotting paper during the operation, so as not to become soiled by its own juices. A straw, or a glass tube drawn to a point at the tip, is then inserted in the protruding portion of the alimentary canal. If a straw is used the larva may be fastened to it by thrusting a pin through the wall of the canal and the straw. In the case of the glass tube the alimentary canal can be caused to adhere by drying for a few minutes and this operation may be hastened and the fastening made more secure by touching the point of union with a drop of glue. The straw or glass tube is then attached to a small rubber bag, previously inflated with air, the ordinary dentist's or chemist's gas bag answering admirably for this purpose. The larva is now ready for drying, and for this purpose a drying oven is required into which it is thrust and manipulated by turning it from side to side, to keep it in proper shape and dry it uniformly until the moisture has been thoroughly expelled. An apparatus which I have found very convenient for this purpose is represented at Fig. 109. It consists of a tin box with mica or glass slides, *e*, to allow the larva to be constantly in sight. It has also a hinged top, *b*, which may be kept closed or partly open, or entirely open, as may be necessary, during the operation. The ends of the box are prolonged downward about 5 inches, forming supports for it, *g*. Beneath it is placed an alcohol lamp, *f*, which furnishes the heat. In the end of the box is a circular opening, *d*, for the introduction of the larva, and this may be entirely or partly closed by a sliding door, *a*. It will be found of advantage to line the bottom of the box (inside) with a brass screen of very fine mesh to distribute and equalize the heat. This apparatus can be very easily made by any tinsmith and will answer every purpose.

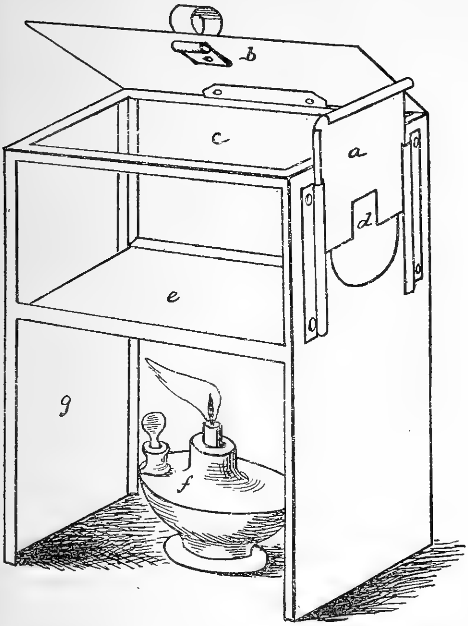


FIG. 109.—Drying oven for the inflation of larvæ (original).

The larvæ of Microlepidoptera or young larvæ may be dried without expressing the body contents, and will keep, to a great extent, their normal shape and appearance. The method consists in placing them on a sand bath, heated by an alcohol lamp. The vapor generated by the heat in the larvæ inflates them and keeps the skin taut until the juices are entirely evaporated. They may then be glued at once to cardboard and pinned in the cases.

In the mounting of large inflated larvæ I have adopted the plan of supporting them on covered copper wire of a size varying with the size of the larva. A pin is first thrust through a square bit of cork and the wire brought tightly about it and wrapped once or twice, compressing the cork and giving a firm attachment to the pin. The wire is then neatly bent to form a diamond-shaped loop about one-sixth of an inch in length and again twisted loosely to the end—the length of the twisted portion about equalling that of the larva to be mounted. This is then either thrust into the blown skin of the larva through the anal opening, the larva being glued to the wire by the posterior extremity, or the larva is glued to the wire by the abdominal legs and venter, thus resting on the wire as on a twig. This style of mounting is illustrated in Pl. I. With a little experience the operator will soon be able to inflate the most delicate larvæ and also the very hairy forms, as for instance *Orgyia leucostigma*, without the least injury, so that the natural colors and appearance will be preserved.

Another very good method, and still safer, is to blow with straw, cut the straw square off at the anus, and then preserve the thoroughly dried and blown specimen in a glass tube of about the same length and diameter as the larva. This arrangement in conjunction with the tube holder, which will be described further on, is one of the most satisfactory for the preservation of inflated larvæ.

For the biological-display collection, larvæ may be blown in various natural positions, to be subsequently fastened on leaf or twig or in burrows which they have occupied. Fastened to artificial foliage in which nature is imitated as much as possible, such blown larvæ are quite effective.

Stuffing Insects.—Large larvæ may sometimes be satisfactorily preserved for exhibition purposes by stuffing them with cotton. The method consists simply in making a small slit with the dissecting scissors or a short scalpel between the abdominal prolegs, and removing the body contents. Powdered arsenic or some other preservative should be put in the body of the larva with the cotton used in stuffing it, and the slit closed by a few stitches, when the larva may be dried and mounted on a twig or leaf. This method of stuffing with cotton is also applicable in the case of certain large-bodied insects which, if mounted and put away without preparation, would be liable to decompose, as, for instance, the larger moths, grasshoppers, etc. A slit can be made in the center of the abdomen or near the anus beneath, and the body contents removed and replaced with cotton. Stuffing in this way with cotton is of especial advantage in the case of certain of the large endophytous insects which grease badly. The cut will not be noticed after the insect has dried, or it may be closed by a stitch or two.

Dry Preservation of Aphides and other soft-bodied Insects.—Difficulty has always been experienced in preserving soft-bodied insects, particularly Aphides, in a condition serviceable for subsequent scientific study. Kept in alcohol or other antiseptic fluid, they almost invariable lose much of their normal appearance, and many of the important characteristics, especially of color, are obscured or lost. The balsam mount is also unsatisfactory in many respects, as the body is always more or less distorted and little can be relied upon except the venation and the jointed appendages. A method of preserving soft-bodied insects by means of the sudden application of intense heat was communicated to the *Entomologische Nachrichten*, Vol. IV, page 155, by Herr D. H. R. von Schlechtendal. It is claimed for this method that the Aphides and other soft-bodied insects can be satisfactorily preserved in form and coloring, the success of the method being vouched for by a number of well-known German entomologists, Kaltenbach, Giebel, Taschenberg, Mayr, and Rudow. A condensed translation of the method employed by Schlechtendal is given by J. W. Douglas in the *Entomologists' Monthly Magazine* for December, 1878, which I quote:

The heat is derived from the flame of a spirit or petroleum lamp Above this is placed a piece of sheet-tin, and over this the roasting proceeds. A bulging lamp cylinder, laid horizontally, serves as a roasting oven. In this the insect to be dried, when prepared as directed, and stuck on a piece of pith, is to be held over the flame; or the cylinder may be closed at the lower end with a cork, which should extend far inwards, and on this the insect should be fastened; the latter mode being preferable because the heat is more concentrated, and one hand is left free. The mode of procedure varies according to the nature of the objects to be treated. For the class of larger objects, such as Hemiptera, Cicadina, and Orthoptera, in their young stages of existence, the heat must not be slight, but a little practice shows the proper temperature required. If the heat be insufficient, a drying up instead of a natural distention ensues. The insect to be roasted is to be pierced by a piece of silver wire on the under side of the thorax, but it is not to be inserted so far as to damage the upper side, and the wire should then be carried through a disk of pith, placed beneath the insect, on which the legs should be set out in the desired position. But with some objects, such, for instance, as a young *Strachia*, the drying proceeds very quickly, so that if distention be not observed then the heat is too great, for the expansion of the air inside will force off the head with a loud report; also, with softer, thicker Pentatomidæ care must be taken to begin with a heat only so strong that the internal juices do not boil, for in such case the preparation would be spoiled. It is of advantage to remove the cylinder from time to time, and test, by means of a lens, if a contraction of the skin has taken place on any part; if so, the roasting is to be continued. The desired hardness may be tested with a bristle or wire.

For *Aphides* the *living Aphis* is to be put on a piece of white paper, and at the moment when it is in the desired position it is to be held over the flame, and in an instant it will be dead and will retain the attitude. Then put it, still on the paper, into the oven; or, still better, hold it over the heated tin, carefully watching the drying and moving the paper about in order to prevent it getting singed. The roasting is quickly accomplished in either way, but somewhat slower out of the oven especially in the larger kinds, such as Lachnus. If the paper turn brown it is a sure sign that caution is requisite. To pierce these brittle preparations for preservation is hazardous, and it is a better way to mount them with gum on card, placing some examples on their back.

For Cecidomyidæ, Agromyzidæ, Cynipidæ, and other small insects liable to shrink, yet containing but little moisture, such as Poduridæ, Pediculidæ, Psyllidæ, etc., another method is adopted. Over the insect, mounted on a wire, etc., as above directed, a thin chemical reagent glass or glass rod, heated strongly at one end, is held, and the heat involved is generally sufficient to bring about the immediate drying and distention, but if the heat be too little the process must be repeated; and, although by this method the danger of burning is not obviated, yet the position of the legs is maintained much better than by the aforesaid roasting.

Larvæ of all kinds, up to the size of that of *Astynomus œdilis*, even when they have long been kept in spirits, may be treated successfully by the roasting method; but with these objects care must be taken that the heat is not too strong or else the form will be distorted. For small larvæ it is preferable to use a short glass, in order better to effect their removal without touching the upper part, which becomes covered with steam, and contact with which would cause the destruction of the preparation. Larvæ of Coleoptera, which contain much moisture or have a mucous surface, must lie on a bed of paper or pith in order to prevent adhesion and burning, and these may be further avoided if the cylinder be slightly shaken during the process, and the position of the object be thereby changed.

Many Aphides and Coccids are covered with a waxy secretion which interferes very materially with their easy examination. Mr. Howard has overcome this difficulty by the following treatment:

"With Aphides and Coccids which are covered with an abundant waxy secretion which can not be readily brushed away, we have adopted the plan of melting the wax. We place the insect on a bit of platinum foil and pass it once over the flame of the alcohol lamp. The wax melts at a surprisingly low temperature and leaves the insect perfectly clean for study. This method is particularly of use in the removal of the waxy cocoon of the pupæ of male Coccidæ, and is quicker and more thorough than the use of any of the chemical wax solvents which we have tried." (*Insect Life*, I, p. 152.)

Mounting Specimens for the Microscope.—The study of the minuter forms of insect life, including Parasites, Thysanura, Mallophaga, the newly hatched of most insects, etc., requires the use of the microscope, and some little knowledge of the essentials of preparing and mounting specimens is needed. The subject of mounting the different organs of insects and the preparation for histological study of the soft parts of insects opens up the immense field of microscopy, the use of the innumerable mounting media, the special treatment of the objects to be mounted, staining, section-cutting, and many other like topics, a full description of which is altogether out of place in the present work. Anyone desiring to become thoroughly versed in the subject should consult some of the larger manuals for the microscopist, of which there are many. For the practical working entomologist, however, a knowledge of all these methods and processes is not essential, and in my long experience I have found that mounting in Canada balsam will answer for almost every purpose. The softer-bodied forms will shrink more or less in this substance, and it is frequently necessary to make studies or drawings of them when freshly mounted; or, if additional specimens are preserved in alcohol, they will supplement the mounted specimens and the material may be worked up at the convenience of the student. The materials for the balsam mounts may be obtained of any dealer in microscopical supplies. They consist of glass slides, 3 inches by 1 inch, thin cover-glasses of different dimensions, and the prepared balsam. The balsam is put up very conveniently for use in tin tubes. A sufficient quantity is pressed out on the center of the glass slide, which has previously been made thoroughly clean and dry, the insect is removed from the alcohol, and when the excess of liquor has been removed with bibulous paper, it is placed in the balsam, the limbs and antennæ being arranged as desired by the use of fine mounting-needles. A cover-glass, also made thoroughly clean and dry, is then placed over the specimen and pressed gently until the balsam entirely fills the space between the cover and the glass slide. The slide should then be properly labeled with a number referring to the notes on the insect, preferably placed on the upper edge of the slide above the cover-glass, and also a label giving the number of the slide and the number of the slide box. On the opposite end of the slide may be placed the label giving the name of the specimen mounted and the date. If a revolving slide table is employed to center the mounts, the appearance of the slide may be improved by adding a circle of asphalt or Brunswick black. With the balsam mounts, however, this sealing is not necessary. The slide (Fig. 110) should then be placed in a slide case with the mount uppermost, and should be kept in a horizontal position to prevent sliding of the cover-glass and specimen until the balsam is thoroughly dried. For storing slides I have found very convenient the box shown at Fig.

111. It is constructed of strong pasteboard and is arranged for holding twenty-six slides. The cover bears numbers from 1 to 26, opposite which the name of each insect mounted, or the label on the slide, may

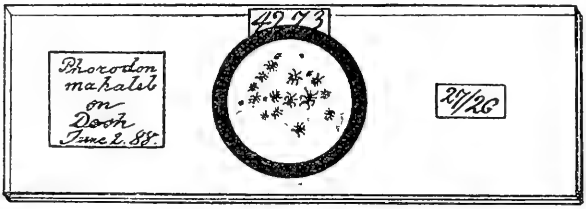


FIG. 110.—Balsam mount, showing method of labeling, etc. (original).

be written. This box when not in use is kept in a pasteboard case, on which may be placed the number of the box. These slide cases may be stored in drawers or on shelves made for the purpose. In mounting specimens taken from alcohol it is advisable to put a drop of

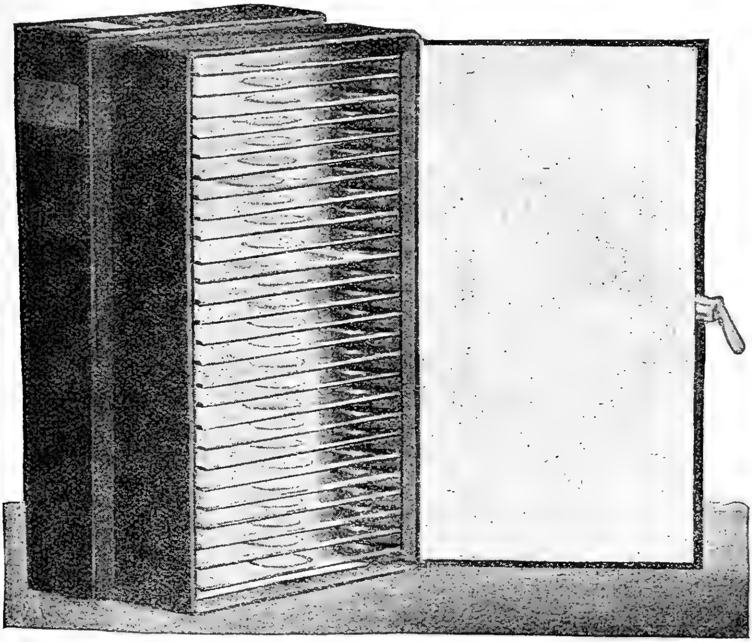


FIG. 111.—Slide case, showing method of labeling case and of numbering and labeling slides (original).

oil of cloves upon them, which unites with the balsam and ultimately evaporates. The occurrence of minute air bubbles under the cover-glass need occasion no uneasiness, for these will disappear on the drying of the balsam.

In mounting minute Acarids or mites it has been found best to kill the insects in hot water, which causes them to expand their legs, so that when mounted these appendages can readily be studied. If mounted living, the legs are almost invariably curled up under the body and can not be seen. This method may also be used in the case of other minute insects. Some insects, such as minute Diptera, are injured by the use of hot water, and for these dipping in hot spirits is recommended.

In the mounting of Aphides the same difficulty is avoided in a measure by Mr. G. B. Buckton, author of "A Monograph of the British Aphides," by first placing a few dots of balsam on the glass slide, to which the insect is transferred by means of a moistened camel's-hair brush. The efforts of the insect to escape will cause it to spread out its legs in a natural position and a cover glass may then be placed in position and a drop of the balsam placed at the side, when, by capillarity, it will fill the space between the slide and cover glass and the limbs will be found to have remained extended. If three or four drops of the balsam are put on the glass the wings may also be brought down and caught to them so that they will remain expanded in shape for examination.

Preparing and Mounting the Wings of Lepidoptera.—The student of Lepidoptera will frequently find it necessary in the study of the venation of wings to bleach them or denude them of their scales in some way. Various methods of bleaching and mounting the wings of these insects have been given, and a few of them may be briefly outlined.

The simplest and quickest, but perhaps the least satisfactory, method is to remove the scales with a camel's-hair brush. This will answer for the larger forms and where a very careful examination is not required. For more careful examination and study the wings are first bleached by the action of some caustic solution and then mounted in balsam for permanent preservation. Chambers's method for Tineina, Tortricina, Pyralidina, and the smaller moths generally, is as follows: The wing is placed on a microscopic slide in from 3 to 4 drops of a strong solution of potash, the amount varying according to the size of the wing. A cover of glass is then placed in position on the wing as in ordinary mounting.

The quantity of liquid should be sufficient to fill the space beneath, but not sufficient to float the cover glass. The mount is then placed over an alcohol flame, removing it at the first sign of ebullition, when the wing will be found denuded, if it be a fresh specimen. An old specimen, or a larger wing, will require somewhat more prolonged boiling. The fluid is drawn off by tilting the glass or with bibulous paper, and the potash removed by washing with a few drops of water. The cover glass is then removed and the wing mounted either on the same slide in balsam or floated to another slide, or at once accurately sketched with the camera lucida. Permanent mounting, however, is always to be recommended.

The Dimmock method of bleaching the wings of Lepidoptera, given in Psyche, Vol. I, pp. 97–99, is as follows: He uses for bleaching a modification of the chlorine bleaching process commonly employed in cotton bleacheries, the material for which is sold by druggists as chlorate of lime. The wings are first soaked in pure alcohol to dissolve out the oily matter, which will act as a repellant to the aqueous chlorine solution. The chlorate of lime is dissolved in 10 parts of water and filtered. The wings are transferred to a small quantity of this solution and in an hour or two are thoroughly bleached, the veins, however, retaining a light brown color. If the bleaching does not commence readily in the chlorine solution the action may be hastened by previously dipping them in dilute hydrochloric acid. When sufficiently decolorized the wings should be washed in dilute hydrochloric acid to remove the deposit of calcic carbonate, which forms by the union of the calcic hydrate solution with the carbonic dioxide of the air. The wings are then thoroughly washed in pure water and may be gummed to cards or mounted on glass slides in Canada balsam, first washing them in alcohol and chloroform to remove the moisture. If either of the solutions known as *eau de labaraque* and *eau de javelle* are used in place of the bleaching powder, no deposit is left on the wings and the washing with acid is obviated. This process does not dissolve or remove the scales, but merely renders them transparent, so that they do not interfere with the study of the venation.

Prof. C. H. Fernald (*American Monthly Microscopical Journal*, I, p. 172, 1880), mounts the wings of Lepidoptera in glycerin, after having first cleared them by the Dimmock process. After bleaching and washing, the wings are dried by holding the slides over an alcohol flame, and a drop of glycerin is then applied and a cover glass put on at once. By holding the slide again over the flame until ebullition takes place the glycerin will replace the air under the wings and no injury to the structure of the wings will result, even if, in refractory cases, the wing is boiled for some little time. The mount in this method must be sealed with some microscopic cement, as asphalt or Brunswick black.

A method of mounting wings of small Lepidoptera for studying venation, which I have found very convenient, is thus described by Mr. Howard in *Insect Life*, Vol. I, p. 151:

"Some years ago we used the following method for studying the venation of the wings of small Lepidoptera. We have told it since to many friends, but believe it has not been published. It is in some respects preferable to the so-called 'Dimmock process,' and particularly as a time-saver. It is also in this respect preferable to denudation with a brush. The wing is removed and mounted upon a slide in Canada balsam, which should be preferably rather thick. The slide is then held over the flame of an alcohol lamp until the balsam spreads well over the wing. Just as it is about to enter the veins, however, the slide is placed upon ice, or, if in the winter time, outside the window for a few moments. This thickens the balsam immediately and prevents it from entering the veins, which remain permanently filled with air and appear black with transmitted light. With a little practice one soon becomes expert enough to remove the slide and cool it at just the right time, when the scales will have been rendered nearly transparent by the balsam, while the veins remain filled with air. We have done this satisfactorily not only with Tortricidæ and Tineidæ, but with Noctuids of the size of *Aletia* and *Leucania.* The mounts are permanent, and we have some which have remained unchanged since 1880. Prof. Riley had for some years before this been in the habit of mounting wings in balsam, in which of course the scales cleared after a time."

Prof. John B. Smith recommends a modification of the Dimmock process of bleaching the wings of Lepidoptera, publishing it in Insect Life, Vol. I, pp. 291, 292, as follows:

"By the Dimmock process the wings are first acted upon by a saturated solution of the chloride of lime, chlorine being, of course, the bleaching agent. Afterward they are washed in water to which hydrochloric acid has been added, to get rid of the slight deposit of lime. The process is a slow one for thickly scaled, dark-colored insects, and it occurred to me to try a mixture of the chloride and acid, liberating the chlorine gas. The method was absolutely successful, the wings decolorizing immediately and being ready for the slide within two minutes. In fact, very delicate wings can scarcely be taken out quick enough, and need very little acid. The advantage is the rapidity of work and the certainty of retaining the wings entire, the chloride of lime sometimes destroying the membrane in part before the bleaching is complete. The disadvantage is the vile smell of the chlorine gas when liberated by the combination of the two liquids. For quick work this must be endured, and the beauty and completeness of the result are also advantages to counterbalance the discomfort to the senses."

For further special directions for mounting, for microscopic purposes, different insects and the different parts of insects, representing both the external chytinous covering and the internal anatomy, the student is referred to special works.

PRESERVATION OF ALCOHOLIC SPECIMENS.

APPARATUS AND METHODS.—The collections of most value, especially to our various agricultural colleges and experiment stations will be largely of a biologic and economic character, and the interest attaching to a knowledge of the life history of insects will induce many collectors to build up independent biologic collections. Very much of this biological material will be alcoholic, and though many immature states of insects may be preserved by dry processes, still the bulk must needs be kept in liquid. This material may, when not abundant, be kept with the general systematic collection, but experience has shown that it is better to make a separate biological collection, and this is recommended especially for State institutions where the collections may be expected to attain some considerable proportions. In the case of such collections it is very desirable to adopt some method of securing the vials in such a manner that they can easily be transferred from one place to another and fastened in the boxes or drawers employed for pinned insects. For directions in this regard I reproduce from an article on the subject in *Insect Life*, Vol. II, pp. 345, 346, which was republished, with slight changes, from my annual report for 1886 as Honorary Curator.*

Vials, Stoppers and Holders.—The vials in use to preserve such specimens as must be left in alcohol or other liquids are straight glass tubes of varying diameters and lengths, with round bottom and smooth even mouth. The stoppers in use are of rubber, which, when tightly put into the vial, the air being nearly all expelled, keep the contents of the vial intact and safe for years.

Various forms of bottles are used in museums for the preservation of minute alcoholic material. I have tried the flattened and the square and have studied various other forms of these vials; but I am satisfied that those just described, which are in use by Dr. Hagen in the Cambridge Museum, are, all things considered, the most convenient and economical. A more difficult problem to solve was a convenient and satisfactory method of holding these vials and of fastening them into drawers or cases held at all angles, from perpendicular to horizontal. Most alcoholic collections are simply kept standing, either in tubes with broad bases or in tubes held in wooden or other receptacles; but for a biologic collection of insects something that could be used in connection with the pinned specimens and that could be easily removed, as above set forth, was desirable. After trying many different contrivances I finally prepared a block, with Mr. Hawley's assistance, which answers every purpose of simplicity, neatness, security, and convenience. It is, so far as I know, unique, and will be of advantage for the same purpose to other museums. It has been in use now for the past six years, and has been of great help and satisfaction in the arrangement and preservation of the alcoholic specimens, surpassing all other methods for ease of handling and classifying.

The blocks are oblong, one-fourth of an inch thick, the ends (*c c*, Fig. 112) beveled, the sides either beveled or straight, the latter preferable. They vary in length and breadth according to the different sizes of the vials, and are painted white. Upon the upper side of these blocks are fastened two curved clamps of music wire (*b b*), forming about two-thirds of a complete circle. The fastening to the block is simple and secure. A bit of the wire of proper length is first doubled and then by a special contrivance the two ends are bent around a mandrel so as to form an insertion point or loop. A brad awl is used to make a slot in the block, into which this loop is forced (*e*, Fig. 112, 5), a drop of warm water being first put into the slot to soften the wood, which swells and closes so firmly around the wire that considerable force is required to pull it out. Four pointed wire nails (*d d d d*), set into the bottom so as

*Annual Report of the Smithsonian Institution for 1886, Part II, Report of the National Museum, pp. 182–186. Washington, 1890.

to project about one-fourth inch, serve to hold the block to the cork bottom of the case or drawer in which it is to be placed. The method of use is simple and readily seen from the accompanying figures, which represent the block from all sides.

The advantages of this system are the ease and security with which the block can be placed in or removed from a box; the ease with which a vial can be slipped into or removed from the wire clamps; the security with which it is held, and the fact that practically no part of the contents of the vial is obscured by the holder—the whole being visible from above.

The beveled ends of the block may be used for labeling, or pieces of clean card-board cut so as to project somewhat on all sides may be used for this purpose, and will be held secure by the pins between the block and the cork of the drawers.

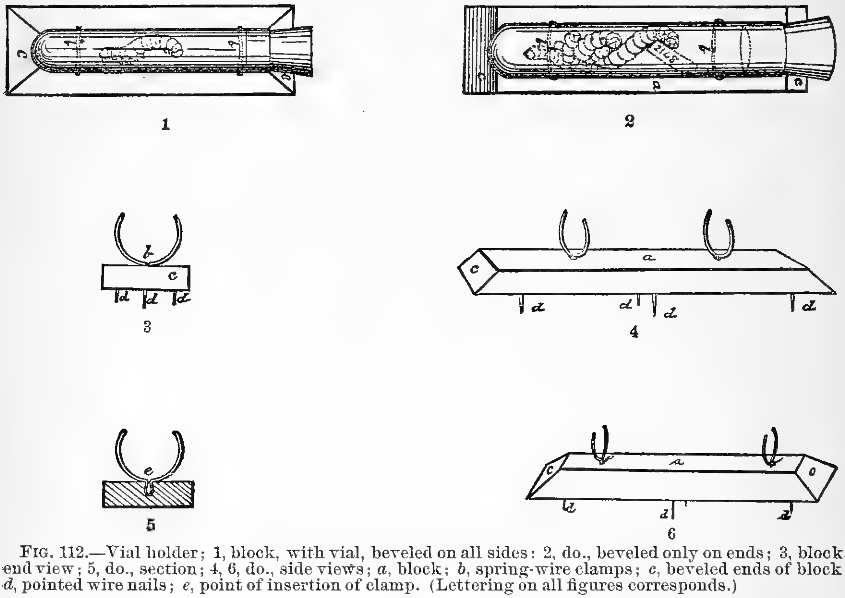


FIG. 112.—Vial holder; 1, block, with vial, beveled on all sides: 2, do., beveled only on ends; 3, block, end view; 5, do., section; 4, 6, do., side views; *a*, block; *b*, spring-wire clamps; *c*, beveled ends of block; *d*, pointed wire nails; *e*, point of insertion of clamp. (Lettering on all figures corresponds.)

The use of rubber stoppers in this country was first instituted by Dr. H. A. Hagen in connection with the Cambridge biological collection, and he has made some very careful records to determine the durability of such stoppers. From an examination of some seven thousand vials with rubber stoppers, two-thirds of which had been in use for from ten to twelve years, he comes to the conclusion that less than one in a thousand gives out every year after twelve years' use, and in the first six years probably only one out of two thousand. Stoppers of large size keep much longer than those of small size. American rubber stoppers are all made of vulcanized India rubber and have the disadvantage of forming small crystals of sulphur about the stopper, which become loosened and attach themselves to the specimens. It is supposed that pure rubber-stoppers used for chemical purposes would not present this disadvantage, which may be obviated, however, or very much reduced, if the stoppers are washed or soaked, preferably in hot water, for an hour or two at least.

If stoppers are stored for a considerable time and exposed to the air they become very hard and unfit for use, and Dr. Hagen has drawn attention to a method recommended by Professsor W. Hemple, of Dresden, Saxony, of preventing them from becoming thus hardened. He says that to keep rubber stoppers or rubber apparatus of any sort elastic, they should be stored in large glass jars in which an open vessel containing petroleum is placed. This treatment prevents the evaporation of the fluids which are fixed in the rubber in the process of vulcanization. It is better also to keep the light from the jar. To soften stoppers which have already become hardened, they should be brought together in a jar with sulphuret of carbon until they are pliable and afterward kept as recommended above.

In the use of the rubber stopper the novice may find some difficulty in inserting it in a vial filled with alcohol. The compression of the alcohol, or alcohol and air when the vial is not completely filled, forces the stopper out, and this is true whether of rubber or cork. If a fine insect pin is placed beside the cork when this is thrust into the bottle, the air or liquid displaced by the cork will escape along the pin and the latter may then be removed and the cork remains securely in position.

If cork stoppers have been used the vials may be stored in large quantities together in jars filled with alcohol. This will prevent evaporation of the alcohol from the vials, and the specimens may be preserved indefinitely. This is only desirable in the storage of duplicate specimens and unarranged material and is not recommended as a substitute for the use of the rubber stopper. With cork stoppers evaporation can be in a measure prevented if the cork is first anointed with the petroleum preparation known as vaseline. This substance is practically unaffected at ordinary temperature and is sparingly soluble in cold alcohol. Experiments with it have shown that at ordinary spring and summer temperatures there is no appreciable loss of alcohol from vials and jars.

My old method of keeping alcoholic specimens, which I abandoned for the method outlined above, was fairly serviceable, inexpensive, and warrants description.

I had special folding boxes constructed resembling in exterior appearance a large insect box. The bottom of the box was solid and was made by gluing together two 1½-inch planks.

Holes extending nearly through the lower plank and of various sizes to accommodate vials of different diameters were bored as closely together as the wood justified without splitting or breaking.

The holes were numbered consecutively and the vials when placed in them were numbered to correspond; the box also had its number, and in the notes the vial was referred to by number of box and vial thus, $\frac{3}{73}$ (box 3, vial 73). The vial should project one-half to 1 inch above the hole, and should be loose enough to provide for the swelling of the wood in moist weather.

To protect the vials a cover having a depth of about $1\frac{1}{2}$ inch was hinged to the back and secured in front by hook-and-eye fastenings.

This method of storing vials is satisfactory enough for private collections, but for larger public collections is not so suitable.

A rather convenient and inexpensive method of storing vials is that used by Dr. Marx. In this method the vials are stored in a wooden

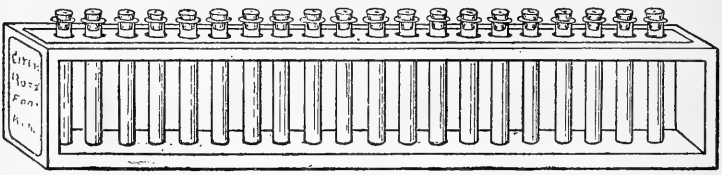


FIG. 113.—The Marx tray for alcoholic specimens (original.)

frame, shown at Fig. 113. The top piece of the tray into which the vials are thrust has a cork center, in which holes corresponding to the size of the vials are made with a gun-wad punch. The outer end of the tray bears a label or labels describing the material in the tray. The vials used by Dr. Marx are of thinner glass than those which I recommend and flare slightly at the top, as shown in the accompanying illustrations. They are made in various sizes to accommodate larger and smaller specimens. A vial thrust into the hole punched in the cork rests on the bottom piece of the tray, the flange or neck preventing it from sliding through. These trays are arranged on shallow shelves in a case or cabinet, especially constructed for the purpose and a large quantity of material may be stored by their use in small compass. The use of the cork center piece in the upper part of the tray is not a necessity, and a wooden piece may be used in which holes are bored with a bitt of proper size.

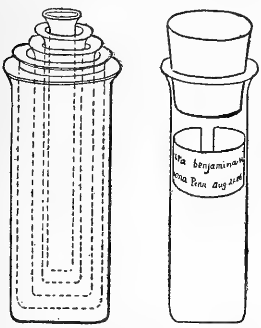


FIG. 114.—Vials used in the Marx tray (original.)

Preserving Micro-larvæ in Alcohol.—The following is quoted from Packard's "Entomology for Beginners," for which it was translated from the "*Deutsche Ent. Zeitg.*," 1887, Heft I:

"Dr. H. Dewitz mounts the larvæ and pupæ of Microlepidoptera, and also the early stages of other small insects, in the following way: The insects are put into a bottle with 95 per cent alcohol. Many larvae turn black in alcohol, but boiling them in alcohol in a test tube will bleach them. They may then be finally placed in glass tubes as small and thin as possible, varying from 0.003 to 0.006 meter in diameter, according to the size of the insects. About 0.07 meter's length of a tube is melted over a spirit lamp, and the tube filled three-quarters full with 95 per cent alcohol, the insects placed within and the contents of the tube heated at the end still open, and then closed by being pulled out with another piece of glass tubing. After the glass has been held a few minutes in the hand until it is slightly cooled off, the end closed last is once more held over the lamp so that the points may be melted together, and this end of the glass may be finished. During the whole time from the closure of the tube until the complete cooling of the glass it should be held obliquely in the hand, so that the alcohol may not wet the upper end, for if the tube is too full it is difficult to melt it, as the steam quickly expanding breaks through the softened mass of glass. The tube may be mounted by boring a hole through a cork stopper of the same diameter as the glass. The stopper is cut into the shape of a cube, a strong insect pin put through it, and the glass tube inserted into the hole. It can then be pinned in the insect box or drawer, near the imago, so that the free end of the glass may touch the bottom, while the other end stands up somewhat; while to keep the tube in place the free end resting on the bottom may be fastened with two strong insect pins. The specimens thus put up can easily be examined with a lens, and if they need to be taken out for closer examination the tube can be opened and closed again after a little practice."

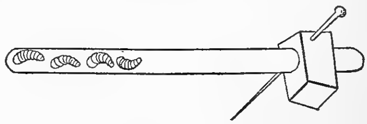


FIG. 115.—Method of preserving minute larvæ etc. (After Dewitz.)

PRESERVATIVE FLUIDS.—The principal liquids in which soft-bodied insects may be successfully preserved are the following:

Alcohol.—As indicated in the foregoing portions of this work, alcohol is the standard preservative used for soft-bodied specimens, and may be used either full strength or diluted with water. Diluted alcohol should always be first used with larvæ, since the pure alcohol shrivels them up. The weak spirits can afterwards be replaced by strong, for permanent preservation.

Alcohol and White Arsenic.—The method of preserving insects recommended by Laboulbène and quoted in Packard's Entomology for Beginners, consists in plunging the insects in the fresh state into a preservative liquid, consisting of alcohol with an excess of the common white arsenic of commerce. The larva placed in this mixture absorbs .003 of its own weight, and when removed and pinned is safe from the attacks of museum pests. This liquid is said not to change the colors, blue, green or red of beetles, if they are not immersed for more than twenty-four hours. This treatment is applicable to the orders Coleoptera, Hemiptera, and Orthoptera. If the insect is allowed to stay in this mixture for a considerable time, say three or four weeks, and then removed and dried, it becomes very hard and brittle and can not be used for dissection or study, but makes a good cabinet specimen.

The white deposit of arsenic which will appear on drying can be washed off with alcohol.

Alcohol and Corrosive Sublimate.—The same author recommends another preparation consisting of alcohol with a variable quantity of corrosive sublimate added, the strength of the solution varying from 100 parts of alcohol to 1 part of corrosive sublimate for the strongest, to one-tenth of 1 part of sublimate in 100 parts of alcohol for the weakest. The insects are allowed to remain in this mixture not longer than two hours before drying. The last-described preparation is said to preserve the specimens from mold. Both of these solutions are very poisonous and should be used with care.

Two Liquids to preserve Form and Color.—Professor Packard also quotes the formula of A. E. Verrill for preserving insects in their natural color and form. Two formulas are given; the first consists of 2½ pounds of common salt and 4 ounces of niter dissolved in a gallon of water and filtered. The specimens should be prepared for permanent preservation in this solution by being previously immersed in a solution consisting of a quart of the first solution and 2 ounces of arsenite of potash in a gallon of water. Professor Packard gives also the formula of M. H. Trois for preserving caterpillars, for which it is claimed that the colors of the caterpillars are preserved perfectly, even when exposed to strong light. The formula for this solution is as follows:

Common salt	grams..	2.35
Alum	do...	55
Corrosive sublimate	centigrams..	18
Boiling water	liters..	5

Allow the liquid to cool and add 50 grains of carbolic acid, and filter after standing five or six days.

Glycerin.—Glycerin, either pure or mixed with water or alcohol, is frequently used to preserve the larvæ of delicate insects. It preserves the color and form better than alcohol, but particularly in the case of larvæ, it causes a softening of the tissues which renders them unfit for study.

The Wickersheim Preserving Fluid.—This valuable preserving fluid has been known for some time, but is not very commonly used, on account of frequent disappointment due to the difficulty attending its preparation. It is claimed for it that animal or vegetable bodies impregnated with it will retain their form, color, and flexibility in the most perfect manner. The objects to be preserved are put in the fluid for from six to twelve days, according to their size, and then taken out and dried in the air. The ligaments remain soft and movable, and the animals or plants remain fit for anatomical dissection and study for long periods, even years. It is said to be especially valuable for the preservation of larvæ and soft-bodied insects. In order to perfectly preserve the colors, it is necessary to leave the specimens in the fluid, or, if they are taken out, they should be sealed up in air-tight vials or vessels. The formula for the fluid is as follows:

Dissolve 100 grams alum, 25 grams common salt, 12 grams saltpeter, 60 grams potash, 10 grams arsenious acid in 3,000 grams boiling water. Filter the solution, and when cold add 10 liters of the liquid to 4 liters of glycerin and 1 liter of methyl alcohol.

LABELING SPECIMENS.

General Directions.—It matters little how much care and pains have been taken in the preparation and mounting of specimens, they will have little value unless accompanied by proper labels giving information as to locality and date of collection, name of collector, and a label or number referring to notebooks, if any biological or other facts concerning them have been ascertained. There should be pinned to the specimen labels referring to, or giving all the information obtainable or of interest concerning it. A somewhat different style of label will be found necessary in the case of the two forms of collections described in the foregoing pages, namely, the biological or economic collection, and the systematic collection. For the former, numbers may be attached to the specimens which will refer to the notes relating to the specimen or species. For the latter, in most cases, all necessary information may be recorded and made available by written or printed labels attached directly to the specimens. In most cases, however, I find a combination of these two systems convenient and desirable. The numbering system is very simple, and is the one which I have followed in all the species for which I have biological or other notes. It consists in giving each species, as it comes under observation, a serial number which refers to a record in a notebook. With this number may be combined, if convenient, the date of rearing or collection of the specimen, and also the locality and food-plant if known. The vast number of species represented in a systematic collection renders the numbering system entirely out of place and inadequate, and the labeling system alone is generally available. If it becomes necessary in the systematic collection to refer to food-plants or life-history or any other fact of interest, the numbering system should be used, and I recommend that the numbers be written in red ink on the labels, to distinguish at a glance the numbers referring to biological notes from other numbers that will occur in the collection.

Labels for pinned Specimens.—The following labels should be employed in the collection: (1) *Locality label*, which should be as explicit as possible. (2) *Date of capture*, which is very useful and sometimes quite important in various ways. It indicates at what time additional specimens of some rare species may be secured, and greatly assists in elaborating the life history of the species, and in other cases assists in the correct determination of closely allied insects, which differ chiefly in habit or date of appearance. (3) *A label to indicate the sex.* This label has recently acquired greater importance than formerly, on account of the value of the sexual differences in the distinction of species. The well-known signs for male, female, and worker, printed in convenient form, are well adapted for collections. (4) *The name of the collector.* This label is of less value, but sometimes becomes important in determining the history of the specimen or the exact place of capture. The name of the species is not necessarily attached to all the specimens in a collection, and ordinarily will be placed with the first specimen in a series in the cabinet. This and other labeling of insects in cabinet is discussed in another place. Other labels are useful to indicate type specimens, namely, those of which descriptions have been drawn up and published, and which should be designated by a special label written by the author himself. Determinations by an authority in a special group should be indicated, and the labels placed on specimens by such an authority should not be removed.

It will not be found necessary to use a separate label for each of the data indicated above, and a single label may be made to combine many of them, as, except for the specific names of the insects themselves (which should always be on the lowermost label), most other words will bear abbreviation, especially localities and dates. "A combination label, which has given general satisfaction to all to whom it has been communicated, is a two-line label printed in diamond type, on heavy writing paper. The upper line consists of the name of the locality, *e. g.*, 'Washngtn' (a name consisting of more than eight letters to be abbreviated), and the lower line has at the right-hand corner 'DC' (interpunctuation and spacing to be avoided so as to save space). This leaves on the second line sufficient room for inserting the date, which can be quickly and neatly written with ink if the labels are printed in columns of ten or more repetitions. The label thus combines locality with date of capture. Or the upper line reads 'Arizona' and the lower line 'Morrison,' the label thus combining locality with the name of the collector."*

In general I indorse the system of labeling suggested in the above condensation from Mr. Schwarz, but there is no particular disadvantage, and in fact many advantages, in special cases, in a larger label or in folded labels. Particularly in visiting large foreign collections I have found it convenient to use large labels of thin paper which will contain a good deal of information closely written in pencil and bear folding several times, so as not to occupy more than the ordinary label space when pinned to the specimens. This involves detaching the label when the specimen or species comes to be studied, but this additional labor is insignificant compared with the large amount of valuable information which in time is thus brought together in condensed availability for the student; for brief notes of opinions of experts, of comparison with types, of special studies, of reference to descriptions, etc., may thus be all brought together. Where there is not room to indicate the authority for a determination on the upper side of a label, I also find it convenient to do so on the lower side.

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*E. A. Schwarz, Proc. Ent. Soc., Wash., II, No. 1, 1891.

Labeling alcoholic Specimens.—Alcoholic specimens, including alcoholic biologic material and collections of Arachnida and Myriopoda, are well adapted to the labeling system, as the vials are always of sufficient size to allow the insertion of one or more labels large enough to contain a pretty full record of the specimen. The label may consist of a number referring to notes, or of a number together with the other data indicated for the systematic collection. The label in my experience is preferably written in pencil, which, in alcohol, is practically permanent. Waterproof inks are sometimes used, and of these the oak-gall ink is undoubtedly the best. Dr. George Marx, in labeling his Arachnida, uses onion-skin paper and waterproof ink, such as Hig-

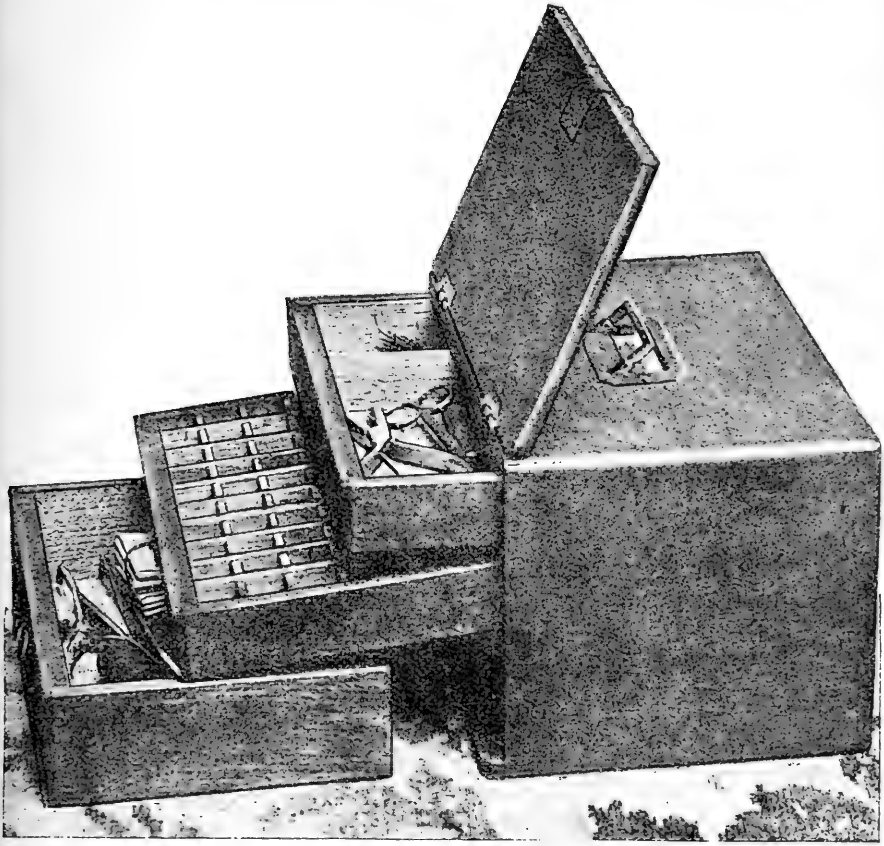

FIG. 116.—Cabinet for apparatus used in mounting and labeling. (Original).

gins's drawing ink. There is some danger, in placing a label in a vial, of its settling against the specimen and injuring it. This, however, can generally be avoided if a little care is used. The label may be long and narrow and folded lengthwise so as to occupy one side only of the vial, or short and inserted in such manner that it will pass around the inside of the vial, where it will be held by the natural adhesion to the glass in the upper portion of the vial, as shown at Fig. 114.

Cabinet for Apparatus.—The work of preparation of insects for the cabinet may be greatly facilitated if a convenient case is provided with drawers and compartments for the keeping of pins of different sizes, labels, braces, implements, tweezers, dissecting apparatus, and the like, with microscopical supplies – slides, cover glasses, mounting media, etc. I present a photograph of a cabinet of this sort used in my earlier work and found very convenient and serviceable (Fig. 116).

INSECT BOXES AND CABINETS.

General Directions.—The boxes or cases which are used to keep insects in permanently may be made of any dimensions to suit the fancy, 12 by 16 inches inside being a convenient size and allowing economic use of cork. They must, however, be perfectly tight and should not be more than 2½ inches deep on the inside. The bottoms should be lined with something which will hold the pins, and the whole inside covered with white paper, which, if delicately cross ruled, will facilitate the regular pinning of specimens. While the size and style of the box and cabinet may be left to individual taste, some choice must be had of material. *Red cedar should never be used.* I have learned, to my sorrow, the baneful effects of this wood, notwithstanding it is recommended—evidently by those who are guiltless of having used it—as having the advantage over other wood of keeping off musuem pests. It seems impossible to get this wood so seasoned but that a certain amount of resin will continually exude from it; and insects in boxes of this material are very apt to soften and become greasy. Paper boxes are also bad, as they attract moisture and cause the specimens to mold. Well-seasoned pine and whitewood are the most satisfactory; and, in such boxes as have glass covers and are intended to form part of a neat cabinet for parlor ornament, the fronts may be of walnut or cherry.

The character of the boxes and cabinets used for storing insects will depend largely on the nature and extent of the collection and the object of the collector. For temporary use, nothing is more convenient and economical than a cigar box lined with cork or pith. Such boxes, however, should be employed only for the temporary storage of fresh specimens, as they afford free access to museum pests, and insects kept in them for any length of time are apt to be destroyed or rendered useless.

The Folding-box.—The use of folding-boxes for the working collector is to be especially recommended in the case of those orders comprising small insects like Coleoptera, Hymenoptera, etc. These boxes have the great advantage of being readily rearranged on the shelves and of being very easily used in study. The boxes of this type now manufactured by John Schmidt, of Brooklyn, N. Y., and John Burr, of Camden, N. J., based on the experience which I have had, have proved so serviceable and satisfactory in this respect that I have employed them for the bulk of the collection in the National Museum. These boxes (Fig. 117) are constructed as follows:

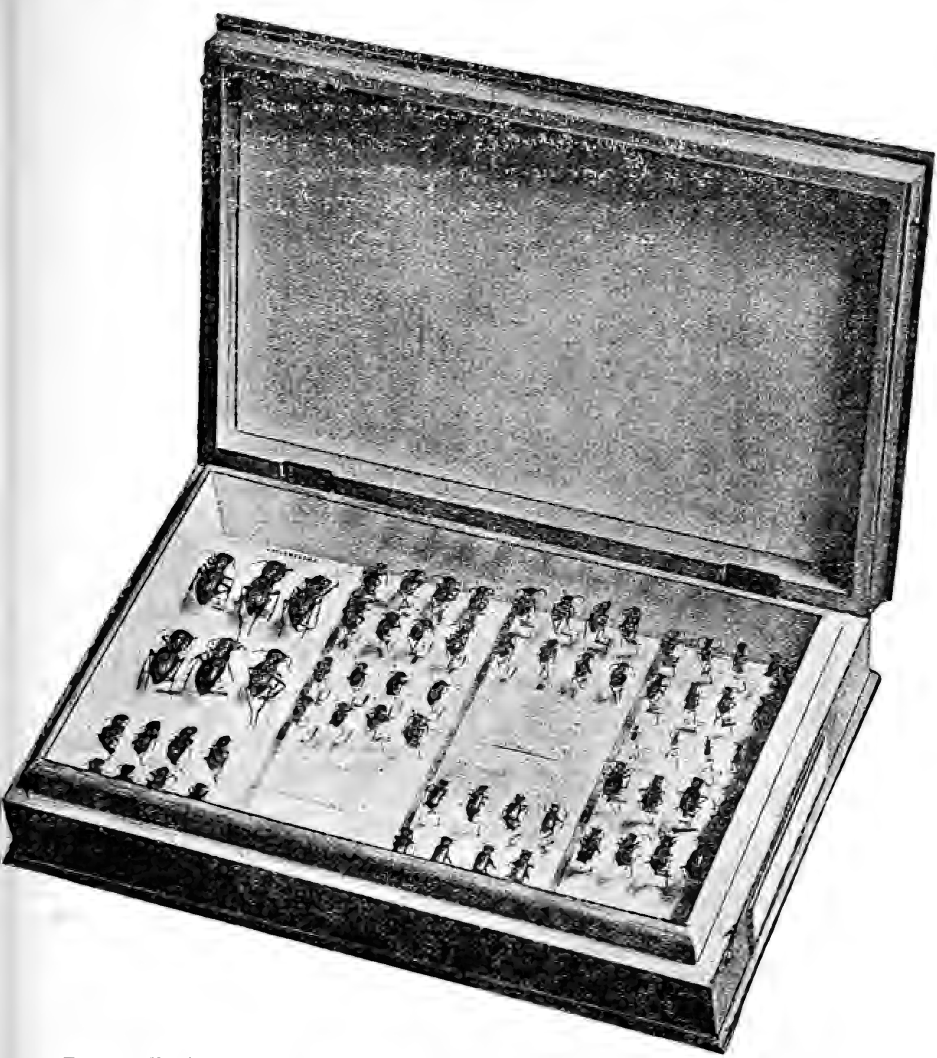

FIG. 117.—The Schmidt folding insect box, opened and showing arrangement of insects (original).

They are of white pine, shellacked and varnished, the bottom and top double and crossgrained, to prevent warping, and projecting slightly at all sides except the hinged back. They are 13 by 8¼ inches outside measurement. The inside measurement is 11¾ by 7. The sides, back, and front are five-sixteenths of an inch thick, with a machine joint, which is neat and very secure. The boxes are 2⅝ inches in outside depth, unequally divided, the lower portion 1½ inches outside depth, lined inside with a thin whitewood strip, projecting three-fourths of an inch above the rim of the outside box. Over this projecting lining the lid closes as tightly as practicable and is kept from springing by hooks and eyes. The bottom is cork-lined and covered with a fine, white, glazed paper.

Similar folding boxes with both sides of equal depth and both lined with cork, when properly covered, may be made to look like books and be set on end in an ordinary bookcase, but the single lining is preferable, as there is less danger of the breakage of specimens and the boxes may either be laid flat one on the other on shelves, or, what is more convenient, placed side by side resting on the front edge, so that the label is attached to one of the narrow ends. The rows of insects are then pinned crosswise, not lengthwise, of the box, with the abdomens turned toward the front which rests on the shelf.

All the boxes are furnished with neat brass label-holders, in which a card containing a list of the contents can readily be placed and removed at pleasure. The chief demerit of this box which I have endeavored to overcome by the above details is the tendency to warp and crack in the trying steam heat of our Government buildings.

The Cabinet.—For larger insects, such as Lepidoptera, Neuroptera, etc., a larger box is desirable, and for these orders I have adopted for use in the National Museum a cabinet which resulted from a careful study in person of the different forms and patterns used for entomological collections both in this country and Europe, whether by private in-

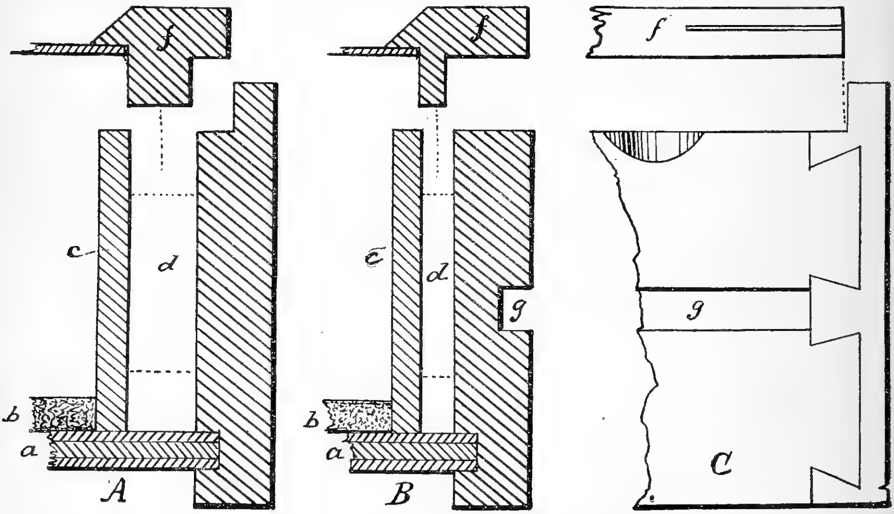

FIG. 118.—Construction of insect cabinet drawer of the National Museum. A, cross-section *f* front; B, same *f* side; C, view of front end of side, $\frac{2}{3}$ natural size (original).

dividuals or public institutions. The drawer and cabinet are essentially after the pattern of those used in the British (South Kensington) Museum, but adapted in size to our own requirements. In the use of the National Museum these cabinets have proved eminently well adapted to their object.

The drawers (Fig. 118, A, B, C) are square, with an outside measurement of 18 inches and an outside depth of 3 inches. The sides and back have a thickness of three-eighths of an inch, while the front is five-eighths of an inch thick. The pieces are firmly dovetailed together, the front being clean and the dovetailing blind. The bottom, *a*, is of three-ply crossgrained veneer, run into a groove at the sides, leaving a clear inside depth of $2\frac{1}{16}$ inches to the frame of the cover. The bottoms are lined in all but forty of the drawers with first quality cork, *b*, one-fourth of an inch thick. At a distance of one-fourth of an inch from the sides and back and three-eighths of an inch from the front there is an inside box of one-eighth inch whitewood, *c*, closely fitted, and held in place by blocks between it and the outer box. There is thus between the inner and outer box a clear space, *d*, all round, in which insecticides or disinfectants can be placed to keep out Museum pests, making it impossible for such to get into the inner box containing the specimens without first passing through this poison chamber. The entire inside is lined with white paper, or, in the case of the uncorked boxes, painted with zinc white. The front is furnished with a plain knob. The cover is of glass, set into a frame, *f*, three-fourths of an inch wide, three-eighths of an inch thick, with a one-fourth inch tongue fitting closely into the space between the inner lining and outer box, which here serves as a groove. This arrangement furnishes a perfectly tight drawer of convenient size and not unwieldy for handling when studying the collection.

The material of which these drawers are made is California red wood, except the cover frame, which is mahogany. The cabinets containing these drawers are 36 inches high, 40 inches wide, 21 inches deep (all outside measurements), and are closed by two paneled doors. Each cabinet contains twenty drawers in two rows of ten each, and the drawers slide by means of a groove, *g*, on either side, on hard-wood tongues, and are designed to be interchangeable.

The Lintner display Box.—For beauty and security and the perfect display of the larger *Lepidoptera*, I have seen nothing superior to a box used by Mr. J. A. Lintner, of Albany, N. Y. It is a frame made in the form of a folio volume, with glass set in for sides and bound in an ordinary book cover. The insects are pinned onto pieces of cork fastened to the inside of one of the glass plates and the boxes may be stood on ends, in library shape, like ordinary books. For the benefit of those who wish to make small collections of showy insects, I give Mr. Lintner's method, of which he has been kind enough to furnish me the following description:

Figs. A, B, and C represent, in section, the framework of the volume, *a* showing the ends, *b* the front, and *c* the back. The material can be prepared in long strips of some soft wood by a cabinet-maker (if the collector has the necessary skill and leisure for framing it) at a cost of 60 cents a frame, if a number sufficient for a dozen boxes be ordered. Or, if it be preferred to order them made, the cost should not exceed 80 cents each.

Before being placed in the hands of the binder the mitering should be carefully examined and any defect in fitting remedied, so that the glass, when placed in position, may have accurate bearings on all the sides. The interior of the frame is covered with tin foil, made as smooth as possible before application, to be applied with thoroughly boiled flour paste (in which a small proportion of arsenic may be mixed) and rubbed smoothly down till the removal of the blisters, which are apt to appear. The tin foil can be purchased, by weight, at druggists', and the sheets marked off and cut by a rule in strips of proper width, allowing for a trifle of overlapping on the sides. Its cost per volume is merely nominal.

First-quality single-thick glass for sides must be selected, wholly free from rust, veins, air-bubbles, or any blemish. Such glass can be purchased at 15 cents a pane. The lower glass, after thorough cleaning, especially of its inner surface, with an alkaline wash, and a final polishing with slightly wetted white printing paper, is to be firmly secured in its place by a proper number of tin points; the upper glass is but temporarily fastened. The binder must be directed to cover the exposed sides of the frame with "combed" paper, bringing it over the border of the permanent lower glass and beneath the removable upper glass.

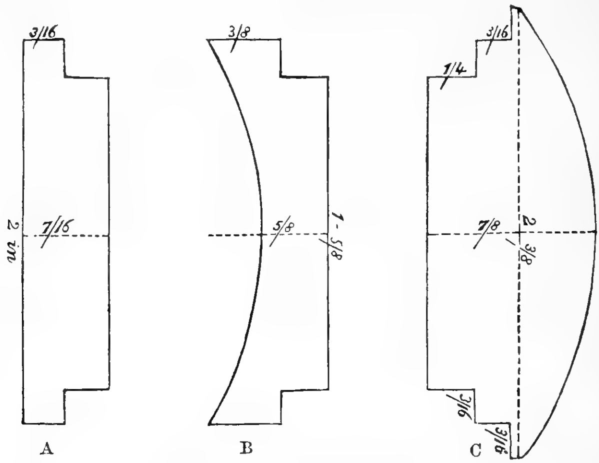

FIG. 119.—Construction of the Lintner box.

The covers of the volume are of heavy binders' board (No. 18), neatly lined within with glazed white paper. On one of the insides of the lids may be attached, by its corners, a sheet with the numbers and names of the species contained in the volume, or these may be placed on the pin bearing the insect. If bound in best quality of imitation morocco, with cloth covers, lettered and gilded on the back, the cost (for a dozen volumes) need not exceed $1 each. If in turkey morocco, it will be $1.50.

The lettering and ornamentation of the back will vary with the taste of the individual. The family designations may be permanently lettered, or they may be pasted on the back, on a slip of paper or gum label, as are the generic names, thus permitting the change of the contents of a volume at any time if desired.

The bits of cork to which the insects are to be pinned are cut in quarter-inch squares from sheet-cork of one-fourth of an inch in thickness. If the trouble be taken to trim off the corners, giving them an octagonal form, their appearance will be materially improved and much less care will be required in adjusting them on the glass.

The cement usually recommended for attaching the cork to the glass is composed of equal parts of white wax and resin. My experience with this has not been favorable, for, after the lapse of a few years, I have invariably been subjected to the serious annoyance of being compelled to renew the entire contents of the volume, clean the glass, and replace the corks with new cement. From some cause, inexplicable to me, a gradual separation takes place of the cork with its cement from the glass, first appearing at the angles of the cork, and its progress indicated by an increasing number of iridescent rings which form within until the center is reached, when, if not previously detached, the insect falls with the cork, usually to its injury and that of others beneath it.

A number of years ago I happened to employ, in attaching a single piece of cork in one of my cases, a cement originally made for other purposes, consisting of six parts of resin, one of wax, and one of Venetian red. Several years thereafter my attention was drawn to this piece by finding it as firmly united as when at first applied, and at the present time (after the lapse of twelve years) it is without the slightest indication of separation. Acting upon this hint, I have, of late, used this cement in the restoration of a number of my cases, and with the most satisfactory results. It is important that the cement, when used, should be heated (by a spirit lamp or gas flame) to as high a degree as it will bear without burning. An amount sufficient to cover the bottom of the small, flat metal vessel containing it to the depth of an eighth of an inch will suffice and prevent the cork from taking up more than its requisite quantity. It should be occasionally stirred to prevent the precipitation of its heavier portions. The cork may be conveniently dipped by the aid of a needle inserted in a handle, when, as quickly as possible, it should be transferred to the glass, for the degree of adhesion seems to depend upon the degree of fluidity of the cement. From some experiments made by me, after the corks had been attached as above, in heating the entire glass to such a degree as thoroughly to melt the cement until it spreads outward from beneath the weight of the cork, and then permitted to cool—the glass meanwhile held horizontally, that the corks might not be displaced—the results appear to indicate that the above cement, applied in this manner on glass properly cleaned, will prove a permanent one. It is scarcely necessary to state that this method is not available where the glass has been bound as above.

Preparatory to corking the glass for the specimens assigned to it, the spaces required for them are to be ascertained by arranging them in order on a cork surface or otherwise. On a sheet of paper of the size of the glass, perpendicular lines, of the number of the rows and at their proper distances, are to be drawn, and cross lines equal in number to the insects contained in the rows. The distances of these lines will be uniform, unless smaller specimens are to occupy some portion of the case, when they may be graduated to the required proportion. With the sheet ruled in this manner and placed beneath the glass, the points where the corks are to be applied are indicated by the intersections of the lines. The sheet, marked with the family of the insects for which it was used and with the numbers designating its divisions, may be laid aside for future use in the preparation of other cases for which it may be suitable. In a series of unbound cases in my collection, in which the glasses measure 11 by 14½ inches, I have used for my Lepidoptera and laid aside the following scales, the citation of which will also serve to show the capacity of the cases: 3 by 8, Catocalas; 2 by 7 and 3 by 9, Sphingidæ; 4 by 11 to 4 by 14, Bombycidæ; 5 by 13 to 6 by 16, Noctuidæ; 8 by 16 and 8 by 20, Lycænidæ and Tortricidæ.

The unbound cases above referred to are inexpensive frames, made by myself, of quarter-inch white wood or pine, the corners mitered, glued, and nailed with three-quarter inch brads, lined within with white paper (better with tin foil), and covered without with stout manila paper. The glasses are cut of the size of the frame, and when placed in position thereon are appressed closely to it by laying upon them, near each corner, a heavy weight, and strips of an enameled green paper, cut to the width of 1 inch, are pasted over their edges, extending a little beyond the thickness of the frame, and brought downward over the outside of the frame. On its back two gum labels, indicating the insects inclosed, are placed at uniform heights (7 and 12 inches), when, if all has been neatly done, they present a tasteful appearance upon a shelf. When there is reason to believe that the case will need to be opened for the change or addition of specimens, it will be found convenient to employ, for the fastening of the left-hand side of the upper glass, paper lined with a thin muslin, to serve as a hinge when the other sides have been cut.

Should it become desirable to bind these cases, outside frames may be constructed after the plans above given, with the omission of the inside quarter inch (the equivalent of these frames), in which these may be placed and held in position by two or three screws inserted in their sides.

The Martindale Box for Lepidoptera.—Mr. Isaac C. Martindale, in the October, 1891, number of *Entomological News*, pp. 126, 127, describes a new form of cabinet for butterflies, the drawers of which present some new features. They are for the same end as the Lintner box described above—namely, for the display of the upper and under surface of the wings of Lepidoptera, and promise to be more useful. The drawer is described as follows:

The especial feature is the drawer itself, which, instead of having a cork bottom, as is usually the case, has both the top and bottom of glass. The top part of the drawer frame fits tightly over a ledge one inch in height, effectually preventing the intrusion of destructive insects, the pest of the entomologist; but it is readily lifted when it is desirable to add to the contents or change the location of the specimens. For the inside arrangement I have taken a strip of common tin, one inch wide, and turned up each side five-sixteenths of an inch, thus leaving three-eighths of an inch for the bottom. The length of the strip of tin, being about two inches longer than the width of the drawer, admits of each end being turned up one inch. Into this tin trough is tightly fitted a cork strip three-eighths of an inch square. The whole being covered with white paper, such as is usually used for lining drawers, conceals the inequalities of the cork and makes a fine finish. They should be made to fit neatly in the drawer, and can be readily moved about to suit large or small specimens. For *Lycænas, Pamphilas*, etc., as many as fifteen of these strips may be used in one drawer, and as few as five for *Morphos, Caligos*, etc. The upturned ends are fastened in place by using the ordinary thumb tacks that can be procured at any stationer's. The frame work of the drawers should be of white pine, well seasoned. Into this the thumb tacks are readily inserted and as easily withdrawn when a change in the position of the cork strips is needed.

Horizontal vs. vertical Arrangement of Boxes.—I have elsewhere discussed the availability of the upright *vs.* the horizontal arrangement of insect boxes.* In the case of Lepidoptera and large-bodied insects I have found the horizontal drawer or box to be preferable. If large-bodied insects are placed in a vertical position they are very liable to become loose on the pins, swing from side to side, and damage themselves and other specimens; but for the smaller insects of all orders, the vertical arrangement is quite safe and satisfactory. If the pin is slightly flattened, as described on p. 69, the danger of large specimens becoming loose is to a great extent avoided.

Lining for Insect Boxes.—The old lining of insect boxes was the ordinary sheet cork of commerce, and if a good quality of cork is procurable it will answer the purpose. A better substance, however, for the lining of insect boxes is the prepared or ground cork, which is now almost

* *American Naturalist*, Vol. XV, p. 401, 1881.

exclusively used. It is simply ground cork mixed with a small amount of glue, compressed into sheets and covered with paper. This gives a very homogenous composition, and is much better than the ordinary cork, having a more uniform and neat appearance, and admitting the insertion of the pins more freely. It may be purchased from H. Herpers, 18 Crawford street, Newark, N. J.

A less expensive substitute is paper stretched upon a frame. Prof. E. S. Morse has given in the "American Naturalist" (Vol. i, p. 156) a plan which is very neat and useful for lining boxes in a large museum, which are designed to be placed in horizontal show-cases (Fig. 120). "A box is made of the required depth, and a light frame is fitted to its interior. Upon the upper and under surfaces of this frame a sheet of white paper (drawing or log paper answers the purpose) is securely glued. The paper, having been previously damped, in drying contracts and tightens like a drum-head. The frame is then secured about one-fourth of an inch from the bottom of the box, and the pin is forced down through the thicknesses of paper, and if the bottom of the box be of soft pine, the point of the pin may be slightly forced into it. It is thus firmly held at two or three different points, and all lateral movemnts are prevented. Other advantages are secured by this arrangement besides firmness: when the box needs cleaning or fumigation, the entire collection may be removed by taking out the frame; or camphor, tobacco, or other material can be placed on the bottom of the box, and concealed from sight. The annexed figure represents a transverse section of a portion of the side and bottom of the box with the frame. A A, box; B, frame; P P, upper and under sheets of paper; C, space between lower sheets of paper and bottom of box."

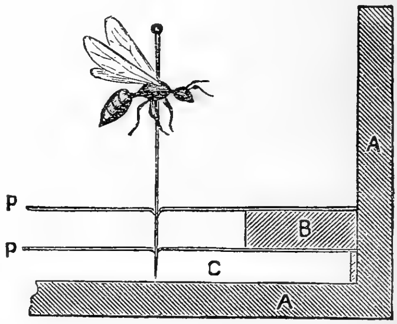

FIG. 120.—Paper lining for insect box. (After Marse.)

Other substitutes are the pith of various plants, especially of corn. Palm wood and "inodorous felt" are also used, being cut to fit the bottom of the box.

Pita wood or the light porous wood of the Agave or Century plant when cut into proper strips also makes a very light and satisfactory lining, while good close bog-peat cut into proper thicknesses is not infrequently used in France and Germany. Druce & Co., 68 Baker street, London, W., England, have lately been manufacturing what is known as cork carpet, which seems to be a combination of ground cork and rubber. It comes in various colors and of the proper thickness, and makes a very smooth and desirable lining, holding the pins very firmly.

It cost 90 cents per square yard in England, and I have had one cabinet lined with it as an experiment, as there is a probability that the pins may corrode in contact with the rubber.

ARRANGEMENT OF INSECTS IN THE CABINET.

Systematic and biologic Collections.—The permanent arrangement of specimens in boxes and drawers will vary somewhat with the nature of the insects. The almost universal custom of collectors, however, is to arrange the insects in vertical columns. In the case of the smaller forms, as Coleoptera, Hymenoptera, Diptera, 2½ to 3 inches in width is allowed for the columns; and for the larger insects, as Lepidoptera, Orthoptera, for which larger drawers are recommended, a greater width of column is needed and 4½ to 5 inches will be found necessary. With alcoholic material, a similar arrangement in columns may be followed.

In spacing or dividing insect boxes into columns for the arrangement of specimens, I have followed the plan of pinning narrow strips of colored paper in the boxes at regular distances to divide the columns of insects. A fine line made with a medium pencil will answer the same purpose and will not materially disfigure the box.

The appearance of the collection will largely depend on the care used in the alignment of the specimens, both vertically and horizontally. It is advisable to have at least four specimens of a species, which, entomologically speaking, constitute a set. The collector, however, should not limit the number of his specimens to four, as it is frequently necessary to have a larger number to represent, firstly, the sexes; secondly, varieties; and thirdly, geographical distribution.

In the systematic collection the species should be arranged serially in accordance with the latest catalogue or monograph, and if the collector intends making a complete study of the group, space should be left for the subsequent insertion of species not at present in his possession and also for new species. This will avoid the rearrangement of the entire collection at brief intervals.

Economic Displays.—In the case of economic displays, which will include pinned specimens, alcoholic material, early states and specimens illustrating the work of the insect—also the parasitic and predaceous enemies—the horizontal arrangement can be followed, and I have found it advisable, in making such displays, to arrange them in this manner, so that any needed width for the display of particular species may be had. A good idea of the system of arrangement adopted for an economic exhibit may be obtained from the accompanying illustration (Pl. I). Every insect will require a somewhat different treatment, owing to its different habit, but the plan indicated in the illustration should, in the main, be followed. Prof. J. H. Comstock uses and recommends a sort of block system, which consists in pinning the insects and specimens showing their work, and alcoholic material, to blocks of soft wood. These are then arranged in the display cases. The advantage claimed for the system is facility in transferring and rearranging the exhibits. This method is somewhat cumbersome, and in making and handling economic exhibits I have found pinning specimens directly to the cork lining of the box, as already described, to be entirely satisfactory. A biologic exhibit should be carefully planned beforehand, and when once completed is permanent and does not require rearrangement, as is frequently necessary in a systematic collection, owing to the constant changes in classification. The only alteration necessary is a renewal of specimens which have become injured, or faded by exposure to light.

Labeling Collections.—I have already fully discussed the subject of labeling insects before placing them in their final resting place in the collection. In the collection certain additional labels are required, viz, labels for the order, family, subfamily, genus, species, and sometimes variety. The label for the order should be placed above the first species in the collection, and should be in large type, as should also be the name of the family, which is to be placed above the first species in the family. The genus label should be in prominent type, somewhat smaller than the family label, and should be placed at the head of the genus. Custom varies as to placing the label of the species. In my practice I have adopted the plan of placing the label below the series of specimens representing the species. Some entomologists reverse this plan and place the label above the series of specimens. Others recommend pinning the label to the first and best-determined specimen of the series. This has the advantage of always keeping the label with the species and preventing the danger of mistake or confusion of the latter. In the case of large insects, however, this plan has the disadvantage that the label can not be seen except by taking out the specimen, and, on the whole, the plan which I have adopted of placing the label below the series of specimens is preferable, but may be supplemented by the other, as in addition to the independent label, one of the specimens should have a label pinned with it. The labels should be neatly written on blanks printed for the purpose; but a better plan, perhaps, and one which I have followed, where possible, in labeling the national collection, is to cut the names neatly from a catalogue of the insects, which will furnish all the labels from order to species, and fasten them with short, inconspicuous pins in their proper places in the collection. Where it is not desired to keep the collection as compact as possible, or where one has limited space, I would advise labeling the species, not only with the recognized name, but also with the synonyms. This requires some space, and will hardly be followed except in public collections. It is also desirable to arrange together, and label as such, the varieties of any given species. The appearance of the collection will depend largely on the uniformity of the labeling, and too much care can not be exercised in this respect.

MUSEUM PESTS, MOLD, ETC.

Unfortunately for the well-being of collections, dried insects are liable to the attacks of various museum pests, the most troublesome of which are themselves insects, but altogether out of their proper place and rôle in the general collection. Unless constant precautions are taken, the collector will discover after a few months that instead of the rare specimens with the preparations of which he has taken no little pains there remains only a series of fragmentary specimens, which a few years' neglect will reduce to little more than a mass of dust or powder. The price, then, of a good collection is eternal vigilance. Most insects, when exposed for any length of time to strong light, fade or lose color, and the only way to prevent such achromatism is to exclude the light.

Insect pests affecting collections include Psocidæ, Mites, Tineidæ, Coleoptera of the families Ptinidæ and Dermestidæ, these last being the most injurious.

The Psocidæ—degraded wingless insects already referred to in the classification (p. 24)—will find their way into the tightest boxes, but ordinarily do little if any damage, except in the case of delicate insects, such as Ephemerids, Microlepidoptera, and Microdiptera. The common forms found in collections are *Atropos divinatorius* and *Clothilla pulsatoria.* Mites or Acari are rarely troublesome in collections, though Dr. H. A. Hagen reports having found a species (probably of Tyroglyphus) with imported insects, and considers them as liable to become dangerous enemies. Tineid larvæ are rarely found in collections, and only affect the larger moths. They are not easily discovered, since they make no dust, as do most other pests. Some persons have been considerably annoyed by one of the common clothes moths, *Tineola biselliella* (Fig. 121). Dr. Hagen found that it attacked freshly collected or newly spread insects, where the spreading-boards were left uncovered, but Mr. F. M. Webster has found it injurious to the general collections at Columbus, Ohio.

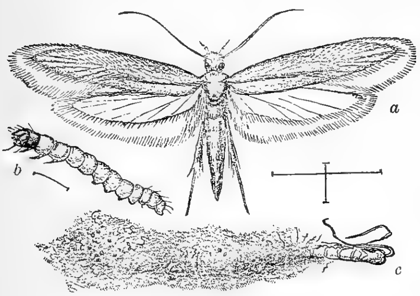

FIG. 121.—*Tineola biselliella: a*, adult; *b*, larva; *c*, cocoon and empty pupa—skin enlarged.

Of beetles, the Ptinidæ are sometimes found in collections but are not common. Two species are known to attack entomological specimens, namely, *Ptinus fur*, which is quite rare, in this country, but much more abundant in Europe, and *Tribolium ferrugineum*, a cosmopolitan species which, however, has several times been associated in injurious numbers with large collections of insects imported from the East Indies.

But by far the most dangerous enemies of insect collections are the larvæ of some half dozen or more species of Dermestidæ belonging to the genera Anthrenus, Attagenus, Trogoderma, and Dermestes. Of these *Anthrenus varius* is the more common pest, in museums, especially in the North and East. In the South and West *Trogoderma tarsale* and *T. ornatum* (?) replace Anthrenus. The European species *Anthrenus musœorum*, is, on the authority of Hagen, rare in this country, and probably occurs chiefly in collections of imported insects. It is the common injurious species of Europe. *Anthrenus scrophulariæ* (see Fig. 67) occurs also in collections, Dr. Hagen stating that he has found it nearly as common as *A. varius*, and certainly more dangerous. In my own experience it is rarely found in insect collections. Two species of Attagenus (*A. pellio* and *A. megatoma*) have also been found in collections. *A. megatoma* has been found by Dr. Hagen to do not a little damage to insect collections in Cambridge, as well as to equal if not exceed the Carpet Beetle in its disastrous attacks upon carpets and household furniture. The other species, *A. pellio*, is rarely found in this country, but is much more common and obnoxious in Europe than *A. megatoma*. *Dermestes lardarius* is sometimes found in collections, and is attracted by the presence of animal matter such as skins, etc. The two particiuliarly destructive pests, as pointed out, are *Anthrenus varius* and *Trogoderma tarsale.* These species, together with most of the others, have no definite breeding period, but, in the uniform temperature of the laboratory or museum, breed all the year round and present no definite broods. It is the experience at the Museum that the boxes on the lower tier of shelves are very much more subject to attack than those on the upper tiers, from which it would seem that the parent beetle deposits her eggs outside the boxes on the floor of the cases and that the young larvæ work their way into the smallest crevices. The danger of infection by these pests is greater in warm climates like that of Washington than in regions further north, as the warm season begins earlier, lasts longer, and furnishes better conditions for breeding and multiplication.

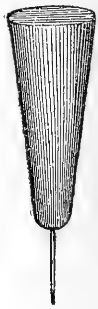

Fig. 122.—A naphthaline cone.

REMEDIES.—The following remedies and preventives will prove efficient in checking or preventing the work of these pests.

Naphthaline.—Where tight boxes are employed little fear of the work of these destructive agents need arise, especially if the boxes are kept supplied with repellent naphthaline cones. These are hard cones of naphthaline, mounted on pins for convenient placing in the boxes (see Fig. 122), and may be obtained of dealers in entomological supplies. Naphthaline cones act as repellents to these insects and also to some extent retard the development of the larvæ in all stages and particularly of the eggs.

Mr. Schwarz states (*Proc. Ent. Soc. of Washington*, Vol. I, page 63) that in place of these cones a form of naphthaline may be used which is known in commerce as "white carbon," and is put up in the form of small square rods for use in intensifying the flames of gaslight. The material is very cheap, costing only 8 cents per pound wholesale, and may be broken up into small pieces, wrapped in paper, and pinned. The use of naphthaline cones is not advisable in boxes containing delicate specimens, as it leaves a deposit which dulls the colors and encourages greasing. The deliquescence of the naphthaline cones produces a blackish, oily residuum which will soil the lining of the box, and it is always advisable either to pin a piece of blotting paper beneath the cone or to wrap this in paper.

Constant watchfulness is necessary to see that the eggs which have been deposited and checked in development by the application of this insecticide do not ultimately hatch and start a new generation in the insect box.

Bisulphide of Carbon.—If the collection is found to be infested with insect pests, it may be renovated by pouring a little bisulphide of carbon into the boxes and closing them at once. This substance evaporates rapidly and will destroy all insect life, and does not injure specimens or pins nor stain the boxes. If infested specimens are received, these should be inclosed in a tight box and treated with bisulphide of carbon before being added to the general collection, and it is always well for those who are receiving pinned specimens by exchange or otherwise to keep a quarantine box of this kind on hand.

Mercury Pellets.—The use of mercury pellets is recommended to free boxes from Mites, Psoci, etc., and also to collect any particles of dust which may gain entrance. A few small pellets of mercury, placed free in the bottom of the horizontal box will, by the movement of the box, be caused to roll to and fro and accomplish the desired end.

Carbolic Acid.—Mr. A. T. Marshall (*Entomologist's Monthly Magazine*, Dec., 1873, p. 176) records that he washes the paper of his boxes with the common disinfecting solution of carbolic acid in two-thirds water, which dries without staining and protects the specimens from Psoci.

A Means of preserving Insects in dry hot Countries.—In the "*Horæ Societatis Entomologicæ Rossicæ*," XXIV, pp. 233, 234 (1889), M. A. Wilkins, writing from Tachkent in Turkestan, alludes to the inefficiency of ordinary preservatives in Central Asia, on account of their rapid volatilization through the hot dry air, so that if a collection be neglected for only two or three months *Anthreni* are sure to be found in the boxes. He has hit upon a plan which he finds effective, and at the same time very simple. He employs India-rubber bands about 1½ inches in width and less than the length of the boxes to which they are to be applied. These bands are stretched over the opening line of the boxes, and effectually prevent the entrance of the most minute destroyers. Possibly a similar plan might be adopted in other countries with a like climate. At any rate, the method has the merit of extreme simplicity. (The *Ent. Mo. Mag.*, Apr., 1891, p. 107.)

MOLD.

Collections kept in damp places or in a moist climate are very liable to mold, and under such conditions it is difficult to avoid this evil. Carbolic acid is recommended, but Mr. Ashmead, who has kept a large collection in the moist climate of Florida, has found the use of naphthaline much more satisfactory. Mr. Herbert H. Smith who has had more extensive experience in the tropics prefers the carbolic acid. Moldy specimens may be cleansed by washing with carbolic acid applied with a fine camel's hair brush.

VERDIGRISING AND GREASING.

The action of the acid juices in the bodies of certain specimens—as many of the Lepidoptera, Coleoptera, and Diptera—will cause the formation of verdigris about the pin, which in time accumulates and disfigures and distorts the specimen, and ultimately corrodes the pin, so that the slightest touch causes it to bend or break. There is no preventive yet known for this trouble other than the use of pins which have no brass to be corroded. Japanned pins are made for this purpose, and are, on the whole, satisfactory, but they bend easily and some caution is required in handling them. In place of these pins, which are somewhat more expensive than the steel pins, iron pins may be used. These are very soft and bend too easily for satisfactory use. The steel pins may be rendered available for use by an immersion in a silver bath, which is comparatively inexpensive.

Insects the larvæ of which live in wood are particularly subject to verdigris, as the Cerambycidæ and Elateridæ in Coleoptera, the Uroceridæ in Hymenoptera and Sesiidæ in Lepidoptera. In Hymenoptera the families Formicidæ, Mutillidæ, and the endophytous Ienthredinidæ verdigris very rapidly, and most Diptera also. With all these insects japanned or silvered pins should be used, or when not too large the insects should be mounted on triangles. This verdigrising is associated with what is known as greasing, and this, as just indicated, is also associated with endophytous larval life. The verdigris may be prevented by the methods indicated, and I would strongly advise, as a good general rule to be followed, the rejection of the ordinary pins for all species which, in the larva state, are internal feeders. But there is no way of preventing greasing or decomposition of the fats of the body, which may affect a specimen years after it has been in the cabinet. If the specimen is valuable the grease may be absorbed by immersion in ether or benzine, or by a longer treatment with powdered pipe-clay or plaster of Paris. Insects collected on seabeaches, and saturated with salt water, also corrode the common steel pin very quickly and should be mounted on japanned pins. It is also advisable to rinse such specimens thoroughly in fresh water before mounting.

The conviction has been forcing itself on my mind for some time that the naphthaline cones tend to promote greasing and verdigris, and carbolic acid in some small vessel secured to the cork, were, perhaps, preferable.

THE REARING OF INSECTS.

General Directions.—The importance, even to the mere collector, of rearing insects to obtain specimens for the cabinet has been referred to from time to time in these pages. The philosophic study of entomology, however, requires much more than the mere collecting of specimens, and one of the most profitable and, at the same time, most fascinating phases of the study relates to the life-history and habits. In no branch of natural history are biologic studies more easily carried on, or the biologic facts more remarkable or interesting. The systematist by such study will be saved from the narrow and hair-splitting tendencies which study of slight difference of characters tends to, while to the economic entomologist it is most essential.

In the rearing of insects success will be attained in proportion to the extent to which the conditions of nature in the matters of temperature, moisture, food-supply, and conditions for pupation, are observed.

"In the hands of the careful breeder an insect may be secured against its numerous natural enemies and against vicissitudes of climate, and will, consequently, be more apt to mature than in a state of nature. The breeding of aquatic insects requires aquaria, and is always attended with the difficulty of furnishing a proper supply of food. The transformations of many others, both aquatic and terrestrial, can be studied only by close and careful outdoor observation. But the great majority of insect larvæ may be reared to the perfect state indoors, where their maneuverings may be constantly and conveniently watched. For the feeding of small species, glass jars and wide-mouthed bottles will be found useful. The mouths should be covered with gauze or old linen, fastened either by thread or rubber, and a few inches of moist earth at the bottom will furnish a retreat for those which enter it to transform and keep the atmosphere in a moist and fit condition.

The Breeding Cage or Vivarium.—"For larger insects I use a breeding cage or vivarium which answers the purpose admirably. It is represented in figure 123, and comprises three distinct parts: First, the bottom board *a*, consisting of a square piece of inch thick walnut with a rectangular zinc pan *ff*, 4 inches deep, fastened to it above, and with two cross pieces *gg* below, to prevent cracking or warping, facilitate lifting, and allow the air to pass underneath the cage. Second, a box *b* with three glass sides and a glass door in front, to fit over the zinc pan. Third, a cap *c*, which fits closely on to the box, and has a top of fine wire gauze. To the center of the zinc pan is soldered a zinc tube *d* just large enough to contain an ordinary quinine bottle. The zinc pan is filled with clean sifted earth or sand *e*, and the quinine bottle is for the reception of the food plant. The cage admits of abundant light and air, and also of the easy removal of excrement or frass which falls to the ground; while the insects in transforming enter the ground or attach themselves to the sides or the cap, according to their habits. The most convenient dimensions I find to be 12 inches square and 18 inches high: the cap and the door fit closely by means of rabbets, and the former has a depth of about 4 inches to admit of the largest cocoon being spun in it without touching the box on which it rests. The zinc pan might be made 6 or 8 inches deep, and the lower half filled with sand, so as to keep the whole moist for a greater length of time."

The sand or earth in the zinc pan at the bottom of the breeding cage should be kept constantly moistened, and in the case of hibernating pupæ the constant adding of water to the top of the earth or sand causes it to become very hard and compact. To overcome this objection it was suggested in the *Entomologists' Monthly Magazine* for June, 1876, page 17, that the base should be made with an inner perforated side, the water to be applied between it and the outer side, and I have for some years employed a similar double-sided base, which answers the purpose admirably (See Figure 124.). It is substantially the same as that made for the Department by Prof. J. H. Comstock in 1879. It consists of a zinc tray *a*, of two or three inches greater diameter than the breeding cage, which surrounds the zinc pan proper containing the earth, and the tube *d* for the reception of the food-plant. The lower portion of the inner pan *b* is of perforated zinc. Zinc supports, *c c*, are constructed about halfway between the bottom and the top of this pan, on which the breeding cage rests. In moistening the earth in the cage, water is poured into the tray, which enters the soil slowly, through the perforations in the zinc pan. I have found this modification of very decided advantage and use it altogether in the work of the Division, and heartily recommend it.

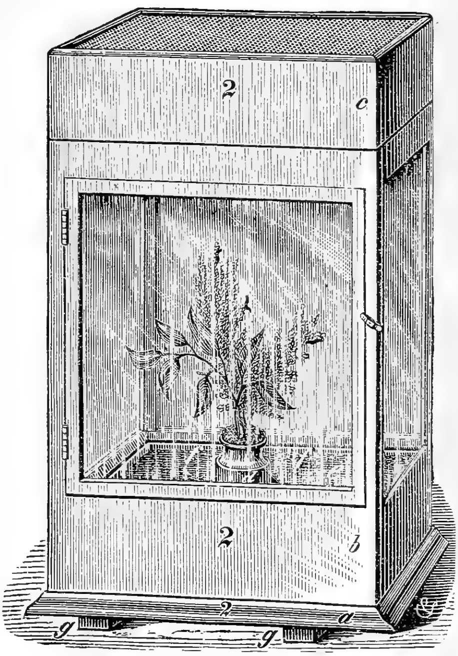

FIG. 123.—Insect breeding-cage or vivarium.

The base of the vivarium or breeding cage should never be made of tin, but always of zinc. If made of tin, it will soon rust out. Galvanized iron may be used in place of the zinc, and will doubtless prove equally satisfactory.

"A dozen such cages will furnish room for the annual breeding of a great number of species, as several having different habits and appearance, and which there is no danger of confounding, may be simultaneously fed in the same cage. I number each of the three parts of each cage to prevent misplacement and to facilitate reference, and aside from the notes made in the notebook, it will aid the memory and expedite matters to keep a short open record of the species contained in each cage, by means of slips of paper pasted on the glass door. As fast as the different specimens complete their transformations and are taken from the cage the notes may be altered or erased, or the slips wetted and removed entirely. To prevent possible confounding of the different species which enter the ground, it is well, from time to time, to sift the earth, separate the pupæ and place them in what I call 'imago cages,' used for this purpose alone and not for feeding. Here they may be arranged with references to their exact whereabouts.

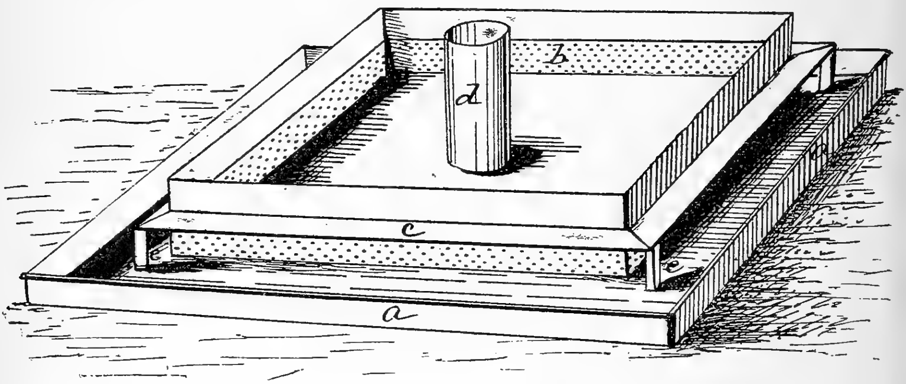

FIG. 124.—Improved base for breeding-cage (original).

"A continued supply of fresh food must be given to those insects which are feeding, and a bit of moist sponge thrust into the mouth of the bottle will prevent drowning, and furnish moisture to such as need it. By means of a broad paste brush and spoon the frass may be daily removed from the earth, which should be kept in a fit and moist condition—neither too wet nor too dry. In the winter, when insect life is dormant, the earth may be covered with a layer of clean moss, and the cages put away in the cellar, where they will need only occasional inspection, but where the moss must nevertheless be kept damp. Cages made after the same plan, but with the sides of wire gauze instead of glass, may be used for insects which do not well bear confinement indoors, the cages to be placed on a platform on the north side of a house, where they will receive only the early morning and late evening sun."

Detailed Instructions for Rearing.—In the rearing of insects every worker will develop a number of methods of value, and it is only by careful study and comparison of the experiences of all that the best system can be elaborated. For this reason I have, in what follows, quoted, in a more or less fragmentary way, the experiences of different entomologists.

As is remarked by Miss Murtfeldt, in an interesting paper read before the Entomological Club of the American Association for the Advancement of Science, August 20, 1890, "there is a great individuality, or rather specificality, in insects, and not infrequently specimens of larvæ are found for which the collector taxes his ingenuity in vain to provide. Not the freshest leaves, the cleanest swept earth, or the most well-aired cages will seem to promote their development."

The greatest care and watchfulness, therefore, are necessary to insure success in the rearing of larvæ. In many cases such larvæ can only be successfully reared by inclosing them in netting on their food-plant out of doors. It is a frequent device of Lepidopterists also to inclose a rare female in netting placed on the food plant of the species, where the male may be attracted and may be caught and placed in the bag with the female, when copulation usually takes place successfully, or a male may be caught in the field and inclosed with such female. Mr. W. H. Edwards, where the plant is a small one, uses for this purpose a headless keg covered at one end with gauze, which he places over the plant inclosing the female.

Mr. James Fletcher, of Ottawa, Canada, one of our most enthusiastic rearers of insects, has given some details of his methods in a recent very interesting account of "A Trip to Nepigon." One style of cage used by him in securing the eggs of large Lepidoptera "is made by cutting two flexible twigs from the willow or any other shrub and bending them into the shape of two arches, which are put one over the other at right angles and the ends pushed into the ground. Over the penthouse thus formed a piece of gauze is placed, and the cage is complete. The edges of the gauze may be kept down either with pegs or with earth placed upon them." This kind of cage is used for all the larger species which lay upon low plants. The species which oviposit on larger plants or trees are inclosed in a gauze bag tied over the branch. This is applicable to insects like *Papilio*, *Limenitis*, *Grapta*, etc. Care must be taken, however, that the leaves of the plant inside the net are in a natural position, for some species are very particular about where they lay their eggs, some ovipositing on the top of the leaves, others near the tip, and many others on the under surface. "When a bag made beforehand is used, the points must be rounded, and in tying the piece of gauze over the branch care must be taken to pull out all creases and folds, or the insect will be sure to get into them and either die or be killed by spiders from the outside of the bag. It is better to put more than one female in the same cage. I have frequently noticed that one specimen alone is apt to crawl about and settle on the top of the cage. and not go near the food plant. When there are two or three they disturb each other and are frequently moving and falling on the food plant, when they will stop for a moment and lay an egg. A stubborn female of *Coleus eurytheme* was only induced to lay by having a male placed in the cage with her, and by his impatient fluttering and efforts to escape she was frequently knocked down from the top, and every time she fell upon the clover plant beneath, she laid an egg before crawling to the top again." Some insects, even with all care in making their surroundings as natural as possible, will persistently refuse to lay. Mr. Fletcher has successfully obtained eggs from some of these by a method which he says one of his correspondents styles "Egg-laying extraordinary." It consists simply in "gently pressing the abdomen of a female which has died without laying eggs, until one and sometimes two perfect eggs are passed from the ovipositor." Mr. Fletcher has secured a number of eggs from rare species in this way, and successfully reared the larvæ. The following directions for obtaining the eggs and rearing the larvæ of Lepidoptera, given in this paper by Mr. Fletcher, are excellent, and I quote them entire:

"There are one or two points which should be remembered when obtaining eggs and rearing larvæ. In the first place, the females should not be left exposed to the direct rays of the sun; but it will be found sometimes that if a butterfly is sluggish, putting her in the sun for a short time will revive her and make her lay eggs. Confined females, whether over branches or potted plants, should always be in the open air. If females do not lay in two or three days they must be fed. This is easily done. Take them from the cage and hold near them a piece of sponge (or, Mr. Edwards suggests, evaporated apple), saturated with a weak solution of sugar and water. As soon as it is placed near them they will generally move their antennæ towards it, and, uncoiling their tongues, suck up the liquid. If they take no notice of it the tongue can be gently uncoiled with the tip of a pin, when they will nearly always begin to feed. It is better to feed them away from the plant they are wanted to lay upon, for if any of the sirup be spilled over the flowerpot or plant it is almost sure to attract ants. I kept one female *Colias interior* in this way for ten days before eggs were laid. When eggs are laid they should, as a rule, be collected at short intervals. They are subject to the attacks of various enemies—spiders, ants, crickets, and minute hymenopterous parasites. They may be kept easily in small boxes, but do better if not kept in too hot or dry a place. When the young caterpillars hatch they must be removed with great care to the food plant; a fine paint brush is the most convenient instrument. With small larvæ or those which it is desired to examine often, glass tubes or jelly glasses with a tight-fitting tin cover are best. These must be tightly closed and in a cool place. Light is not at all necessary, and the sun should never be allowed to shine directly upon them. If moisture gathers inside the glasses the top should be removed for a short time. Larvæ may also be placed upon growing plants. These can be planted in flowerpots and the young caterpillars kept from wandering either by a cage of wire netting or, by what I have found very satisfactory, glass lamp chimneys. These can be placed over the plant, with the bottom pushed into the earth, and then should have a loose wad of cotton batting in the top. This has the double effect of preventing too great evaporation of moisture and keeping its occupants within bounds. Some larvæ wander very much and climb with the greatest ease over glass, spinning a silken path for themselves as they go. When caterpillars are bred in the study it must not be forgotten that the air inside a house is much drier than it is out of doors amongst the trees and low herbage, where caterpillars live naturally. The amateur will require some experience in keeping the air at a right degree of moisture when breeding upon growing plants. In close tin boxes or jars, where the leaves must be changed every day, there is not so much trouble. An important thing to remember with larvæ in jars is to thoroughly wash out the jars with cold water every day. If, however, a caterpillar has spun a web on the side and is hung up to moult, it must not be disturbed. In changing the food it is better not to remove the caterpillars from the old food, but having placed a new supply in the jar, cut off the piece of leaf upon which they are and drop it into the jar. If they are not near the moult a little puff of breath will generally dislodge them. Some caterpillars, as *Papilio turnus*, which spins a platform to which it retires after feeding, can best be fed upon a living tree out of doors, but must be covered with a gauze bag to keep off enemies. A piece of paper should be kept *attached* to each breeding jar or cage, upon which regular notes must be taken *at the time*, giving the dates of every noticeable feature, particularly the dates of the moults and the changes which take place in the form and color at that time."

The necessity of outdoor work is further felt in the determination of the facts in the life-history of some insects which have an alternation of generations, as some Gall-flies (*Cynipidae*), and most Aphides. To successfully study these insects constant outdoor observation is necessary, or the species must be inclosed in screens of wire or netting outdoors on their food-plant. Many insects which breed on the ground or on low herbage may be very successfully watched and controlled by covering the soil containing them or the plant on which they feed with a wire screen or netting. The use of wire screens is also advisable in the case of wintering pupæ or larvæ out of doors. Many species can be more easily carried through the winter by placing them outdoors under such screens during the winter, which insures their being subjected to the natural conditions of climate, and then transferring them to the breeding cage again early in the spring. This is advisable in the case of Microlarvæ and pupæ. Species which bore in the stems of plants may be easily cared for and leaf-mining and leaf-webbing forms can be secured under screens or covers out of doors for the winter in sheltered situations. Many species which, if kept in a warm room can not be reared, will, if subjected to freezing weather under slight protection in the open air, emerge successfully the following spring.

The greatest care is necessary in the breeding of Tenthredinidæ, as most of them transform under ground and are single brooded, the larvae remaining in the ground from midsummer until the following spring. Nothing but constant care in maintaining uniform moisture and temperature of the soil will insure the success of such breeding. Some species bore into rotten wood or the stems of plants to undergo their transformations, as for instance the Dogwood Saw-fly (*Harpiphorus varianus*). This species, unless supplied with soft or rotten wood in which to bore, will wander ceaselessly round the cage, and in most cases eventually perish.

Where a small room can be devoted to the purpose, an excellent wholesale method of obtaining wood-boring insects (*Coleoptera, Lepidoptera*, etc.) is to collect large quantities of dead or dying wood of all sorts or any that indicates the presence of the early states of insects, and store it in such apartment. The following spring and summer the escaping insects will be attracted to the windows and may be easily secured. The objection to this method is that, in many cases, it will be impossible to determine the food-habit of the insect secured, owing to the variety of material brought together.

The Root Cage.—For the study of insects which affect the roots of plants a root cage has been devised by Prof. J. H. Comstock which is of sufficient importance to warrant full description. It consists of a zinc frame (Fig. 125*a*) holding two plates of glass in a vertical position and only a short distance apart, the space between the plates being filled with soil in which seeds are planted or small plants set. Outside of each glass is a piece of zinc or sheet iron (*b*) which slips into grooves and which can be easily removed. When these zincs are in place the soil is kept dark.

The idea of the cages is, that the space between the glasses being very narrow, a large part of the roots will ramify close to the surface of the glass, so that by removing the zinc slides the roots may be easily seen, and any root-inhabiting insects which it may be desirable to breed may thus be studied in their natural conditions without disturbing them. Prof. Comstock has used this cage very successfully in studying the habits of wire-worms, and its availability for many of the underground insects, such as the Cicadas, root-lice, larvæ, etc., is apparent. These frames may be made of various sizes, to accommodate particular insects. It will be of advantage in many cases, in order to secure the natural conditions as nearly as possible, to sink the cage in the soil, and for this purpose Prof. Comstock has had constructed a pit lined with brick for the reception of his cages, and employs a small portable crane to lift them out of the ground when it is desirable to examine them.

Other Apparatus.—Much of the breeding of insects can be done with the simplest apparatus, and for the rearing of Microlepidoptera, Gall-insects, and the keeping of cocoons and chrysalides of small species, nothing is more convenient than a medium sized test-tube, the end of which may be plugged with cotton. I have recently successfully carried over the winter the larva of *Sphecius speciosus*, which had been removed early in the fall from its earthen pod or cocoon, the larva transforming to a perfect pupa in the spring. In this case the test tube was plugged with cotton and inserted in a wooden mailing tube to exclude the light. Smaller jars with glass covers or with a covering of gauze may be employed for most insects, with the advantage of occupying comparatively little space and of isolating the species under study.

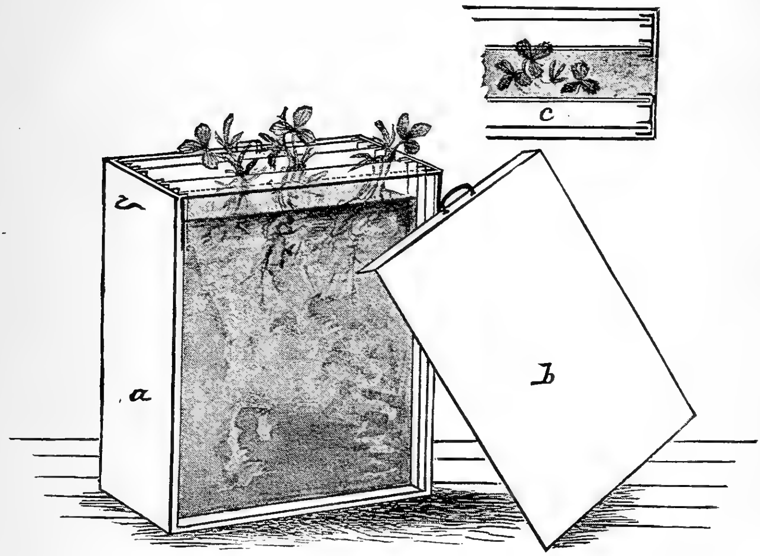

FIG. 125—Root cage: *a*, frame with slide removed; *b*, movable slide; *c*, top view (original).

Long glass tubes, open at both ends, are useful in many other ways, especially in the rearing and study of the smaller hypogean insects or those which bore and live in the stems of plants. An infested stem cut open on one side and placed in such a tube will generally carry any insect that has ceased feeding, or any species like the wood-boring bees which feed upon stored food, successfully through their transformations; while root-lice may be kept for a lengthy period upon the roots in such tube, providing a portion of the root extends outside of the tube and is kept in moistened ground or water. In all such cases these tubes, with their contents, should be kept in the dark, either in a drawer or else covered with some dark material which can be wound around or slipped over them, and the ends must be closed with cotton or cork.

The rearer of insects will frequently experience difficulty in carrying his pupæ through the winter, and, even though ordinary precautions are taken, the mortality will frequently amount to 50 per cent of the specimens. Mr. H. Bakhaus, of Leipsic, thus describes a device which is substantially the base of the vivarium shown on page 114.

"The base consists of a round plate of strong zinc, with two vertical rims, an inch high, placed one within the other, an inch apart, and soldered to the basal plate so that the outer one is water-tight. The inner rim must be perforated with small holes as close to the bottom as possible. The space inside the inner rim must be filled with fine sand, on which the pupæ should be laid. The space between the two rims is then filled with water, which, finding its way through the holes in the inner rim to the sand, causes the necessary moisture. Over the whole is put a bell-shaped cover of wire gauze, which must fit tightly over the outer rim. In this receptacle the pupæ remain untouched, and receive fresh moisture, as above indicated, if required by the drying of the sand."

The hardy pupæ of most Noctuids and Bombycids, as well as those of many Rophalocera, may be handled with little danger, but other species, if handled at all, or if the cocoons which they make for themselves are broken, can seldom be reared. Constant precautions also must be exercised in the care of the soil and the breeding cages. One of the great drawbacks is the presence of mites and thread worms (Entozoöns), etc., which affect dying or dead pupæ and larvæ in the soil. They also affect living specimens and are capable of doing very considerable damage. To free the soil of them it is necessary at times to allow the earth to become dry enough to be sifted, and then after removing the pupæ submit it to heat sufficient to destroy any undesired life there may be in it.

The Insectary.—Up to the present time the work of rearing insects has been largely confined to the breeding cage and breeding jar, already described, which have been kept in the rooms of the investigator. The advantages of having a special building for this purpose are at once apparent and need not be insisted upon. One of the best establishments of this kind is that of the Cornell University Experiment Station, which was fully described in Bulletin No. 3, of that station, November, 1888. The Kansas Experiment Station has a similar building, and one has recently been built for the use of the Entomological Division of the United States Department of Agriculture. The insect-breeding house, or insectary, should comprise a building having workrooms, or laboratories, for microscopic and general work in the study and preparation of specimens, and also a conservatory for the rearing of specimens and the growth of plants, and, where applied entomology is concerned, special rooms for the preparation and the test of insecticides. The building proper should also have a basement storage room for hibernating insects. The laboratory should be fitted with all the apparatus used in the study of insects, including microscopes and accessories and a dark-room for photographic purposes.

DIRECTIONS FOR TRANSMITTING INSECTS.

It is very desirable in transmitting insects from the field of exploration, or from one entomologist to another, for information, exchange, or other purpose, that they be properly secured and packed. Pinned and mounted specimens should be firmly fixed in a cigar box, or a special box for mailing, and this should be carefully but not too tightly wrapped with cotton or other loose packing material to a depth of perhaps an inch, and the whole then inclosed in stiff wrapping paper. It is preferable, however, to inclose the box containing the specimens in a larger box, filling the intervening space, not too firmly, with cotton or other packing material. Where specimens are to be sent to a considerable

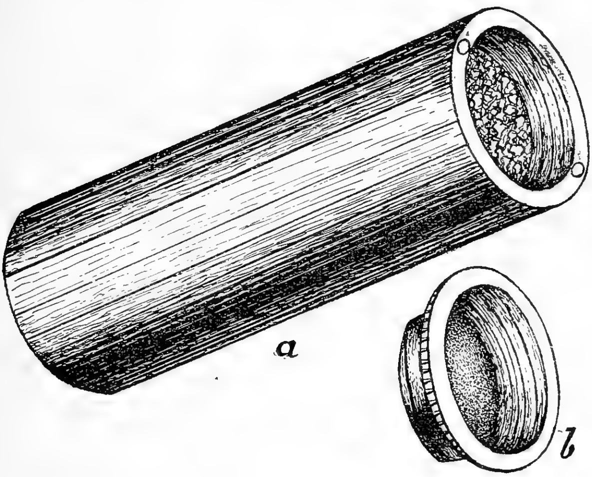

FIG. 126.—Wooden-tube mailing-box: *a*, tube; *b*, cover (original.)

distance it is advisable also to line the box in which they are placed with cotton, which serves to catch and hold any specimens which may become loose in transit. In the case of alcoholic specimens each vial should be wrapped separately in cotton and placed in a strong wooden or tin box. Special mailing boxes for alcoholic specimens have been devised, and a very convenient form is herewith figured. It is an ordinary tube of wood, with a metal screw top, and the interior lined with rough cork. These tubes are made in various sizes to accommodate vials of different dimensions.

In mailing living specimens the essential thing is a strong box, preferably tin, made as nearly air-tight as possible. I have found it very convenient on long trips to carry with me a number of tin boxes in the flat (Fig. 127), combined in convenient packages, ready to be bent and improvised in the field. For this purpose get any tinsmith to make out of good tin a number of pieces cut of the requisite dimensions both for the bottoms and the covers, carefully cutting the corners to permit the proper bending of the sides. These improvised boxes will prove useful for keeping living larvæ with their food-plants, especially if tied up in stout brown paper to prevent any exit from the unsoldered angles. They will also answer admirably for mailing or otherwise send-

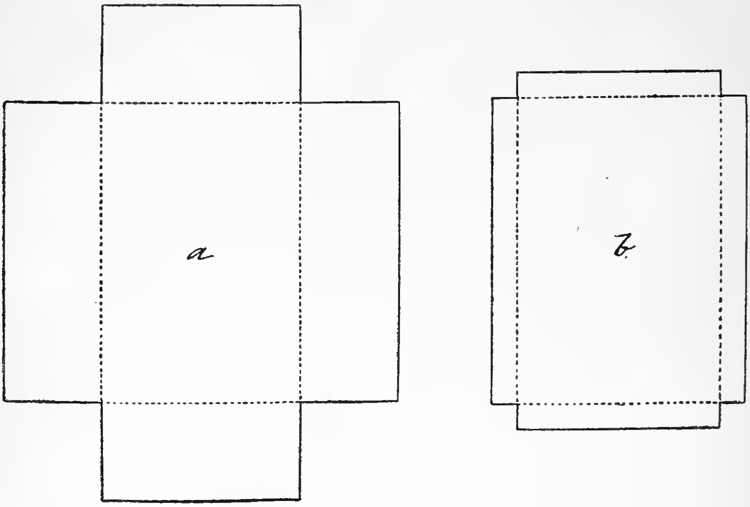

FIG. 127.—Tin mailing-box in the flat: *a*, box; *b*, cover (original).

ing specimens to their ultimate destination. In the case of larvæ a quantity of the food-plant should always be inclosed in the box.

In transmitting insects for information the greatest care should be taken to relieve the person of whom information is sought of as much unnecessary work as possible. It is easy for any beginner to collect more in a single day than an experienced entomologist can well mount, study, and determine in a week, and as those who have the means and information to give determinations or otherwise to assist beginners are generally very much occupied, and their time is valuable, they are justified in ignoring miscellaneous collectings where the sender has made no effort to either properly mount or otherwise study and care for his specimens.

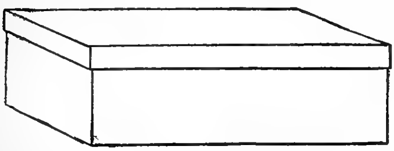

FIG. 128.—Tin mailing-box, bent into shape for use (original.)

Living specimens, especially larvæ, should be packed in tin, with a supply of their appropriate food. The tighter the box the fresher will the food as well as the specimens keep. Insects do not easily suffocate, and it is worse than useless, in the majority of cases, to punch air-holes in such boxes. Dead specimens, when not pinned, may be sent in a variety of ways. Small ones may be dropped into a quill and inclosed in a letter, or a small vial fitted into a piece of bored wood. Those which do not spoil by wetting may be sent in alcohol, provided the bottle is absolutely filled, or, what is better, in sawdust moistened with alcohol, or between layers of cotton saturated with alcohol.

The postal regulations permit the sending by mail of "dried insects * * * when properly put up, so as not to injure the persons of those handling the mails, nor soil the mail bags or their contents." Specimens in alcohol may also be sent by mail, provided that the containing vial be strong enough to resist the shock of handling in the mail, and that it be inclosed in a wooden or papier-maché tube not less than three-sixteenths of an inch thick in the thinnest part, lined with cork or other soft material, and with a screw top so adjusted as to prevent the leakage of the contents in case of breakage. Entomological specimens are of the fourth class of mail matter, the postage on which is 1 cent an ounce or fraction thereof, the limit of weight for a single package being 4 pounds, and the limit as to bulk 18 inches in any direction. Saleable matter is also non-mailable at fourth-class rates; so that the safer method, with small packages, is to send under letter postage. It is far better, however, for long journeys, and especially for transatlantic shipment, to send by express.

NOTES AND MEMORANDA.

In the foregoing pages are given some of the more useful directions for those wishing to commence to collect and study insects. Experience will soon teach many other important facts not mentioned here, and the best closing advice I can give the novice is, to get acquainted, if possible, with some one who has already had large experience. He will be very apt to find such a person pleasant and instructive company whether in the field or in the closet. One important habit, however, I wish to strongly inculcate and emphasize: The collector should never be without his memorandum or note book. More profitless work can scarcely be imagined than collecting natural-history specimens without some specific aim or object. Every observation made should be carefully recorded, and the date of capture, locality, and food-plant should always be attached to the specimens when these are mounted. More extended notes may be made in a field memorandum book carried in the pocket or in larger record books at home. For field memoranda I advise the use of a stylographic pen, as pencil is apt to rub and efface in time by the motions of the body. The larger record book is especially necessary for biologic notes. Notes on adolescent states which it is intended to rear to the imago can not be too carefully made or in too much detail. The relative size, details of ornamentation and structure, dates of moulting or transformation from one state to another—indeed, everything that pertains to the biography of the species—should be noted down, and little or nothing trusted to mere memory where exact data are so essential. Many insects, particularly dragon-flies, have brilliant coloring when fresh from the pupa, which is largely lost afterward. The time of laying and hatching of eggs, the number from a single female, the character of the eggs, general habits, records of parasites and their mode of attack—all should be entered as observed. A great many species have the most curious life histories, which can not be ascertained except by continued and persevering observation, not only in the vivarium or insectary but in the field. It is almost impossible to follow, under artificial conditions, the full life cycle of many species like the Aphididæ, or the Gall-flies, etc., which involve alternation of generations, dimorphism, heteromorphism, migration from one plant to another, and various other curious departures from the normal mode of development, without careful field study and experiment. These studies are possible only to those who are able to frequent the same localities throughout the whole year, and can hardly be carried on by the traveling naturalist or collector.

INSTRUCTIONS FOR COLLECTING AND PRESERVING ARACHNIDS AND MYRIAPODS.

The foregoing portions of this manual have dealt almost exclusively with the subject of the securing and preservation of Hexapods, but it is deemed advisable to include brief instructions for the collection and care of the near allies of the true insect, Spiders and Myriapods, the study of which will in most cases be associated with that of Hexapods.

DIRECTIONS FOR COLLECTING SPIDERS.

Apparatus.—Many of the directions and methods given in the foregoing pages for the collection of Hexapods apply also to the animals named above. Little apparatus is necessary in the collection of spiders and other Arachnids. The essentials are vials containing alcohol, an insect net, a sieve, and forceps. Narrow vials without necks are best for collecting purposes, as the corks can be more quickly inserted. They should be of different sizes, from 1 dram to 4 or 6 drams, and the alcohol used should be at least 50 per cent strong and in some cases it is advisable to use it at a strength of 70 or 80 per cent. The net may be of the same construction as that used to collect insects and is used in the same way. Some arachnologists, however, use a net of a somewhat different make, which is much stronger. The iron ring is heavier and larger than in the case of the insect net, resembling in this respect the ring of the Deyrolle net. The bag is short and the handle is fastened to both sides of the ring. This net is used for beating the leaves of trees, bushes, and grass. Dr. Marx uses a net which is already described and figured under the name of the Umbrella Net (see p. 34, Fig. 52). The sieve is the same as that described on p. 35, Fig. 54, and is used to sift the spiders from leaves and rubbish, especially during winter. A mass of leaves and other material is thrown into the sieve and then shaken, the spiders falling through on a piece of white cloth, which is spread under the sieve on the ground. Many hibernating species can be readily secured in this manner. A forceps similar to that described for the collecting of hexapods should be used to capture or pick up specimens, for if handled with the fingers they are apt to be crushed, especially the smaller forms. As soon as the collecting is finished or the vial is filled a label should be placed in this last indicating place and date of collection. Egg sacs and cocoons should be collected in pill boxes and properly labeled, and if possible the adults should be reared. Both sexes should be collected and descriptive notes or drawings made of the webs as found in nature.

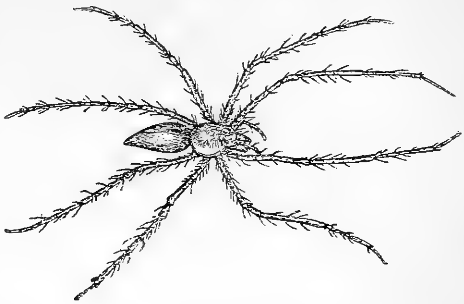

Fig. 129.—A ground Spider (*Oxyopes viridans*). (After Comstock.)

Time and Locality for Collecting.—The best time to collect spiders is in the early fall, during the months of September and October. The great majority of the species are then mature. Many forms, however, occur in the adult state in late spring and early summer. Numerous species may also be collected during winter, some of these hibernating under stones, the bark of dead trees, etc., and others, more particularly the small forms, under dead leaves and rubbish on the ground in woods. Other species which have hibernated may be found about the earliest flowers in spring. No particular localities can be indicated for the collection of spiders, since they occur in all sorts of places, in wooded or open regions and also in and about dwellings. Many Lycosidæ are found in dry and rocky situations and quite a number in open fields. Thomisidæ may be found on flowers. The Therididæ affect shady places, and many Epeiridæ will be found in similar situations. The Attidæ love the sun and are found very actively engaged in hunting insects on plants and dead leaves. Many species of this family will be found in cases under loose bark in winter. Evergreen trees are also quite good collecting grounds for Attidæ. The Drassidæ are ground spiders and are mostly nocturnal, hiding during the day under leaves and stones; a few forms,

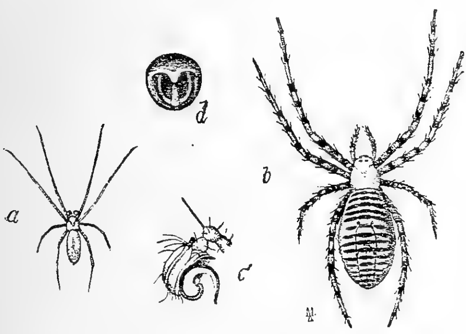

Fig. 130.—An orb-weaver (*Argiope argyraspides* Walck): *a*, male; *b*, female; *c* and *d*, enlarged parts.

however, disport in the hottest sunshine. Some genera are found most frequently near water or in damp places, as Dolomedes and Tetragnatha; others in sandy places, as Micaria, Targalia.

COLLECTING OTHER ARACHNIDS: MITES, TICKS, SCORPIONS, ETC.

Other Arachnids—as mites, ticks, scorpions, daddy longlegs or harvest-men—may be collected in the same way as spiders.

The Phalangidæ (Harvest-men) somewhat resemble spiders, and are at once recognized by their extremely long legs. They occur about houses, especially in shady places, under the eaves, etc., and in the woods and fields. They are carnivorous and feed on small insects, especially Aphides. They should be pressed a little when captured to extrude the genital apparatus, if possible, and are best collected in the early fall.

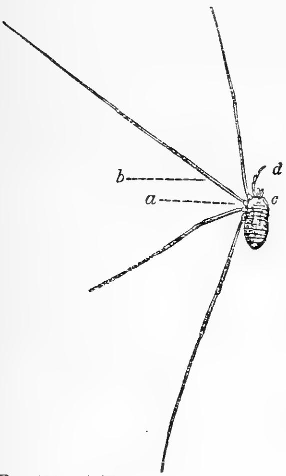

FIG. 131.—A Harvest-man (*Phalangium ventricosum*).—From Packard.

The Phrynidæ are very peculiar looking animals, the anterior legs being very long and slender and the maxillary palpi very large. The genus *Thelyphonus* is not uncommon in the South, and is known by its oblong body, ending usually with a long, slender, many-jointed filament, from which they are called Whip-tailed Scorpions. *T. giganteus* is the common species. They occur in moist situations, and are carnivorous, feeding on insects and small animals.

The false scorpions, Chermetidæ, may at once be recognized by their large maxillary palpi, resembling the maxillæ of the true scorpion. They are small insects, rarely exceeding a quarter of an inch in length, and are found in dark shady places and feed upon mites, Psoci, and other small insects. A common species is represented at figure 132.

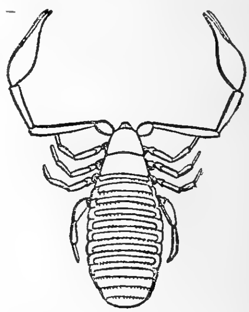

FIG. 132.—False Scorpion (*Chelifer cancroides* L.).—From Packard.

The true scorpions, Scorpionidæ, are well-known forms, and are easily recognized by their large, powerful, forceps-like maxillæ, and the long slender tail continuous with the thorax and ending with a sting, which is, in most cases, quite poisonous. They are found mostly in the Western and Southwestern States, and are dangerous in proportion to their size. The poisonous nature of the sting of these animals is, however, generally overrated, and the wounds, even of the larger species, are rarely fatal.

The Acarina or true mites are the lowest representatives of the Arachnida and include many genera and species differing very widely in habit and characters. Some of them are mere sacs, on which the mouth parts or other organs are scarcely discernible. In general they resemble spiders. The young, however, when they leave the egg, almost invariably have but three pairs of feet, resembling in this respect the Hexapods. The fourth pair is added in the later stages. They are parasitic on insects and other animals, and some of them are vegetable feeders or live in decaying vegetable and animal matter.

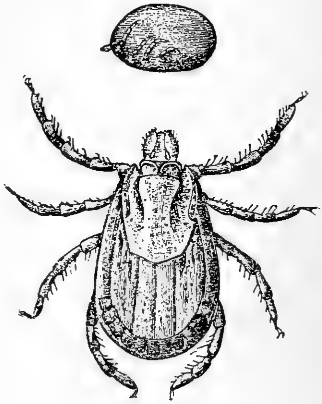

FIG. 134.—The Cattle-tick. (After Packard.)

A very interesting group is comprised in the family Phytoptidæ or gall-making mites which occur on the leaves of various trees and shrubs and produce curious galls or abnormal growths. These mites are elongate in form, have rudimentary mouth-parts and but four legs. A common form, *Phytoptus quadripes*, produces a gall on the leaves of the soft maple. The galls of all species should be collected and pinned and also preserved in alcohol, and specimens of the mites should be mounted in balsam.

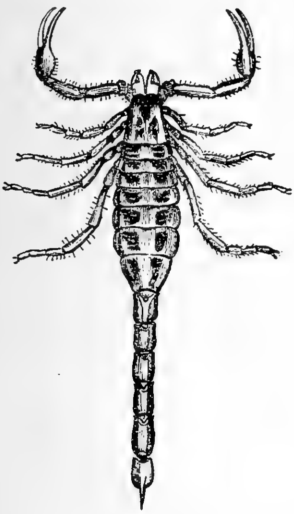

FIG. 133.—A true Scorpion (*Buthus carolinianus*).—From Packard.

The members of the genus Sarcoptes are very minute and are the active source of the itch in the lower animals and man. Another common genus is Tyroglyphus, which includes the common cheese mite, *T. siro.* Other species of this genus also sometimes occur in enormous numbers in grocers' supplies. Still others are parasitic on insects, and one species, *T. phylloxeræ* Riley, is very beneficial, since, as its name indicates, it feeds on the Phylloxera of the grapevine.

The Ixodidæ comprise the ticks which attach themselves to cattle, hogs, and man, and are not at all uncommon objects. These insects can be found on the animals they infest, and distinct species will be found to occur on most wild mammals. The common Cattle-tick *Boophilus bovis* Riley, is represented at Fig. 134.

The family Orobatidæ includes a number of small terrestrial mites, which occur on the moss on trees and stones. Some species are known to feed on the eggs of insects, and the one shown in the accompanying figure, *Nothrus ovivorus* has been observed by Dr. Packard to eat the eggs of the Canker Worm.

The members of the family Gamasidæ are parasitic upon animals, but chiefly upon insects. The Hydrachnidæ are parasitic also upon the aquatic insects, and also affect fish or mussels or occur on fresh-water plants.

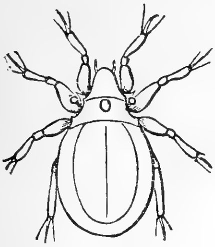

FIG. 135.—*Nothrus ovivorus* Packard.

One of the most important families of mites is the Trombidiidiæ which includes a large number of species, some of which occur in immense numbers. Most of them are vegetable feeders, but some species feed on the eggs of insects.

The genus Trombidium includes a number of the Red Mites which feed on insects in all their stages. The Locust Mite, *Trombidium locustarum* Riley, is one of the most interesting as well as one of the most important of our locust enemies, and will serve to illustrate the habits of the group. It differs so much in infancy and maturity that it has been referred to different genera and is known under different names. The mature form lives on the ground and feeds on all sorts of animal or decomposing vegetable matter, and wherever the ground is filled with locust eggs these afford an abundance of food and the mites flourish and multiply rapidly. In the spring the female lays 300 or 400

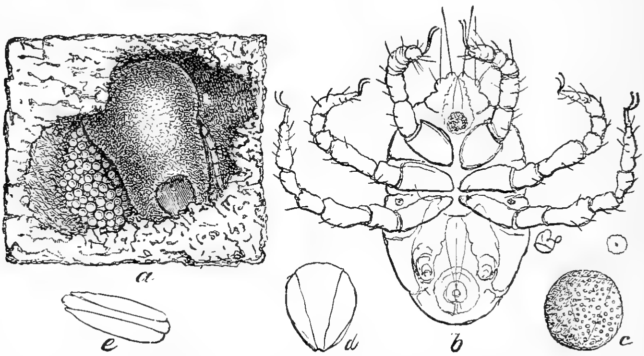

FIG. 136.—*Trombidium locustarum*: *a*, female with her batch of eggs; *b*, newly hatched larva—natural size indicated by the dot within the circle; *c*, egg; *d e*, vacated egg-shells.

minute spherical orange-red eggs in the ground (Fig. 136*a*). From these eggs, as shown enlarged at *c*, *d*, and *e* (the two latter being the vacated egg shells) emerge the six-legged larva shown at *b*. These are mere specks and crawl actively about, fastening themselves to the locusts mostly at the base of the wings or along the upper veins. They subsist on the juices of their host. They firmly attach themselves by the mouth and increase rapidly in size, the legs not growing and becoming mere rudiments. In this form they are shown at Fig. 137*a*. When fully developed they let go their hold, drop to the ground, and crawl under the shelter afforded by holes in the earth or under sticks. Here, in the course of two or three weeks, they transform within the

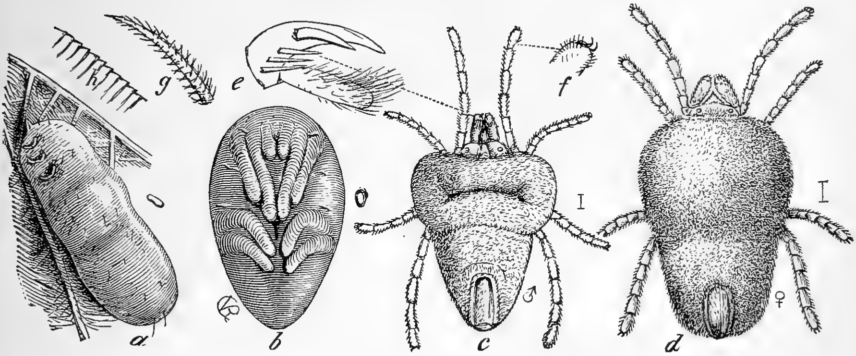

FIG. 137.—*Trombidium locustarum*. *a*, mature larva when about to leave the wing of a locust; *b*, pupa; *c*, male adult when just from the pupa; *d*, female—the natural sizes indicated to the right; *e*, palpal claw and thumb; *f*, pedal claw; *g*, one of the barbed hairs; *h*, the striations on the larval skin.

larval skin to the pupal stage shown at *b*, and eventually break through the old larval skin and escape in the form shown at *c* and *d*. This mature form passes the winter in the ground and is active whenever the temperature is a few degrees above the freezing point. A larger species *T. giganteum* Riley, also attacks locusts, while a third species attacks the common House-fly. This was formerly known in the larva state only and was referred to the genus Astoma, to which also the larval form of Trombidium was referred. I have described the adult together with the larva and pupa as *Trombidium muscarum*. An allied mite, *Hydrachna belostomæ*, attacks the large aquatic water bug, Belostoma, and has a mode of development precisely similar to that of Trombidium.

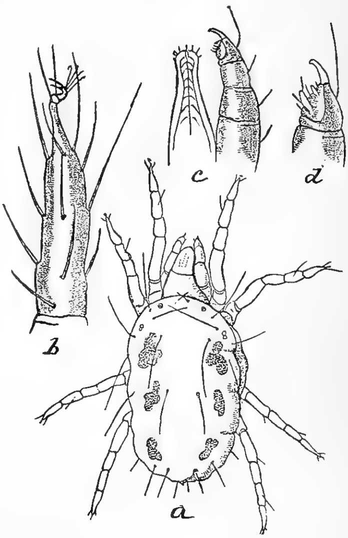

FIG. 138.—The Six-spotted Mite of the Orange (*Tetranychus 6-maculatus*): *a*, from above—enlarged; *b* tarsus; *c*, rostrum and palpus—still more enlarged; *d*, tip of palpus—still more enlarged.

To this family also belong the common greenhouse mite, *Tetranychus telarius*, and also the Bryobia mite, *B. pratensis*, which of late years has attracted very considerable attention by its appearance in immense numbers about dwellings, coming from the adjoining fields of clover or grass. Generically allied to the greenhouse mite is the Six-spotted Mite of the Orange (*T. 6-maculatus* Riley), which is shown in the accompanying figure.

Spiders and mites thus collected may be transferred to alcohol. Dr. Marx, who has had a very considerable experience in the preservation of spiders, recommends the use of the following mixture: Glycerin and Wickersheim's fluid, 1½ ounces of each, and distilled water 3 ounces, the whole to be shaken and thoroughly mixed and added to 30 ounces of 95 per cent alcohol. Alcohol which has previously been used for preserving spiders, and which has therefore dissolved some of the fatty matters from the specimens, he prefers to pure alcohol, using with this, however, somewhat less of the distilled water. The liquid thus composed answers all demands and keeps the specimens flexible and preserves their coloring. Should the stopper become loose and the liquid evaporate, there is always sufficient liquid, water or glycerine, left in the vial to keep the specimens from drying and thus save them from destruction. Dr. Marx also prefers to use cork stoppers rather than the rubber stoppers recommended for other alcoholic material. His objection to the rubber stopper is that, in a collection in which the specimens are often used and the stoppers are frequently removed, he finds that small particles of the rubber stopper come off and settle upon the specimens as a white dust, which it is difficult to remove. This objection applies only to a poor quality of rubber, and in all other respects the rubber is much to be preferred. The colors of spiders are apt to fade somewhat if exposed to light, and the collection should therefore be kept in closed boxes or in the dark.

COLLECTING MYRIAPODA.

Centipedes and Millipedes are collected in the same manner as spiders. They live in damp places, under sticks and stones, and in decaying vegetation. They should be preserved in alcohol, and on account of their usually strong chitinous covering, precautions as to the strength of the alcohol are less necessary here than with softer-bodied specimens.

The members of this subclass comprise a number of well-marked groups. The Iulidæ are cylindrical insects and occur in moist places, as do most of the representatives of this subclass. A common form is represented in the accompanying figure. The Chiliopodæ comprise the flattened forms having many-jointed antennæ and but a single pair of limbs to each segment of the body, and are the forms to which the name centipede may properly be applied. They are predaceous in habit, live largely on living animal matter, and are very quick in their movements. Some forms are poisonous, having poison glands at the base of the first pair of legs, but the majority of the species are

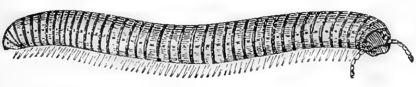

FIG. 139.—A Milliped (*Cambula annulata*).

entirely harmless. A number of common species belong to the genus Geophilus and occur under stones and logs. The genus Scolopendra includes some of the larger species of the order. The largest known species, *S. gigantea*, occurs in the East Indies and attains a length of from 9 inches to more than a foot. Several species found within the limits of the United States attain a length of 5 inches or more. The family Cermatiidæ includes the very common species *Cermatia forceps*, which, while abundant in the South and West, occurs somewhat more rarely in the North. It is commonly found in moist situations, in houses or conservatories, and on account of its long legs and agile movements frequently creates considerable consternation. It is, however, an entirely harmless and very beneficial species, since it feeds on various household pests, including flies, roaches, etc.

TEXT BOOKS—ENTOMOLOGICAL WORKS.

Bulletin No. 19 of the Division of Entomology, U. S. Department of Agriculture, contains an enumeration of the published synoposes, catalogues, and lists of North American insects, together with other information intended to assist the student of American entomology. This can be had upon application, and I would refer the student to it for specific information as to synopses, catalogues, and lists. I have deemed it advisable, however, to include here an enumeration of the more useful works of a general character; a list of the entomological periodicals, both home and foreign; and the entomological works published by the different departments of the Government, with some information as to how and of whom they can be obtained. Many of these publications are no longer to be had except as they may be picked up through book-dealers; but the titles even of those which are out of print will be useful to the student as a guide to what he should find in every good library. Requests for this kind of information are constantly received at the Department of Agriculture and at the National Museum. The most useful general works are given first, and, while a great many others in foreign languages might be cited, I would strongly advise the beginner in America to confine himself to these, and especially to read Harris's Insects Injurious to Vegetation, Kirby & Spence's Introduction, and Westwood's Introduction. This last, though published over half a century ago, is still one of the most useful entomological works in the English language. While these Introductions will be of great service in arranging and classifying material and in giving a knowledge of the relationships of species, there is no better text-book than the great book of nature, which is always ready to unfold its truths to every earnest inquirer. In field and wood alone can he become familiar with the insects in all their wondrous life habits, instincts, and intelligence. There alone will he receive the fullest inspiration and pleasure in his work or find the highest reward for his efforts.

COMPREHENSIVE WORKS MOST USEFUL FOR THE STUDY OF NORTH AMERICAN INSECTS.

H. C. C. BURMEISTER.—Handbuch der Entomologie. Berlin, 1832–1855. 5 vols.

MANUAL OF ENTOMOLOGY.—A translation of the above, by W. E. Shuckard. London, 1836.

J. O. WESTWOOD.—An introduction to the modern classification of insects, founded on the natural habits and corresponding organization of the different families. 2 vols. London, 1839–'40.

THOMAS SAY.—Complete writings on the Entomology of North America; edited by John L. Le Conte. New York, 1859.

H. A. HAGEN.—Bibliotheca Entomologica. Die Litteratur über das ganze Gebiet der Entomologie bis zum Jahre 1862. Leipzig, 1862.

A. S. PACKARD.—Guide to the Study of Insects. Henry Holt & Co., Philadelphia and New York. (First edition, Salem, 1869.)

——— Entomology for Beginners. Henry Holt & Co., New York, 1888.

THE STANDARD NATURAL HISTORY.—Edited by John Sterling Kingsley. S. E. Cassino & Co., Boston, 1884–'85.

Volume II contains the insects, which are treated by the following authors: *Hymenoptera*, J. H. Comstock and L. O. Howard; *Coleoptera*, George Dimmock; *Lepidoptera*, H'y Edwards and C. H. Fernald; *Diptera*, S. W. Williston; *Orthoptera*, C. V. Riley; *Hemiptera*, P. R. Uhler; *Neuroptera*, A. S. Packard; *Arachnida*, J. H. Emerton.

J. H. COMSTOCK.—An Introduction to Entomology. Published by the author. Ithaca, N. Y. 2 parts. Part I, 1888.

ALPHEUS HYATT AND J. M. ARMS.—Guides for Science Teaching, No. III. Insecta. Bos. Soc. Nat. Hist. D. C. Heath & Co., Boston, 1890.

GENERAL WORKS ON CLASSIFICATION.

HYMENOPTERA.

E. T. CRESSON.—Synopsis of the Families and Genera of the Hymenoptera of America, north of Mexico, together with a Catalogue of the described Species and Bibliography. Transactions Am. Entom. Society, Supplementary volume. 2 parts. Philadelphia, 1887.

COLEOPTERA.

JOHN L. LE CONTE AND GEORGE H. HORN.—Classification of the Coleoptera of North America. Prepared for the Smithsonian Institution. Washington, Smithsonian Institution, 1883.

This is the most recent and the only complete classification of North American Coleoptera. It contains also Appendix II, a "list of bibliographical references to memoirs, in which more or less complete synopses of the families, genera, and species of the Coleoptera of the United States have been published."

J. T. LACORDAIRE.—Histoire naturelle des Insectes. Genera des Coléoptères, ou exposé méthodique et critique de tous les genres proposés jusqu'ici dans cet ordre d'insectes. [Completed by J. Chapuis.] Paris, France, 1854–1876. 12 vols. and 1 vol. plates.

*WILLIAM LE BARON.—Outlines of Entomology, published in connection with the author's Annual Reports upon injurious insects. Part first. Including the Order of Coleoptera. Fourth Annual Report on the Noxious and Beneficial Insects of the State of Illinois. Sep. Edit. Springfield, 1874.

LEPIDOPTERA.

G. A. W. HERRICH-SCHAEFFER.—Sammlung neuer oder wenig bekannter aussereuropäischer Schmetterlinge. Vol. I. Regensburg, 1850–'58; Vol. II, Pt. 1, 1869.

Contains a classification of the Lepidoptera, which forms the basis of our present arrangement.

JOHN G. MORRIS.—Synopsis of the described Lepidoptera of North America. Part I. Diurnal and Crepuscular Lepidoptera. Washington, Smithsonian Institution, 1862.

Compiled descriptions of the North American Lepidoptera, from the Rhopalocera to the Bombycidæ.

H. STRECKER.—Lepidoptera, Rhopaloceres et Heteroceres, indigenous and exotic; with descriptions and colored illustrations. Reading, Pa., 1872–'77.

Fifteen parts of this work have been published containing figures and descriptions of many North American species.

JOHN B. SMITH.—An Introduction to a Classification of the North American Lepidoptera. <Bull. Brookl. Ent. Soc., Vol. VII, 1884, pp. 70–74 and 81–83.

A synopsis of the families of Lepidoptera based on Herrich-Schaeffer's classification.

——— Synopsis of the Genera of the North American Rhopalocera. <Bull. Brookl. Ent. Soc., Vol. VI, 1883, pp. 37–45.

E. DOUBLEDAY AND W. C. HEWITSON.—The genera of diurnal Lepidoptera, comprising their generic characters, a notice of their transformations, and a catalogue of the species of each genius; illustrated, with 86 colored plates from drawings by W. C. Hewitson. 2 vols., London, 1846–'52.

This work was completed by Westwood after the death of Doubleday.

S. H. SCUDDER.—Butterflies: Their structures, changes, and life-histories, with special reference to American forms. Being an application of the "Doctrine of descent" to the study of Butterflies, with an appendix of practical instructions. 321 pp. and 201 text figs. New York, Henry Holt & Co., 1881.

——— The Butterflies of the Eastern United States and Canada with special reference to New England. 3 vols., Cambridge, Mass., 1889; pp. 1958, plates 59. (Published by the author. Cost about $75 for 3 vols.)

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*Out of print.

G. H. FRENCH.—The Butterflies of the Eastern United States. For the use of classes in Zoölogy and private students. Philadelphia, Lippincott & Co., 1886.

Gives synopses of the genera and species, and description of the species.

W. H. EDWARDS.—Butterflies of North America. Boston, Houghton, Mifflin & Co.

Two volumes are completed and the third is in course of publication.

HEMIPTERA.

HERBERT OSBORN.—Classification of Hemiptera. <Entomologica Amer., Vol. I, 1885, pp. 21–27.

Short characterization of the whole order, with tables of suborders and families.

——— Pediculi and Mallophaga affecting Man and the Lower Animals. Constituting Bulletin No. 7 of the Division of Entomology, U. S. Department of Agriculture. Washington, 1891.

P. R. UHLER.—List of Hemiptera of the region west of the Mississippi River, including those collected during the Hayden explorations of 1873. <Bull. U. S. Geolog. and Geogr. Survey of the Terr., Vol. I, 1875, pp. 267–361, Pl. XIX–XXI.

——— Report upon the insects collected by P. R. Uhler during the exploration of 1875, including monographs of the families Cynidæ and Saldæ, and the Hemiptera collected by A. S. Packard, jr., M. D. <U. S. Geolog. and Geogr. Survey, Bulletin, Vol. III, No. 2, 1877, pp. 355–475.

TOWNEND GLOVER.—Report of the Entomologist. <Report of the Commissioner of Agriculture for the year 1877, pp. 17–46.

A popular treatise on the Homoptera, with illustrations.

A. H. HALIDAY.—An Epitome of the British genera in the Order Thysanoptera, with indications of a few of the species. <Entomol. Mag., Vol. III, 1836, pp. 439–451.

DIPTERA.

H. LOEW AND C. R. OSTEN-SACKEN.—Monographs of the Diptera of North America. (Smithsonian Miscellaneous Collections.) 4 parts. Washington, Smithsonian Institution, 1862–'72.

The several monographs will be found enumerated under the respective families.

H. LOEW.—Diptera Americæ septentrionalis indigena. 2 parts. Berlin, 1861–'72. (Originally published in 10 centuriæ in the Berliner Entomol. Zeitschrift.)

Descriptions of 1,000 North American Diptera, but without synoptic arrangement.

C. R. OSTEN-SACKEN.—Western Diptera: Descriptions of new genera and species of Diptera from the region west of the Mississippi and especially from California. <Bull. U. S. Geolog. and Geogr. Survey of the Territories, Vol. III, 1877, pp. 189–354.

F. BRAUER.—Die Zweiflügler des Kaiserlichen Museums zu Wien. I–III. Wien, 1880–'83.

Important contributions to the classification of the Diptera.

ORTHOPTERA.

HENRI DE SAUSSURE.—Orthoptera nova Americana (Diagnoses præliminares). Series I–III. <Revue et Mag. de Zool., 1859–'61.

Contains synoptical tables of species, besides descriptions of numerous North American Orthoptera.

SAMUEL H. SCUDDER.—Materials for a monograph of the North American Orthoptera. <Boston Journal of Nat. Hist., Vol. VII, 1862, pp. 409–480.

Contains synoptical tables and a review of the system used for classification.

———Remarks upon the arrangement of the families of Orthoptera. <Proc. Boston Soc. Nat. Hist., Vol. XII, 1868–'69; also separate under the title: Entomological Notes, Vol. II, pp. 7–14.

———Synoptical tables for determining North American insects. Orthoptera. <Psyche, Vol. I, 1876, pp. 169–171.

Synopsis of families; also list of useful works in the study of North American Orthoptera.

NEUROPTERA.

HERMANN HAGEN.—Synopsis of the Neuroptera of North America, with a list of the South American species. Smithsonian Miscellaneous Collections, Washington, 1861.

———Synopsis of the Odonata of America. <Proc. Boston Soc. Nat. Hist., Vol. XVIII, 1875, pp. 20–96.

SIR JOHN LUBBOCK.—Monograph of the Collembola and Thysanura. London, Ray Society, 1873.

The introduction gives the full bibliography up to date.

MYRIAPODA.

THOMAS SAY.—Descriptions of the Myriapoda of the United States. <Journ. Ac. Nat. Sc. Phil., Vol. II, 1821, pp. 102–114; Say's Entom. Writings, ed. Le Conte, Vol. II, pp. 24–32.

This is the first paper of importance on the North American Myriapoda.

GEORGE NEWPORT.—Monograph of the class Myriapoda, Order Chilopoda. <Trans. Linnean Soc. of London, Vol. XIX, 1845, pp. 265–302 and 349–439.

HORATIO C. WOOD, JR.—On the Chilopoda of North America, with Catalogue of all the specimens in the collection of the Smithsonian Institution. <Journ. Ac. Nat. Sc. Phil., New Ser., Vol. V, 1863, pp. 5–42.

———The Myriapoda of North America. <Trans. Amer. Philos Soc., Vol. XIII, 1865, pp. 137–248, 3 pl.

This is the first and only monograph of the Myriapoda published in this country.

ROBERT LATZEL.—Die Myriapoden der Oesterreichisch-Ungarischen Monarchie. Erste Hälfte: Die Chilopoden, Wien, 1880. Zweite Hälfte: Die Symphylen, Pauropoden und Diplopoden, Wien, 1884.

The most recent comprehensive work on this order, and very important from a classificatory standpoint.

LUCIEN M. UNDERWOOD.—The North American Myriapoda. <Entomol. Amer., Vol. I, 1885, pp. 141–151.

A complete bibliographical review of the subject, with tables of families and genera.

ARACHNIDA.

N. M. HENTZ.—Descriptions and figures of the Araneides of the United States. <Journ. Boston Soc. Nat. Hist., Vols. IV–VI, 1842–'50.

These papers form the basis of the study of American arachnology. Numerous species are described, but not in synoptic form.

T. THORELL.—On European Spiders. Part I. Review of the European genera of Spiders. Upsala, 1869–'70.

N. M. HENTZ.—Araneæ Americæ septentrionalis. The Spiders of the United States. Edited by J. H. Emerton and E. Burgess. <"Occasional Papers" of the Boston Society of Natural History, 1875.

A reprint of Hentz's papers on North American spiders.

GRAF EUGEN KEYSERLING.—Amerikanische Spinnen aus den Familien Pholcoidæ, Scytodoidæ und Dysderoidæ. <Verh. k. k. zool.-bot. Ges. in Wien, Vol. XXVII, 1877, pp. 205–234.

———Neue Spinnen aus Amerika. (Six parts.) <Verh. k. k. Zool.-bot. Ges. in Wien, Vols. XXIX–XXXIV, 1879–'84.

E. SIMON.—Les Arachnides de France. Paris, Vols. I–V, 1874–'84.

These two works represent the most recent systems of classification, and are therefore of great general value, although they deal only with the European fauna.

LUCIEN M. UNDERWOOD.—The Progress of Arachnology in America. <Amer. Natur., Vol. XXI, 1887, pp. 963–975.

A very useful review of the bibliography, with synoptic table of the families of the Araneæ.

AMERICAN PERIODICALS.

THE AMERICAN NATURALIST. A monthly journal devoted to the natural sciences in their widest sense (24 volumes published up to date. Now published at Philadelphia).

*ANNALS OF THE LYCEUM OF NATURAL HISTORY OF NEW YORK (8 volumes, 1824–'67. Continued since 1876 as Annals of the New York Academy of Sciences).

*BULLETIN OF THE BROOKLYN ENTOMOLOGICAL SOCIETY (7 volumes, 1878–'85. Continued as Entomologica Americana).

BULLETIN OF THE BUFFALO SOCIETY OF NATURAL HISTORY (4 volumes completed; 1874 to 1883.

BULLETINS OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES, F. V. Hayden in charge (Department of the Interior; 1875 to 1879.

* Publication discontinued.

BULLETINS OF THE UNITED STATES GEOLOGICAL SURVEY, J. M. Powell, director; beginning with 1883.

BULLETINS OF THE UNITED STATES NATIONAL MUSEUM (Department of the Interior; beginning with 1875).

THE CANADIAN ENTOMOLOGIST. (Published by the Entomological Society of Ontario; 22 volumes issued up to the end of 1890. Published at London, Ontario.)

*ENTOMOLOGICA AMERICANA. (Published by the Brooklyn Entomological Society at Brooklyn, N. Y. 1885 to 1890.)

ENTOMOLOGICAL NEWS [and Proceedings of the Entomological Section of the Academy of Natural Sciences] (Vol. I issued in 1890. Published at Philadelphia).

JOURNAL OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA (commencing with 1817).

MEMOIRS OF THE BOSTON SOCIETY OF NATURAL HISTORY (commencing with 1866).

*NORTH AMERICAN ENTOMOLOGIST. (Published by the Buffalo Society of Natural Sciences, 1 volume, Buffalo, N. Y. 1879–'80.)

*PAPILIO. Devoted exclusively to Lepidoptera. Organ of the New York Entomological Club (4 volumes, 1881–'84).

PSYCHE. Organ of the Cambridge Entomological Club (5 volumes issued up to date. Published at Cambridge, Mass. Publication begun in 1874).

PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA (beginning with 1841).

PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY OF PHILADELPHIA (beginning with 1860).

PROCEEDINGS OF THE BOSTON SOCIETY OF NATURAL HISTORY (commencing with 1841).

*PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF PHILADELPHIA (6 volumes, 1861–'67).

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF WASHINGTON (2 volumes, beginning with 1884).

PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM (Department of the Interior; beginning with 1878).

REPORTS OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES (Department of the Interior; beginning with 1867).

SMITHSONIAN MISCELLANEOUS COLLECTIONS (Smithsonian Institution, Washington, D. C.; beginning 1862).

TRANSACTIONS OF THE ACADEMY OF SCIENCE OF ST. LOUIS (4 volumes hitherto published).

TRANSACTIONS OF THE AMERICAN ENTOMOLOGICAL SOCIETY and Proceedings of the Entomological Section of the Academy of Natural Sciences (beginning with 1868; published at Philadelphia).

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*Publication discontinued.

TRANSACTIONS OF THE AMERICAN PHILOSOPHICAL SOCIETY OF PHILADELPHIA (2d series beginning with 1818).

Papers on entomology are also published occasionally in other American periodicals, among which the following might be mentioned:

JOURNAL OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY. Chapel Hill, N. C.

JOURNAL OF THE NEW YORK MICROSCOPICAL SOCIETY.

NATURALISTE CANADIEN. Edited by Abbé Provancher, Cap Rouge, Quebec.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES, San Francisco, Cal.

FOREIGN PERIODICALS.

ANNALES DE LA SOCIÉTÉ ENTOMOLOGIQUE DE BELGIQUE. Publication begun in 1857. Brussels.

ANNALES DE LA SOCIÉTÉ ENTOMOLOGIQUE DE FRANCE. Publication begun in 1832. Paris.

* BERLINER ENTOMOLOGISCHE ZEITSCHRIFT. 18 volumes, Berlin, 1857–1874.

Succeeded by the Deutsche Entomologische Zeitung.

BULLETIN DE LA SOCIÉTÉ ENTOMOLOGIQUE DE FRANCE.

BULLETIN DE LA SOCIÉTÉ ENTOMOLOGIQUE SUISSE. (See Mittheil d. Schweiz. Entom. Gesell.)

BULLETINO DELLA SOCIETÀ ENTOMOLOGICA ITALIANA. Florence. (Publication commenced in 1869.)

DEUTSCHE ENTOMOLOGISCHE ZEITSCHRIFT. Published by the Entomological Society of Berlin. (Publication begun in 1875.)

ENTOMOLOGISCHE NACHRICHTEN. (Now edited by Dr. F. Karsch. Berlin. Publication commenced in 1875.)

ENTOMOLOGISK TIDSKRIFT, PÅ FÖRANSTALTANDE AF ENTOMOLOGISKA FÖRENINGEN I STOCKHOLM. (Commenced with 1880.)

* ENTOMOLOGISCHE ZEITUNG. HERAUSGEGEBEN VON DEM ENTOMOLOGISCHEN VEREIN ZU STETTIN. 36 volumes. Stettin. 1840–'75.

ENTOMOLOGISKE MEDDELELSER UDGIVNE OF ENTOMOLOGISK FORENING. Edited by Fr. Meinert, Copenhagen (beginning with 1887).

THE ENTOMOLOGIST. A popular monthly journal of British entomology. Vol. I, 1840–'42. (Publication resumed in 1864. London.)

* THE ENTOMOLOGIST'S ANNUAL. Edited by H. T. Stainton. London. (Publication begun in 1855; 22 vols. published up to 1876.)

ENTOMOLOGIST'S MONTHLY MAGAZINE. London (beginning with 1864).

Horae . . . Variis sermonibus rossiæ usitatis. Societas Entomologica Rossica. (Publication begun in 1861.)

* LINNÆA ENTOMOLOGICA. HERAUSGEGEBEN VOM ENTOMOLOGISCHEN VEREINE ZU STETTIN (16 volumes, Berlin, 1846–'66).

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* Discontinued.

MITTHEILUNGEN DER SCHWEIZERISCHEN ENTOMOLOGISCHEN GESELLSCHAFT. Bulletin de la Société entomologique suisse. (Publication begun at Schaffhausen, Switz., in 1862. Afterward published at Geneva.)

REVUE D'ENTOMOLOGIE. (Published by the Société Française d'Entomologie, Caën, France. Publication begun in 1882.)

TIJDSCHRIFT VOOR ENTOMOLOGIE. NEDERLANDSCHE ENTOMOLOGISCHE VEREENIGING, Leiden, Holland (beginning with 1857. Published by the Dutch Entomological Society).

TRANSACTIONS OF THE ENTOMOLOGICAL SOCIETY OF LONDON. (Begun in 1834.)

*WIENER ENTOMOLOGISCHE MONATSSCHRIFT (8 volumes, Vienna, 1857–'64).

WIENER ENTOMOLOGISCHE ZEITUNG. Vienna. (Commenced 1882.)

*ZEITSCHRIFT FÜR DIE ENTOMOLOGIE. Edited by E. F. Germar (5 volumes. Leipzig, 1839–'44).

ZEITSCHRIFT FÜR ENTOMOLOGIE. VEREIN FÜR SCHLESISCHE INSECKTEN-KUNDE ZU BRESLAU. (Publication begun at Breslau in 1847).

ZEITSCHRIFT FÜR WISSENSCHAFTLICHE ZOOLOGIE. Leipzig. (Begun in 1848).

A large number of other periodicals devoted to entomology have been issued, principally in Europe, but after continuing for a year or more their publication has been abandoned, and they are not included here. Important entomological papers have also been published in many serials devoted to zoölogy or the natural sciences generally. Among them may be mentioned the following:

ANNALS AND MAGAZINE OF NATURAL HISTORY. London (beginning with 1838).

ARCHIV FÜR NATURGESCHICHTE. Berlin (beginning with 1835).

ÖFVERSIGT AF KONGL. SVENSKA VETENSKAPS ACADEMIENS FÖRHANDLINGAR (beginning with 1844. Published at Stockholm).
Proceedings of the Royal Swedish Academy of Sciences.

PROCEEDINGS OF THE ZOÖLOGICAL SOCIETY OF LONDON.

REVUE ET MAGASIN DE ZOOLOGIE PURE ET APPLIQUÉE. Paris (beginning with 1839).

SITZUNGSBERICHTE DER MATHEMATISCH-NATURWISSENSCHAFTLICHEN CLASSE DER KAISERLICHEN ACADEMIE DER WISSENSCHAFTEN ZU WIEN (beginning with 1848).

TRANSACTIONS OF THE LINNEAN SOCIETY OF LONDON (beginning with 1791).

TRANSACTIONS AND PROCEEDINGS OF THE NEW ZEALAND INSTITUTE. Wellington, New Zealand.

VERHANDLUNGEN DER ZOOLOGISCH-BOTANISCHEN GESELLSCHAFT IN WIEN (beginning with 1852).

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*Publication discontinued.

LIST OF MORE USEFUL WORKS ON ECONOMIC ENTOMOLOGY.

T. W. HARRIS, Insects Injurious to Vegetation. (Flint edition.) New York, Orange Judd Co. $4 or $6. (First edition, Cambridge, 1841.)

† ASA FITCH, Reports of the State Entomologist of New York. I–XIV, Albany, 1855–'70. (For a full account of these, see First Annual Report, by J. A. Lintner, State Entomologist of New York, pp. 294–297.)

* The Practical Entomologist. Vols. I and II. Published by the Entomological Society of Philadelphia, 1865–'67.

* The American Entomologist, edited by B. D. Walsh and C. V. Riley. Vol. I. St. Louis, Mo., 1868. (Out of print.)

* The American Entomologist and Botanist, edited by C. V. Riley and Dr. George Vasey. Vol. II. St. Louis, Mo., 1870.

* The American Entomologist, edited by C. V. Riley. Vol. III. [Second series, Vol. I.] New York, Hub Publishing Co., 1880.

† B. D. WALSH, Annual Report on the Noxious Insects of the State of Illinois. Chicago, Prairie Farmer Co., 1868.

† C. V. RILEY, Reports of the State Entomologist of Missouri. I–IX, Jefferson City, 1869–'77.

† WILLIAM LE BARON, Reports of the State Entomologist of Illinois. I–IV, Springfield, 1871–'74.

† CYRUS THOMAS, Reports of the State Entomologist of Illinois. I–VI, Springfield, 1876–'81.

J. A. LINTNER, Reports of the State Entomologist of New York. Albany (beginning with 1882).

S. A. FORBES, Reports of the State Entomologist of Illinois. Springfield (beginning with 1883).

———Miscellaneous Essays on Economic Entomology. Springfield, Ill., 1886. (Published instead of Annual Report.)

MARY TREAT, Injurious Insects of the Farm and Garden. New York, Orange Judd Co., 1882. (A small work compiled from Riley's reports.)

WILLIAM SAUNDERS, Insects Injurious to Fruits. Philadelphia, J. B. Lippincott & Co., 1883.

MATTHEW COOKE, Injurious Insects of the Orchard, Vineyard, etc. Sacramento, 1883. (8vo., pp. 472.)

P. J. VAN BENEDEN, Animal Parasites and Messmates. New York, D. Appleton & Co., 1876. International Scientific Series.

† Reports of the Entomologists of the U. S. Department of Agriculture, T. Glover (1863–1878), J. H. Comstock (1879–1880), and C.V. Riley (1878–1879, 1880 to date). ‡

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* Publication discontinued. † Out of print.

‡ The annual reports of the Entomologist are contained in the corresponding annual reports of the Department of Agriculture. A limited author's edition, separately bound, and with table of contents and index, is published each year.

Bulletins of the Division of Entomology of the U. S. Department of Agriculture, C. V. Riley, Entomologist (1883 to date).

Reports and Bulletins of the U. S. Entomological Commission.

JOHN CURTIS, Farm Insects. London, Blackie & Son, 1860.

ELEANOR A. ORMEROD, Manual of Injurious Insects, and Methods of Prevention, etc. London and Edinburgh, 1881. (A small work, costing about $1.50.)

———Reports of Observations of Injurious Insects and Common Farm Pests, with Methods of Prevention and Remedy. London. Simpkin, Marshall, Hamilton, Kent & Co., limited. (Fourteen reports issued up to 1891.)

J. H. KALTENBACH.—Die Pflanzenfeinde aus der Classe der Insekten. 8vo. Stuttgart, 1874. (A useful work for determining what insects infest plants in Europe.)

INSECT LIFE. Periodical Bulletin.—Devoted to the economy and the life-habits of insects, especially in their relations to agriculture. Edited by C. V. Riley, entomologist, and L. O. Howard, first assistant, with the assistance of other members of the divisional force. (Publication begun in 1888.)

E. L. TASCHENBERG.—Praktische Insekten-Kunde. Parts I–V. Bremen, 1879.

FELICE FRANCESCHINI.—Gli Insetti Nocivi. Milan, 1891.

J. T. C. RATZEBURG.—Die Waldverderbniss, oder dauernder Schade, welcher durch Insektenfrass, Schälen, Schlagen, und Verbeissen an lebenden Waldbäumen entsteht. Two parts. Berlin, 1866–'68.

ENTOMOLOGICAL WORKS PUBLISHED BY THE UNITED STATES ENTOMOLOGICAL COMMISSION AND BY THE UNITED STATES DEPARTMENT OF AGRICULTURE.

UNITED STATES ENTOMOLOGICAL COMMISSION.

(Members of the Commission: C. V. Riley, A. S. Packard, jr., and Cyrus Thomas.)

*BULLETIN NO. 1.—Destruction of the young or unfledged Locusts (*Caloptenus spretus*). (1877.) [pp. 15.]

BULLETIN NO. 2.—On the Natural History of the Rocky Mountain Locust and on the habits of the young or unfledged insects as they occur in the more fertile country in which they will hatch the present year. (1877.) [pp. 14, figs. 10.]

BULLETIN NO. 3.—The Cotton Worm. Summary of its Natural History, with an Account of its Enemies, and the best Means of controlling it; being a Report of Progress of the Work of the Commission. By Chas. V. Riley, M. A., Ph. D. (1880.) [pp. 144, figs. 84, plates 1.]

BULLETIN NO. 4.—The Hessian Fly. Its Ravages, Habits, Enemies, and Means of preventing its Increase. By A. S. Packard, jr., M. D. (1880.) [pp. 43, figs. 1, plates 2., maps 1.]

*All of these bulletins and reports, with the exception of the fifth report, are out of print.

BULLETIN No. 5.—The Chinch Bug. Its History, Characters, and Habits, and the Means of destroying it or counteractering its Injuries. By Cyrus Thomas, Ph. D. (1879.) [pp. 44, figs. 10, maps 1.]

BULLETIN No. 6.—General Index and Supplement to the nine Reports on the Insects of Missouri. By Charles V. Riley, M. A., Ph. D. (1881.) [pp. 177.]

BULLETIN No. 7.—Insects injurious to Forest and Shade Trees. By A. S. Packard, jr., M. D. (1881.) [pp. 275, figs. 100.]

First Annual Report for the year 1877, relating to the Rocky Mountain Locust and the best Methods of preventing its Injuries and of guarding against its Invasions, in pursuance of an Appropriation made by Congress for this purpose. With maps and illustrations. (1878.) [pp. 477+294, figs. 111, plates 5, maps 1.]

Second Report for the years 1878 and 1879, relating to the Rocky Mountain Locust and the Western Cricket, and treating of the best Means of subduing the Locust in its permanent Breeding grounds, with a view of preventing its Migrations into the more fertile Portions of the trans-Mississippi country, in pursuance of Appropriations made by Congress for this purpose. With Maps and Illustrations. (1880.) [pp. XVIII+322+22, figs. 10, plates 17, maps 7.]

Third Report relating to the Rocky Mountain Locust, the Western Cricket, the Army Worm, Canker Worms, and the Hessian Fly; together with Descriptions of Larvæ of injurious Forest Insects, Studies on the embryological Development of the Locust and of other Insects, and on the systematic Position of the Orthoptera in Relation to other Orders of Insects. With Maps and Illustrations. (1883.) [pp. XVIII+347+91, figs. 14, plates 64, maps 3.]

Fourth Report, being a revised Edition of Bulletin No. 3, and the Final Report on the Cotton Worm and Bollworm. By Charles V. Riley, Ph. D. (1885.) [pp. XXXVIII+399+147, figs. 45, plates 64, maps 2.]

Fifth Report, being a revised and enlarged edition of Bulletin No. 7, on Insects Injurious to Forest and Shade Trees. By Alpheus S. Packard, M. D., Ph. D., with woodcuts and 40 plates. (1890 (1). Small edition; only a few for general distribution.

BULLETINS OF THE DIVISION OF ENTOMOLOGY, U. S. DEPARTMENT OF AGRICULTURE, UNDER DIRECTION OF C. V. RILEY, ENTOMOLOGIST.

*No. 1.—Reports of Experiments, chiefly with Kerosene, upon the Insects injuriously affecting the Orange Tree and the Cotton Plant, made under the Direction of the Entomologist. (1883.) [pp. 62.]

*No. 2.—Reports of Observations on the Rocky Mountain Locust and Chinch Bug, together with Extracts from the Correspondence of the Division on Miscellaneous Insects. (1883.) [pp. 36.]

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* Out of print.

*No. 3.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomlogist. With plates. (1883.) [pp. 75, plates III.]

No. 4.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist, together with Extracts from Correspondence on miscellaneous Insects. (1884.) [pp. 102, figs. 4.]

*No. 5.—Descriptions of North American Chalcididæ from the Collections of the U. S. Department of Agriculture and of Dr. C. V. Riley, with biological Notes. [First paper.] Together with a list of the described North American species of the family. By L. O. Howard, M. Sc., Assistant, Bureau of Entomology. (1885.) [pp. 47.]

*No. 6.—The imported Elm-leaf Beetle. Its Habits and Natural History, and Means of counteracting its Injuries. (1885.) [pp. 18, figs. 1, plates I.]

No. 7.—The Pediculi and Mallophaga affecting Man and the lower Animals. By Prof. Herbert Osborn. (1891.) [pp. 54, figs. 42.]

*No. 8.—The Periodical Cicada. An account of *Cicada septendecim* and its tredicim race, with a chronology of all of the broods known. By Charles V. Riley, Ph. D. (1885.) [pp. 46, figs. 8.)

No. 9.—The Mulberry Silk-worm; being a Manual of Instructions in Silk culture. By Charles V. Riley, M. A., Ph. D. (1886.) [pp. 65, figs. 29, plates II.]

No. 10.—Our Shade Trees and their Insect Defoliators. Being a consideration of the four most injurious species which affect the trees of the capital, with means of destroying them. By Charles V. Riley, Entomologist. (1887.) [pp. 75, figs. 27.]

*No. 11.—Reports of Experiments with various Insecticide Substances, chiefly upon Insects affecting garden Crops, made under the Direction of the Entomologist. (1886.) [pp. 34.]

*No. 12.—Miscellaneous Notes on the work of the Division of Entomology for the Season of 1885; prepared by the Entomologist. (1886.) [pp. 45, plates I.]

*No. 13.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. (With illustrations.) (1887.) [pp. 78, figs. 4.]

No. 14.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. (1887.) [pp. 62, figs. 2, plates I.]

No. 15.—The Icerya, or Fluted Scale, otherwise known as the Cottony Cushion-scale. (Reprint of some recent Articles by the Entomologist and of a Report from the Agricultural Experiment Station, University of California.) (1887.) [pp. 40.]

No. 16.—The Entomological Writings of Dr. Alpheus Spring Packard. By Samuel Henshaw. (1887.) [pp. 49.]

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*Out of print.

*No. 17.—The Chinch Bug: A general Summary of its History, Habits, Enemies, and of the Remedies and Preventives to be used against it. By L. O. Howard M. S., Assistant Entomologist. (1888.) [pp. 48, figs. 10.]

*No. 18.—The Life and Entomological Work of the late Townend Glover, first Entomologist of the United States Department of Agriculture. Prepared under the Direction of the Entomologist, by C. R. Dodge. (1888.) [pp. 68, figs. 6, plates I.]

No. 19.—An enumeration of the published Synopses, Catalogues, and Lists of North American Insects; together with other information intended to assist the student of American Entomology. (1888.) [pp. 77.]

*No. 20.—The Root Knot Disease of the Peach, Orange, and other Plants in Florida, due to the Work of Anguillula. Prepared under the Direction of the Entomologist, by J. C. Neal, Ph. D., M. D. (1889.) [pp. 31, plates 21.]

*No. 21.—Report of a Trip to Australia, made under the Direction of the Entomologist to investigate the Natural Enemies of the Fluted Scale, by Albert Koebele. (1890.) [pp. 32, figs. 16.]

No. 22.—Reports of the Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. (1890.) [pp. 110.]

No. 23.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. (1891.) [pp. 83.]

No. 24.—The Boll Worm. Preliminary Report, made under the Direction of the Entomologist. By F. W. Mally. (1891.) [pp. 50.]

No. 25.—Destructive Locusts. A popular consideration of a few of the more injurious Locusts or "Grasshoppers" of the United States, together with the best means of destroying them. By C. V. Riley, Ph. D. (1891.) [pp. 62, figs. 11, plates 12.]

†No. 26.—Reports of Observations and Experiments in the practical Work of the Division, made under the Direction of the Entomologist. (1892.)

†No. 27.—Reports on the Damage by destructive Locusts during the season of 1891, made under the Direction of the Entomologist. (1892.) [pp. 64.]

†No. 28.—The more destructive Locusts of America, north of Mexico, by Lawrence Bruner, prepared under Direction of the Entomologist. (1892.)

SPECIAL REPORTS AND BULLETINS.

* REPORT ON COTTON INSECTS.—By J. Henry Comstock. (1879.) [pp. 511, figs. 77, plates III.]

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* Out of print.

† Bulletins 26 and 27 are in press, and Bulletin 28 is in course of preparation.

† SPECIAL REPORT, No. 11.—The Silkworm; being a brief Manual of Instructions for the Production of Silk. Prepared, by direction of the Commissioner of Agriculture, by C. V. Riley, M. A., Ph. D., Entomologist. (First ed., 1879; fifth ed., 1885.) [pp. 37, figs. 8.]

* SPECIAL REPORT, No. 35.—Report on Insects injurious to Sugar Cane. Prepared, under Direction of the Commissioner of Agriculture, by J. Henry Comstock, Entomologist. (1881.) [pp. 11, figs. 3.]

* DIVISION OF ENTOMOLOGY.—INSECTS AFFECTING THE ORANGE.—Report on the Insects affecting the Culture of the Orange and other plants of the Citrus Family, with practical Suggestions for their Control or Extermination. By H. G. Hubbard. (1885.) [pp. x+227, figs. 95, plates XIV.]

* SPECIAL REPORT.—Catalogue of the Exhibit of Economic Entomology at the World's Industrial and Cotton Centennial Exposition, New Orleans, 1884–'85. (1888.) [pp. 95.]

SPECIAL BULLETIN.—The Horn Fly (Hæmatobia serrata), being an account of its Life-history and the means to be used against it. By C. V. Riley and L. O. Howard. (Reprinted from Insect Life, Vol. II, No. 4, October 1889.) (1889.) [pp. 11, figs. 5.]

BIBLIOGRAPHY OF THE MORE IMPORTANT CONTRIBUTIONS TO AMERICAN ECONOMIC ENTOMOLOGY. By Samuel Henshaw. Parts I, II, and III. The more important writings of Benjamin Dann Walsh and Charles Valentine Riley, Washington, 1890.

HOW TO OBTAIN ENTOMOLOGICAL BOOKS AND PAMPHLETS.

Comparatively few of the works treating of the classification of North American insects have been published as separate books; but such as have been so published, if of comparatively recent date, can be obtained through the regular book trade. By far the greater number of the monographs and synopses mentioned in the preceding pages have been published in scientific periodicals and in the proceedings or transactions of scientific societies. These may be obtained either through the societies or through the publishers; but single volumes of transactions or proceedings, and more especially single papers, are seldom sold, and the older volumes are liable to be out of print. Moreover, the expense attending the purchase of all of the periodicals containing the publications on a given order of insects will be so great as to put them beyond the reach of most entomologists. The custom of placing at the disposal of authors a number of separate copies of their papers overcomes this difficulty to some extent and creates a small supply. Thus it often happens that a person interested can obtain a copy of a scientific paper by addressing the author personally. Many of

* Out of print.

† Bull. No. 9 of the Division of Entomology covers this subject.

these separate copies also fall into the possession of dealers in second-hand books, and may be purchased from them. The American Entomological Society of Philadelphia, and also a few other societies here and in Europe, offer for sale from their duplicates many of these authors' extras, and in some cases publish lists. There are, moreover, certain business establishments which make a specialty of the sale of works and pamphlets on natural history, including entomology, and it is chiefly through such establishments that the student is enabled to secure the larger portion of the works needed.

By subscribing to the entomological periodicals published in this country (a matter of but slight expense) the student may keep abreast of the current literature. Short book reviews or notes published therein call attention to the more important publications in other countries. Moreover, the Zoölogischer Anzeiger, edited by Prof. J. Victor Carus, in Leipzig, Germany, and published every fortnight, gives a tolerably complete bibliography of the current entomological literature at intervals of about six or eight weeks. The "Naturæ Novitates," published every fortnight by R. Friedlaender & Sohn, Carlstrasse, 11, Berlin, Germany, gives the titles of most recent works and pamphlets.

There are also three great annual publications, viz: "Die Fortschritte auf dem Gebiet der Entomologie," published in Wiegmann's "Archiv für Naturgeschichte;" "The Zoölogical Record," published by the Zoölogical Record Society, in London, England; and the "Zoölogische Jahresberichte," published by the Zoölogical Station at Naples, Italy, which give the full literature of the previous year, discussing the more important papers and giving a list of the new species, besides other information. These three publications are almost indispensable to the student in any branch of zoölogy, and some one of them at least ought to be found in every public library in the country. The volumes of the "Zoölogische Jahresberichte" since 1887 contain no titles upon systematic and classificatory zoölogy, but only such as refer to biology.

A not inconsiderable portion of the North American literature on the classification of insects has been published by the Government of the United States through various channels, foremost among which are the Smithsonian Institution, the U. S. Department of Agriculture, the U. S. National Museum, the U. S. Geological and Geographical Survey, and the various surveys of the Territories. Some of these publications are distributed free of cost; while others, like certain of the publications of the Smithsonian Institution and the Geological Survey, are sold at a moderate price to cover the cost of publication. Many of them are out of print, and can only be obtained through natural history book-dealers.

Of the more general works, some may be obtained direct from the publishers, and in such cases the publishers are mentioned in the general list. The older works are mostly out of print and can only be obtained from second-hand dealers. The current State reports of Lintner and Forbes may be obtained from the secretaries of the respective

State agricultural societies at Albany, N. Y., and Springfield, Ill., while the bulletins and reports of the entomologists of the various State experiment stations, of which a large number are being published, may be obtained from the directors of the respective stations. The older reports of the State entomologist of Missouri and the State entomologists of Illinois (Walsh, Le Baron, and Thomas) are all out of print and can only be obtained by purchase from second-hand dealers. The same may be said of the well-known and oft-quoted reports of Dr. Fitch, which were published with the old volumes of the Transactions of the New York State Agricultural Society.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

INSTRUCTIONS FOR COLLECTING MOLLUSKS, AND OTHER USEFUL HINTS FOR THE CONCHOLOGIST.

BY

WILLIAM H. DALL,

Honorary Curator of the Department of Mollusks, U. S. National Museum.

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INSTRUCTIONS FOR COLLECTING MOLLUSKS, AND OTHER USEFUL HINTS FOR THE CONCHOLOGIST.

BY

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INTRODUCTORY.

Invertebrates of the molluscan type are found in all parts of the world and in nearly every situation. The highest mountains, the widest prairies, the least accessible oceanic islets, and even the desert of Sahara and the frosty moss of Arctic tundras, afford specimens of mollusks on careful and intelligent search.

For the purposes of the collector the group may be divided into three classes, including, respectively, land, fresh-water, and marine species. Each of these classes requires special treatment and will be discussed separately. Every land area which borders on the sea and contains permanent bodies of fresh water will be found to support representatives of each class. Geologically, each goes back to a remote antiquity.

LAND SHELLS.

From the standpoint of the collector this class includes gastropods both of the pulmonate and gill-bearing types, forms which are united in the amphibious *Siphonaria*, which possesses both gills and a true lung. They may be limpet-shaped or spiral; operculate or inoperculate; shell-bearing or naked; herbivorous or carnivorous.

HABITAT AND STATION.

They are found at all elevations, from the beaches moist with sea spray to the alpine heights of 14,000 feet in the vicinity of perpetual snow. Some, like *Testacella*, are subterranean in their habits, pursuing earthworms through their burrows and never visiting the light of day; or nestling in the cancellated recesses of bones in ancient graveyards (*Acicula*) where they browse on fungoid mycelium. Others are contented with the protection afforded by dead leaves, decaying logs, under the bark starting from rotting stumps, or in the shelter of loose stones and bowlders. Other groups live on the leaves of sedges, grass, and shrubbery, retreating to the soil for winter quarters; while in the lofty tree tops of tropical forests still others live permanently, never visiting the ground, and, in their airy domicile, exhibit colors almost as varied and brilliant as the arboreal flowers which surround them. In arid regions some seek the shade of stones or attach themselves to the stems of cacti or other desert plants, while others again adhere to the sunburnt surfaces of rocks so hot as to be uncomfortable to the touch, on which their white or rusty shells stand out conspicuously. It has been generally noted that the color of the shell bears a certain relation to its favorite station, the arboreal forms presenting the brightest and most varied colors; the moss lovers and terrestrial species being usually dull, horny, or greenish, though often with a brilliant, polished, or delicately sculptured surface; while subterranean forms are usually pale or pellucid. The slugs are usually nocturnal in their habits, retreating to holes and crevices at dawn; the cultivator, whose succulent vegetables they destroy, seeing his harvest ravaged without a visible enemy. On one of the Florida keys, built of the debris of coral, and as full of holes and crevices as a sponge, a settler raising early tomatoes for the New York market found to his dismay as the fruit began to ripen that every red one was immediately eviscerated, leaving nothing but the skin. There were no birds, worms, or mice to do such damage, which was not occasional but general over his whole farm. Finding nothing by day he took to scrutiny by night and was rewarded by the discovery of myriads of slugs which proceeded from the interstices of the coral and devoured every ripe fruit. The plague admitted of no remedy, the enemy was too numerous, and the unfortunate cultivator was obliged to abandon his undertaking and go into bankruptcy, ruined by *Veronicella*.

In general, limestone regions are most favorable for land shells and those of flinty rock least advantageous. Woods of coniferous or resinous trees are unsuited to their tastes, while those of deciduous soft wooded nature offer a congenial home for the mollusks. Certain pungent herbs, especially cruciferæ, are said to be obnoxious to slugs. Gardeners in Europe are said to protect their lettuce beds by a hedge of mustard or pepper grass. Nettles, on the other hand, are a favorite haunt of certain small land shells. Dry coal ashes, alkaline wood ashes wet or dry, sand and lime in a pure state, are more or less effectual in repelling the slugs, which they irritate mechanically. It is probable as far as the smaller species are concerned that the unfavorable nature of resinous trees is due more to the fact that they decay less easily and afford a less favorable nidus for fungi upon which the snails feed than to any direct influence of the resin upon the mollusks. Salt is inimical to most of the *Helicidæ*, but the *Auriculidæ* or many of them, *Truncatella* and *Polygyra*, seem to prefer the vicinity of the sea.

Spring is the most active season for snails as for most animals, they attain their fullest development toward midsummer, and as winter approaches they penetrate the ground or in warm regions attach themselves to the bark of trees or to stones for a period of hibernation. They close the aperture of the shell with a leathery secretion, sometimes strengthened by more or less limy matter, or if naked may surround themselves with it like a cocoon. This temporary defense, common to most of the inoperculate forms, is called the epiphragm, and, in the many whorled species, there are often several of these partitions between the retracted animal and the aperture of its shell. In the arboreal Bulimi the secretion is often of great strength, and the collector who finds them fastened to trees and attempts to pull them off will often see the shell or the bark break before the epiphragm will give way. In such cases it is better to cut off a thin slice of the bark with the adherent shell. On an immersion in warm water the mollusk will awake and soon release itself in the natural way. It is the habit of many snails on waking from their hibernation to make their first repast on their own epiphragm. The period of attachment is often marked by a band of color in harmony with the lines of growth, not elsewhere repeated on the shell, and usually bluish or dark brown. This indicates the formation of a special secretion at such times. The life of most land shells is probably short, a majority probably do not live more than a year or two, though, under suitable conditions, there would seem to be no reason why this period should not be much prolonged. The species of arid regions become accustomed to long periods of enforced hibernation and are the longest lived. Instances are known of their surviving four or five years without food in this state, and it is a common thing for them to survive transportation through long sea voyages to distant countries. These facts have an important bearing on their distribution. There would seem to be no doubt that in some cases the ancestors of a land shell fauna have reached oceanic islets by drifting on vegetation dislodged by freshets and carried out to sea, especially in the warmer regions.

COLLECTING OUTFIT.

The collector of land shells needs only a very simple and inexpensive outfit. For most purposes, in temperate and northern regions, the things needed may be easily carried in one's pocket. First in point of usefulness is a pair of spring forceps, which should have a delicate spring requiring no sensible exertion to make the points meet. The points themselves should be slender and the file cutting on their inner sides should not be coarse. These forceps, which any surgical instrument maker should furnish at a cost of $1 or less, are indispensable in collecting the more minute forms, for which the fingers are far too clumsy. After a little practice the most minute *Vertigo* or *Hyalinia* may be picked up without injury, though the beginner is apt to crush a goodly number before he learns the necessary delicacy of manipulation. The forceps come into play almost as much in separating the day's collections as in making them; in fact, after a little, one feels lost without them.

Two or three stout homeopathic vials, with good long corks, may be put in the vest pocket. A thread may be put through the top of the cork and tied to the neck of the vial, thus obviating the necessity for hunting a dropped cork in the underbrush, or a few spare corks may be carried. Either method is preferable to delay and possible loss of temper when collecting is good.

A couple of wide-mouthed two-ounce bottles, with strong corks, will serve for somewhat larger species, while for snails of the size of *Helix albolabris* wooden pill boxes, or small tin boxes, such as mustard or yeast powder is put up in, will be found convenient. A little cotton or moss should be put in the bottom of the box before it is used for shells.

If it is desired to study the living animals the vials or boxes into which the specimens are dropped should be dry and clean, but for ordinary collecting it will be found more convenient to have the vials for small species half filled with alcohol diluted with one third its volume of water. This alcohol abstracts the moisture from the soft parts, so that they may be dried afterward without making an offensive odor, and prevents the snails from adhering to each other and to the glass, which otherwise they are very apt to do, when it is difficult to separate them or get them out of the vial unbroken. The larger species do not need this precaution and may be treated later, at home. For collecting the minute *Pupidæ* and similar species a small net is very convenient. This should be made of stout (say ¼ inch) steel or brass wire, circular, with a projection fitted to screw into a socket fastened to a stout cane or stick. The frame may be permanently fastened to the stick if preferred and should be 10 or 12 inches in diameter. The net may be made of brown linen or cheese cloth in the form of a cone sewed over the frame at its base, and should be twice as long as the diameter of the frame. The coarse grass and high sedges of moist places, on which the little mollusks love to creep up, may be beaten with the net, into which they fall, and afterward the net turned inside out over a newspaper, the larger rubbish rejected and the remainder shaken into a box to be examined at leisure. The moist leaves which collect on the ground where meadow and woodland meet may be put into a sack, taken home, dried, well shaken, and the dirt collected from them when picked over will often afford large numbers of the minute species in which the collector delights. Loose moss from favorable localities may be treated in the same way and will often well repay the trouble.

Over most of the United States no further equipment is necessary for collecting land shells, but if the collector is in a particularly rich field where the larger species abound it may be convenient for him to take a garden trowel for digging in the soft earth under fallen logs, and a miniature pick with one end hatchet-shaped, such as are used for trimming ice by housekeepers. The latter he will find convenient in prying off the bark from stumps and fallen logs, the surface of which, as well as that of the log itself, should be closely scrutinized as a favorite retreat of *Hyalinia*, *Pupa*, *Vertigo*, and other small species. With good eyes no hand lens should be necessary, but occasionally a collector will find it of use, and one of the cheap triplets with rubber frames, if carefully selected, will be found quite as efficient as the expensive achromatic lenses mounted in German silver which the optician is so prone to recommend.

LOCALITIES FAVORABLE FOR COLLECTING.

The margins of brooks and ponds, the under surface of old weather-worn bits of board, leather or bones such as every pasture affords, the earth around rotten stumps and under fallen logs or flat stones, the moist moss near rocks and especially under overhanging ledges, or in marshes, and in general all cool, moist places where decaying, not resinous, vegetation may afford food and shelter for his prey, will be found worth searching by the collector. The fine debris left by freshets along the borders of streams will often yield many small land shells in good condition if carefully searched. In the tropics Morelet has observed that land mollusks are more or less nocturnal. During the day it is necessary to seek them in their retreats under stones, logs, dead leaves, or in the crevices of rocks, unless the atmosphere is moist enough to induce them to remain abroad. During the heat of the day the imbricated leaves of aloes or agaves often hide snails which protect themselves thus from the sun. One may even set traps in the form of fagots, flat stones, pieces of wood or logs, especially in meadows or prairies, where the snails will take refuge during the heated hours of the day. Some mollusks have peculiar habits, as in the case of a little Algerian helix, which, during the day, buries itself in the loose sand to a depth of several inches, or until it reaches a moist stratum. Some forms, like *Strophia* in the Antilles, seem to enjoy places where they are exposed to the full glare of the sun. These usually have heavy whitish shells. There are, however, no rules so absolute in such matters as to be without exception. Certain little snails live permanently on the dry, harsh leaves of palms and palmettos or the hispid stalks of tall ferns. In general, whatever the soil, hilly or mountainous regions are the most prolific in snail life unless too arid, but a certain number seem to prefer the salty moist air of the borders of the sea and these seldom hibernate. The meadows should not be absolutely neglected, especially in the rainy season. Many small Bulimi prefer to reside there and may be found on the stalks of coarse grasses, often in multitudes. Forests are more prolific, especially in clearings and places where the light may penetrate. When the trees stand in marshy places or are subject to overflow, mollusks are less numerous, but multiply where the soil is more or less broken by masses of rock. They are more abundant in broken and irregular woods than when the trees extend uniformly over level ground. In many regions magnificently colored snails live in the tree tops, where they are only accessible by climbing or cutting down the trees. It is said that Cuming, the celebrated collector in the Philippine Islands, maintained a corps of several hundred natives constantly occupied in cutting down trees for the purpose of obtaining the fine *Helicidæ*, for which the forests of that region are renowned.

EGGS.

Most terrestrial mollusks lay eggs which are covered with a pellucid membrane, a white and leathery or even a solid calcareous shell, like that of a tortoise egg. These eggs may be found in the haunts of the mollusks themselves, most commonly in cool, moist places. Those of American *Helicidæ* are usually white, translucent, and associated together, though not deposited in a mass. *Bulimus* lays eggs that usually have a calcareous shell. The *B. ovatus* of the Antilles has an egg-shell half an inch in length, in which the young mollusk develops, emerging with several whorls of its spire completely formed and differing from the adult only in size. The amphibious *Ampullaria* lays its eggs on the the stalks of plants growing in marshy places, to which they adhere by an abundant secretion of a partly calcareous nature, which, when dry, forms a brittle animal cement. In *Stenogyra* the eggs may be seen through the translucent shell and apparently are only discharged when ready to hatch. They are so nearly the full size of the caliber of the whorl, that it is astonishing how they can, together with the soft parts, be contained in it. The oviposition and biography of reproduction in many species are entirely unknown. By careful and patient observation the collector has it in his power to add largely to the sum of our knowledge in this particular.

ENEMIES OF LAND SHELLS.

As it is often advantageous for the collector to know the enemies of the objects of his search, a word or two on that point may be in place here. The chief enemies of land mollusks are birds and small mammals, mice, shrews, etc. In North America the birds seem to pay less attention to snails and slugs than do their analogues in Europe. Still the thrushes, blackbirds, and some water birds make use of them for food. A singular sausage-shaped parasite, of which one end is attenuated into a slender tube, is found in *Succinea*. The soft parts of snails thus affected are much distorted. The parasite is one phase of a *Distoma* or fluke-worm, and is of a dark brown color and over an inch in length. It is known as *Leucochloridium americanum* Dall. An analogous species has been described from French Succineas, which is of a mottled green. This parasite attains its development in the intestines of thrushes which feed on the *Succinea*, and may perhaps be fatal to these birds. Smaller Distomas are found in certain species of *Limnæa*, and develop into the liver-fluke, so fatal to sheep. The mollusks are eaten, with the grass upon which they rest, by the sheep, which also eat in the same way large numbers of Helices in Britain, and are said to fatten upon them. In America we have no species of snail which lives in such numbers among the herbage as do the British forms alluded to. Birds usually destroy the shells of the snails upon which they feed, and so are injurious to collectors. But *Glandina*, a carnivorous snail common in the Southern States, swallows the smaller Helices whole and digests the soft parts at leisure, as the walrus does with sea snails. As many as a dozen specimens of *Polygyra* have been extracted from the gullet of a single *Glandina*. Many of the snails of the type of *Zonites* are carnivorous, and the collector must beware of putting species he would keep alive into a box or fernery with such forms as *Selenites concava*. The latter will make short work of them, extending its slender body far into the whorls of its defenseless prey and eating them, all alive, voraciously. A single *Selenites* will clean out a dozen *Helices* of its own size in a single night. A Floridian bird of prey, the everglade kite (*Rostrhamus sociabilis*), is said to have a special fondness for *Ampullaria*, and the curve of its beak and the formation of its claws are specially adapted for preying upon them and extracting the body of the snail from behind its protecting operculum. Certain millipedes of the genus *Julus* are often found feasting upon slugs and snails, but whether they attack specimens in good health is not positively determined.

The treatment of specimens collected, including methods of cleaning and preservation of the soft parts, will be discussed later.

FRESH-WATER SPECIES.

The molluscan fauna of fresh waters includes both Gastropods and Pelecypods. All regions having permanent bodies of fresh water, whether lakes, ponds, rivers, brooks, or even springs, present a certain number of species, which, however, varies greatly with the more or less favorable nature of the environment.

HABITAT AND STATION.

As lime forms the chief component in shell, waters containing an abundant supply of this mineral are more favorable for the multiplication of shell-bearing animals than those which contain but little lime. As the development of molluscan embryos is more rapid and effective in warm than in cold water, a temperate or warm climate favors the multiplication of individuals. The character of the bottom influences the welfare of mollusks; a coarse crystalline gravel, more or less disturbed by a rapid current, is distinctly less adapted to them than softer and less gritty sands, mud, or even solid rock, over which the water flows more gently. The food supply is, of course, of great importance and the presence of algæ or other plants in abundance, by promoting the multiplication of the microscopic organisms upon which many mollusks feed, is indirectly advantageous to those species which may not feed on the plants themselves.

The presence of carbonic acid (carbon dioxide) released by the decay of vegetation and taken up by the water is not only unfavorable to molluscan life directly when present in quantity, but indirectly, by causing erosion of exposed parts of the shell and rendering necessary an exceptional secretion of shell substance to repair these damages, is weakening to the animals and very injurious to the shells, viewed as material for study.

The range of temperature borne by fresh-water mollusks is very great. Some species of *Pisidium*, *Sphærium*, and *Limnæa* are found at great altitudes (6,000–14,000 feet) in pools where the temperature seldom rises much above the melting snow from which they spring. On the other hand species of the same genera as well as *Planorbis* and gastropods belonging to the *Amnicolidæ* occur in the waters of thermal springs which have a high temperature. Most of the fresh-water mollusks appear to enjoy a certain amount of sunlight, or at least are not repelled by it, though as Dr. Lea has shown, some of the Naiades (and possibly all of them), though without organs of sight, are distinctly sensible to the influence of light. On the other hand a certain number of species, mostly of small size, frequent subterranean waters, deep wells, or the lower depths of great lakes.

The presence of impalpable mud suspended in the water is as obnoxious to gill-bearing mollusks as clouds of dust are to air-breathing animals, and for the same reason. Salts of borax, magnesia, soda, and potash are injurious, and, when abundant, are fatal to molluscan life, although when the change is brought about with extreme slowness some hardy species may survive in the presence of salt enough to render the water perceptibly brackish. The effect of the change is generally apparent in a tendency of the shells to become ribbed, dwarfed, abnormally thickened, or distorted under such conditions. Conversely, marine species, if the change be sufficiently gradual, may survive in water which has become nearly or quite fresh, and thus present the naturalist with such anomalies as the fresh-water arks, cockles, and teredos of India and the river limpets (*Acmæa*) of Borneo.

As lakes become saline the species which can not migrate die, but those capable of doing so are apt to retreat to the streams feeding such lakes, and finally to the springs which feed the streams. So that in the case of the Pleistocene Lake Bonneville, of which the Great Salt Lake of Utah is a remnant, the mollusks, long thought to be extinct, which lie fossil in myriads on the ancient shore lines, have one by one been discovered living in the few springs which remain in that arid region, until the discovery of *Tryonia*, in 1891, by Dr. Merriam, made the list complete. In mountain pools, wet meadows, ditches, and ponds are found the small bivalves of the genera *Pisidium* and *Sphærium;* in larger ponds, canals, and slow-moving waters *Anodonta* flourishes, while *Unio* and the larger Naiades seem to prefer streams, often lying in full view on a hard rocky bottom or slowly pushing themselves about on the mud or sand. Marshes give shelter to the operculate

Viviparidæ, *Ampullaria*, and *Hydrobiinæ;* in ponds and sluggish streams *Planorbis*, *Limnæa*, and *Amnicola* abound; estuaries afford *Corbicula*, *Cyrena*, and *Melanopsis*, beside such modified marine species as *Azara*, *Tagelus*, some *Rissoidæ*, *Neritina*, and *Bithinia*, and occasionally half marine *Cyrenoidea* and *Psammobiidæ*. Swift streams often teem with Melanians of different genera, and under their pebbles lurk fresh-water *Neritina*, *Planorbis*, and *Ancylus*. Lily pads are a good collecting ground for small specimens, and in the tufts of water-loving grasses as well as the soft mud about their roots numerous mollusks may be found.

OUTFIT.

For carrying the larger bivalves a bag or basket is convenient and a dip net with rather wide meshes will enable the collector to search soft mud for bivalves or pick up Naiades from water too deep for the arm alone. A few vials for the smaller species, a tin water pail for preserving interesting forms alive, a thin-bladed knife for roughly cleaning large bivalves, and the ever useful forceps will make an outfit quite sufficient for the collector's needs.

FAVORABLE LOCALITIES.

The preceding remarks will have indicated places where search may preferably be made. The drift along river and lake beaches and the vicinity of muskrat burrows will often afford dead specimens in good condition. Trailing weeds and the long fibrous roots of trees often conceal rarities in their meshes.

EGGS.

The eggs of fresh-water gastropods are often deposited in little masses of clear jelly, which may be preserved in fresh water and reared in an extemporized aquarium. Goldfish globes or thin jars of plain glass are quite as good and much cheaper for such purposes than the more pretentious metal-framed aquaria for sale by dealers.

ENEMIES AND PARASITES.

The muskrat and the wild duck feed largely on mollusks. In the crop of the latter and about the burrows of the former specimens still suitable for study may often be found. The embryos of fresh-water bivalves are often provided with temporary hooklets, by which they adhere to the fins of small fishes or the legs of other water animals, and are thus transported from one pool or stream to another. In the gill pouches of many species the young remain until their development is well advanced. This is especially the case in the *Unionidæ*, and the swelled organs in their season are often very remarkable and offer an inviting field for special study. The sexes are separate, and as the growth of the shell goes on during the gravid season its form in the female is often modified by the mechanical pressure of the soft parts, so that the male and female differ widely in their shape. The extern sculpture, of which so many species offer examples, is probably initiate in most instances by growth of the shell over the plicated network o the gills, another field open for much needed research. The very young shells often have characteristic sculpture, lost by erosion in the adult, and they should be carefully sought for and preserved. The young o the *Corbiculidæ* generally nestle in a sort of marsupium within the parent until of considerable size, affording a good opportunity for identification and for the study of the larval calyculate beaks found i various species.

The tropical forms of *Sphærium* show black maculations not foun in northern forms, which on close examination will be found to b external to the shell on its inner surface. Their nature is still to b explained, and the naturalists of our southern border would do well t examine into the matter.

The parasites of fresh-water species are not numerous. They comprise rhizopods, infusoria, and cercarian worms, like the embryoni stages of the sheep and other flukes. These occur in *Limnæa* especially. Small mites are found on them also, and they may sometimes be seen on *Unio*. The beautiful pearls which occur occasionally in *Unio* an its allies are said to be frequently initiated by the irritation of a *Gregarina*, over which the tormented mollusk pours out a film of nacre to protect itself. Other pearls are due to the accidental intrusion of grains of sand or the hooked embryos before referred to. Pearl hunting is not part of the naturalist's work, though he may sometimes be rewarded by a "find." It has been calculated that one *Unio* in a hundred contains a pearl, that one pearl in five hundred has a commercial value, and about one in a thousand is worth more than $5. So it will be seen that pearl-hunting is not a profitable pursuit in the long run, and, by its involving the destruction of myriads of interesting animals in regard to which the naturalist has almost everything yet to learn, it is placed in the category of pursuits which those interested in biology may reasonably discourage.

Fresh-water collecting in the tropics does not differ essentially from the same pursuit in more temperate regions, except by the greater prevalence of paludal fevers in the haunts of the collector's prey.

In deep lakes interesting collections may sometimes be made by means of dredging, but as this does not differ in any essential way from marine dredging the reader is referred for details to the section of this paper relating to explorations of the sea.

In closing this part of our remarks we would emphasize the desirability of maintaining aquaria for the study of the habits of the living animals. Fresh-water aquaria may easily be made by anybody and require hardly any attention, while they afford an indispensable method of learning the ways, habits, and life history of fresh-water animals and offer an attractive ornament to the study or the parlor.

MARINE SPECIES.

As everyone is aware, the sea is the most prolific region for mollus-
n life, far exceeding in the number of its species the land and fresh-
ater regions combined. A similar disproportion exists between the
pective numbers of families and genera. The earliest known mol-
ks were coëval with the earliest fossiliferous rocks and were marine
rms. Air-breathers are not known to have existed before the Car-
oniferous period, but when the much more ancient Cambrian forms
e living the molluscan type was already old and exhibited develop-
at in several of its principal lines. There can be no doubt that the
has continuously existed since the earliest development of life on
globe, and most naturalists believe that in it the first organic life
k rise. Marine mollusks, regarded as a whole, have therefore formed
ontinuous series, and in the depths of the sea are to be sought those
ecesses where change of conditions from age to age has remained at
minimum. There linger forms which are of incalculable antiquity,
ne of which differ little, regarded as generic types, from some of those
ich existed in Paleozoic time; while representatives of genera devel-
ed in Cenozoic time are numerous.

REGIONAL DISTRIBUTION OF SPECIES.

The existing sea, with reference to its molluscan population, is divis-
ble into two sorts of regions. One set is most easily defined as that
f areas differing by differences of latitude, the other by differences in
epth of water. These differences in either case are not absolute
ut relative, depending on temperature and food supply, but, in a gen-
al way, we are not inaccurate when we speak of Arctic, Boreal, Tem-
erate, Subtropical, and Tropical mollusk-faunas, or those of the shores,
he shallows, and the abysses.

The waters immediately adjacent to the shores were long ago divided
y Forbes and other pioneers in marine exploration into zones or areas
according to the conditions characterizing them; as, for instance, the
aminarian zone or region of brown kelp, the Coralline zone or region
f stony algæ, etc. But for general purposes and to contrast the areas
of the whole sea, one with another according to their chief characteris-
tics, we may divide the entire sea bottom into three regions.

The first is that to which light can penetrate and therefore where marine vegetation can exist. This is the Litoral region, and in a general way, modified by especial conditions at particular places, it may be regarded as extending from the actual shore out to the limit of 100 fathoms. Beyond this it is practically certain that no light reaches the bottom of the sea and no sea weeds grow. Outside of this the borders of the continents slope gradually to the bottom of the ocean, which is found usually at a depth of about 2,500 fathoms.

On the upper parts of these continental slopes the conditions are often very favorable for marine life. Currents of comparatively warm water, like the Gulf Steam, sweep along, bringing fresh, pure water and supplies of food to the animals along their track. The division between the abysses and the slopes is rather a matter of temperature than of mere depth. But the temperature itself is somewhat dependent on the depth, the influence of the great warm currents rarely extending below seven or eight hundred fathoms, and this depth corresponds roughly to a temperature of about 40° F. Below this it diminishes as the depth increases, at the rate of about one-tenth of a degree to 100 fathoms until the freezing point is reached, though there is no reason to suppose that the abyssal water ever actually becomes congealed.

To the cold, dark area of the ocean bottom has been applied the name of the Benthal or Abyssal region, while that between the Litoral and Abyssal areas has been designated as the Archibenthal region.

DEEP-SEA MOLLUSKS.

While the average collector may not hope to explore the recesses of the Abyssal and Archibenthal regions, a few observations on the relative conditions which obtain there will assist in the comprehension of the general subject of the life of marine mollusks, and may therefore be permitted.

Deep-sea mollusks, of course, did not originate in the depths. They are the descendants of those venturesome or unfortunate individuals who, by circumstances carried beyond their depth, managed to adapt themselves to their new surroundings, survive, and propagate. Many species must have been eliminated to begin with. Others more plastic, or more numerous in individuals, survived the shock and have gradually spread over great areas of the oceanic floor. In accordance with these not unreasonable assumptions, we should expect to find among the newer comers at least some characters which were assumed under the stress of the struggle for existence in the shallows, and which, through specific inertia, have not become wholly obsolete in the new environment. We should also expect to find a certain proportion of Archibenthal species in any given area, identical with or closely related to the analogous Litoral region forms of the adjacent shores.

In the Abyssal region alone should we expect to find that any considerable proportion of the fauna has lost all its litoral characteristics, assumed characters in keeping with its environment and become disseminated over the ocean bottom throughout a large part of its extent. These expectations in the main are fairly satisfied by the facts as far as the latter are positively ascertained.

In order that their existence may be maintained the abyssal mollusks require oxygen to ærate their circulation, food to eat, and a foothold upon which they may establish themselves. It is necessary that the conditions should be such as will not prevent the development of the eggs by which successive generations are propagated, and that they do permit it may be assumed from the very fact that mollusks in large numbers have been shown beyond all question to exist on the oceanic floor wherever this has been explored.

In general it seems as if we might safely assume that the composition of abyssal sea water shows no very important differences from that of other sea water, and that the animals existing in it are not exposed to any peculiar influences arising from this source alone.

This can not be said of the physical conditions. Everyone knows how oppressive to the bather is the weight of the sea water at only a few feet below the surface, and how difficult it is to dive, still more to remain on the bottom, if only for a few seconds.

But it is difficult to convey any adequate idea of the pressure at such a depth as 2,000 fathoms, or about 2 miles below the surface.

Rope made impervious by tarring is said to have become reduced one-third in its diameter by a descent into these depths. Any hollow object not pervious or elastic is at once crushed. There is no doubt that at some points on the ocean floor the pressure may amount to several tons to the square inch.

If we recall that the average pressure in steam boilers is probably much less than 100 pounds to the square inch it may help toward an appreciation of the abyssal conditions.

The inevitable conclusion is, therefore, that all the animals living under these conditions must have their tissues so constituted as to permit the free permeation of the water through every part in order that the pressure may be equalized. How this is possible without putting an end to all organic functions is perhaps the greatest mystery of abyssal life. How can a large egg, like those of various deep-sea animals, pass through the stages of segmentation and development, with every molecule of its structure in actual contact with ordinary sea water and every solid particle subjected to a pressure of say a thousand pounds to the square inch?

Such questions are much easier to ask than to answer, in fact no attempt at an answer has, so far as I am aware, ever been offered to biologists.

The looseness of tissue necessary to such a permeation is conspicuous in abyssal animals, whose flabby and gelatinous appearance when they reach the surface is notorious. It is perhaps most noticeable in the fishes, which nevertheless are often armed with formidable teeth. But under the great pressures of the deeps it is quite conceivable that each of these loose and half dissolving muscles may be compressed and reduced to a condition resembling steel wire; and that the organization thus sustained may be as lithe and sinewy in its native haunts as its shallow water relatives are in theirs.

The operculum is generally horny in abyssal mollusks, frequently disproportionately small, compared with that of congeneric litoral species, and in a remarkably large number of cases is absent altogether.

The genus most abundantly represented of all is *Mangilia*, which is entirely without an operculum, and affords a conspicuous example of the obsolescence of protective devices, originally acquired in shallow water, resulting from long residence in the deeps.

In the Unio and Melania of fresh-water streams and the pond snails of our lakes and ponds, the waters of which from the decay of vegetable matter are overcharged with carbonic acid, we find a dense thin greenish epidermis developed as a protection against erosion. In the deep sea where every portion of the shell must be permeated by the surrounding element to equalize the external pressure, and where carbonic acid exercises its usual malign influence on the limy parts of all organisms, we find a strikingly similar protective epidermis developed in most unexpected places. Thus it comes about that in the *Trochi*, *Pleurotomidæ* and other characteristic abyssal animals we find those puzzling and remarkable counterparts of land and fresh-water shells which have astonished every student of the mollusca who has seen them.

The influence of darkness upon the inhabitants of the Abyssal Region has often been expatiated upon. The absence of visual organs or their preternaturally excessive development beyond the normal of the groups to which the individuals belong is evidence enough that the deeps are markedly darker than the shallows. But this evidence proves too much for the claim that the deeps are mathematically dark. Whatever notions may be entertained or conclusions deduced by the physicist from the premises, the presence of large and remarkably developed eyes in many abyssal animals shows that light of some sort exists even on the oceanic floor. It is inconceivable that these organs should be developed without any light and if the experiments and reasoning of the physicist result in the apparent demonstration of absolute darkness in the depths, the facts of nature show that in his premises or his experiments there lurks some vitiating error. It is ridiculous to suppose that the phosphorescence of certain animals in the deep-sea fauna is a factor of sufficient importance to bring about the development of enormous and exquisitely constructed eyes in a multitude of deep-sea species. A greater or general phosphorescence, such as would amount to a general illumination, has never been claimed by any scientific biologist and, as a theory, requires a mass of proof which seems unlikely to be forthcoming.

In general, then, we find the physical conditions simpler than those of the shallows, and yet much more energetic. The effect of temperature is marked in the distribution of life over cold and warmer areas of sea bottom. The relative importance of the effects of pressure, partial darkness, and of the quietness of abyssal waters, our knowledge is yet too imperfect to allow us to precisely estimate. All doubtless have their effect; some of the effects are more obvious than others, but it is by no means certain that the most obvious are necessarily the most important to the organisms concerned.

We are yet ignorant as to whether the abyssal and archibenthal faunæ shade gradually into one another, as seems most probable; or whether there is any line of depth, coincident with a temperature limit, which really fixes a boundary for the abyssal fauna.

To give the student some idea of the kind and distribution of life in the different benthal regions of the sea, two tables have been prepared which illustrate the peculiarities of the collection made during the past ten years on the southeastern shores of the United States and in the Antilles by the United States steamer *Blake* and recently reported on. It is probable that it offers a fair example of abyssal mollusk faunas, but this can not be claimed with certainty.

The first table shows the general numerical results for the *Blake* collection, assorted among the great systematic groups and the three bathymetric zones or areas. The second table shows the proportion to the whole population of the abyssal region borne by those genera which exceed a single species. The result here shown is that less than 37 per cent of the genera comprise more than 68 per cent of the species; and out of these, three families, *Pleurotomidæ*, *Ledidæ*, *Dentaliidæ*, furnish nearly 28 per cent of the species of the abyssal fauna collected by the *Blake*.

TABLE I.—*General numerical results.*

Groups.	No. of genera.	No. of species.	Species in the—			Species common to—		Abyssal fauna.	
			Litoral area.	Archibenthal area.	Abyssal area.	Two areas.	All areas.	Families.	Genera.
Brachiopods	7	13	8	12	3	8	2	2	3
Pelecypods	52	170	98	114	31	64	10	15	19
Scaphopods	2	35	17	28	12	17	5	1	2
Gastropods	119	491	280	222	83	161	32	29	41
Total	180	709	403	376	129	250	49	47	65

TABLE II.—*Genera represented by more than one species in the abyssal area.*

Genera.	No. of species.	Genera.	No. of species.
Mangilia	17	Fluxina	2
Margarita	5	Liotia	2
Pleurotoma	4	Leptothyra	2
Drillia	3	Cocculina	2
Marginella	3		
Scala	3	Leda	5
Calliostoma	3	Limopsis	3
Triforis	3	Pecten	3
Actæon	3	Abra	2
Utriculus	2	Myonera	2
Fusus	2		
Columbella	2	Dentalium	8
Benthonella	2	Cadulus	4

Total, 24 genera and 87 species.

For the naturalist of to-day the most interesting feature of abyssal life is not that it furnishes him with singular and archaic forms, useful in his study of extinct genera; nor the beauty and rarity of the creatures living under such unusual conditions. The most important characteristic of abyssal life is, that it, and it alone, exhibits a fauna in which reciprocal struggle is nearly eliminated from the factors inducing variation and modification.

Hence the course of evolution and modification, though still complex, is certainly much less so than in the shallower parts of the ocean. For this reason we may hope to penetrate more deeply into its mysteries with deep-sea animals than with those less fortunately situated. In this opportunity lies the chief importance of research into the biology of deep-sea mollusks. Nowhere else may we hope to find the action and reaction of the contending forces less obscure, and modification in most cases has not extended so far that we can not compare the deep-sea forms with their shallow-water analogues and draw valuable conclusions.

For an account of the methods and apparatus employed in deep-sea researches the student may be referred to the following works:

Three cruises of the U. S. Coast and Geodetic Survey Steamer *Blake* in the Gulf of Mexico, etc., by Alexander Agassiz. Boston: Houghton, Mifflin & Co., 1888; 2 vols. 8°. With many maps and illustrations.

Deep Sea Sounding and Dredging (etc.), by Chas. D. Sigsbee, Lieut. Com. U. S. Navy. Washington: Coast and Geodetic Survey, 1880. 4°. With many illustrations and supplement dated 1882.

MOLLUSKS OF THE LITORAL REGION.

The litoral region may be divided into several subordinate areas, the first of which is the beach, or litoral proper, between the extreme range of the tide or high and low water mark. The next has been called the area of sea-weeds or laminarian zone from the *Laminaria*, or long-leaved kelp, which grows in it. Its extent varies in different parts of the world, but in general is regarded as between the low-water mark of spring tides and a depth of about 15 fathoms or 90 feet of water.

Outside of the laminarian zone and extending to the limits of the penetration of light into the depths is the coralline zone, where the vegetation consists chiefly of stony algæ, or nullipores, and in which *Polyzoa* or corallines are most abundant. The outer limit of this zone is usually taken as 100 fathoms (600 feet), an arbitrary limit, but approximating to the truth.

Most collectors find their chief resource in the beach, where they obtain not only the mollusks proper to that region but many others cast up by the sea which normally inhabit the outer zones.

Those fortunate enough to secure the use of a rowboat and dredge, find a rich field accessible to them in the laminarian zone and the inner margin of the coralline zone. For work in the deeper parts of the latter a sailboat or small tug and a crew of several men are necessary for effective work, but the trouble and expense are well repaid by the rarities which can be secured in this and no other way.

The mollusks of the beach differ widely in different latitudes. In the north *Litorina*, *Purpura*, and various limpets frequent the rocky and stony shores, while near low water on the under surface of flat stones and under overhanging ledges several species of *Chiton* find a congenial home. Among the barnacles and under the profuse fronds of the bladder weed small Rissoids and the urnlike ovicapsules of Purpura are common. On the Californian coast *Haliotis*, *Acmæa*, and many Chitons abound in such localities. As we go south the fauna of stony beaches becomes richer, and a vast number of small shell-bearing and naked mollusks inhabit them. Where there is a mixture of stones and sand, large sea-anemones or *Actinia* live between the pebbles, often covered with fragments of shell and bits of gravel, amongst which careful examination often reveals many small shells sticking to the adhesive surface of the polyps. These must be secured by means of the forceps, as they are not easily detached.

On the sandy beaches will be found a special fauna, without taking into account the species thrown up by the waves from deeper water. *Natica* is one of the most common gastropods, and living specimens may readily be detected by the little mound of sand which they push before them as they plow their way just below the surface. *Nassa* is one of the most familiar forms in such places and, like *Natica*, is predacious, living on the flesh and juices of bivalves, which it seeks beneath the sand, drilling in their shells the small circular holes which may be noticed in the majority of the dead bivalves strewn upon the beach. In the south *Fulgur* is one of the largest and most common of the gastropods characteristic of the sand beaches, and its horny coils of ovicapsules, in the shape of angular spiny disks adhering by one edge to a connecting lamina, are among the most frequent objects on the shore. The drills, *Urosalpinx* and *Eupleura*, so destructive to young oysters, abound in many places. The bivalves exceed all others in the number of individuals. *Mactra*, *Petricola*, and *Macoma* in the north, with *Donax*, *Tellina*, *Venus*, and *Dosinia* in the south, are among the most conspicuous forms. Living specimens are usually concealed under the surface. Small holes in the sand, by which water obtains access to their siphons, indicate the spot they occupy. Advancing waves will often uncover thousands of small specimens of *Donax*, which disappear as if by magic as the water recoils. *Olivella* and *Oliva* frequent sand beaches near low-water mark and also are burrowers. In Florida *Strombus pugilis*, *Melongena corona*, and *Pyrula papyratia* are very abundant in such places.

On muddy flats, especially if somewhat sprinkled with gravel or pebbles, another set of mollusks may be found. *Mya* and *Petricola*, certain species of *Macoma*, and the mud-loving *Ilyanassa* are invariable members of the fauna and wherever a sprinkling of wiry salt-water grasses checks the motion of the water there one finds hosts of *Astyris*, *Cerithiopsis*, *Triforis*, *Bittium* and small species of *Odostomia* and *Mangilia*. A little further seaward where the water rarely leaves them are the oysters, with their attendant *Anomia*, *Crepidula* and little gastropods, not to mention the drills and other enemies varying with the latitude. In the narrow ditches commonly cut in New England for the quicker drainage of salt marshes as the tide recedes, *Littorinella* is often abundant with *Bittium* upon the vegetation. In half submerged beds of peat *Petricola* and *Zirphæa* live in borings which they enlarge as they grow, while the piles of old jetties or the softened wood of wrecks when split open usually reveal the borings of *Teredo*, *Xylotrya*, and *Martesia*, often containing the author of the damage. The canals of sponges, of the brittle sort known as "bread sponges," often contain small gastropods which take refuge there; and such sponges are common on the oyster beds and in the pools on stony beaches just below low-water mark, especially on our southern and southeastern shores. The crannies of old weed-grown seawalls are a good collecting ground and in such places and on floats and old piling some minute species usually occur which may be vainly sought elsewhere.

In tropical regions the coral reefs, whose tops are usually accessible at low water, have a rich and varied fauna of their own. The stems and aerial roots of the mangrove are favorite haunts of *Litorinidæ*, tree-oysters, *Cerithidea*, and the like, many of which remain for hours out of the water. In the mud at their base *Arca*, *Saxicava* and many others are almost inextricably mixed with the tubes of *Vermetus*, *Petaloconchus*, and various worms. When the roots extend into clear water they are a favorite haunt of the salt-water species of *Neritina* and of *Nerita*. Under the overhang of rocks and the sides of bowlders which stand between tide marks the amphibious *Siphonaria* and *Gadinia* may be found associated with chitons and true limpets. Among the pebbles at low-water mark may be found hosts of *Turbinidæ*, like *Uvanilla* and *Pachypoma*, *Trochidæ*, like *Chlorostoma* and *Liotia*, the slipper limpets, the cup and saucer limpets (*Crucibulum*), *Capulus*, and *Amalthea*. In gravelly places occur myriads of *Cerithium* and *Columbella*; while the cones prefer muddy places, the bivalves the sandy beaches, and the murices the rocks and oyster beds. The catalogue might be almost indefinitely prolonged, but the above hints will be sufficient to start any intelligent collector on the right track, when after a little experience he will not need more detailed suggestions.

OUTFIT.

For ordinary beach collecting the collector, beside pill boxes and vials for frail or minute specimens, and a supply of alcohol in one or two wide-mouthed bottles or screw-topped jars, will find a basket or bag convenient for the larger species; a knapsack of painted canvas being best, as fluids do not leak out of it. A hammer, or small pick and hammer combined, is frequently useful to crack rocks or coral for pholads, or rake the gravel for hidden gastropods. To dig out living bivalves a spade and a good deal of energy are required; such collecting is best made the subject of a special excursion. On the Pacific coast a small rod of three-eighths inch iron, hammered to a chisel-shape at one end and to a point at the other, is very useful in detaching *Haliotis*, or large chitons, from the rock. If the blow is sharp and unexpected the mollusk will usually fall without injury, and in many places a small dip net will be of use for securing it. But if the mollusk is irritated or disturbed before the collector strikes in earnest, it is better to pass on, for the creatures when aroused will hardly be detached without injury, so effective is their hold on the rock. The same is true to a minor degree of the limpets. If chitons are collected they should be placed on a narrow strip of smooth wood like a ruler, well wetted with salt water, before they have time to curl up. By putting them opposite one another and tightly winding soft twine, list, or lamp-wicking around both chitons and stick, they will be kept in a normal posture until the tissues are relaxed and they can then be preserved in spirits or cleaned. If this precaution is not taken they are apt to curl up in a shape which renders them almost useless for dissection or for cabinet specimens and they will break rather than flatten out. A large number may be set on a single stick. If, however, they curl before they can be set, it is best to put them in a pan of salt water when they will, if alive, eventually resume a normal position. A small sieve, with meshes of one-sixteenth of an inch, is often useful for sifting the sand out of drift material which collects at high water and along the ripple marks. This can be put in a bag or bottle and picked over at home. It is often very rich in small species. An old table knife is useful for detaching limpets or chitons from smooth rocks. The dip net, if the frame is solid and the meshes small, may be used to dredge out small bivalves from the loose sand near low-water mark or from the soft mud of marshy shores.

FAVORABLE LOCALITIES FOR SHORE COLLECTING.

In the preceding remarks a statement of the special habitat preferred by special groups has been embodied, and as conditions vary in different regions, the collector will find experience the best teacher in seeking favorable spots for his work. It may be said, however, that the richest fauna is likely to occur where a combination of varied elements constitutes the shore. A beach composed of a mixture of mud, sand, and gravel, or of mud and sand diversified by projecting rocks is always more fruitful in species than a stretch of exclusively sandy, rocky, or muddy shore. This is partly because of the varied conditions which suit a larger variety of mollusks, and partly because the same diversity of bottom promotes the multiplication of the organisms which serve the mollusks for food.

Again, as a reasonable degree of motion in the water brings to sedentary animals a larger supply of food than would otherwise be within their reach, we usually find points and headlands, or islets, washed by marine currents far richer in species than those beaches subject only to the ordinary ebb and flow of the tide.

Places where fishermen draw their seines are apt to afford specimens accidentally brought in from deeper water. The haddock and some other fishes live partly on mollusks, and therefore the bits of beach where fish are cleaned often repay a search, in spite of incidental annoyances common to such places.

The late Dr. A. A. Gould had a regular understanding with certain fishmongers that they were to empty the paunches of their haddock into a bucket of clean water, which was afterward strained off, the debris affording many rarities which could be obtained in no other way. The crops of sea ducks are often crammed with small bivalves, such as *Nucula* and *Leda.* Among other facilities for collecting which the markets of a large city afford, apart from the supply of edible species brought for sale, may be mentioned the mud which remains in the barrels in which oysters are brought to market. This will often afford a great many small species if washed and sifted.

Among other out-of-the-way places where rare and singular mollusks may be obtained are the burrows of crustaceans which are frequently inhabited by species of *Lepton.* This genus appears to be frequently commensal in its habits. Around the mouth and in the channels which radiate from that aperture, in such Echini as *Hemiaster*, a small commensal species of *Lepton* is frequently found. A burrowing crustacean (*Gebia pugettensis* Dana), living on Puget Sound and the coast of British Columbia, frequently carries under its abdomen a species of *Lepton*, attached to the crab by its byssus, as a lady carries a chatelaine bag at her belt. The margin of the shell is curved to fit the rotundity of its host, and the mollusk has not been found alive in any other situation. A minute hyaline gastropod (*Stilifer*) is an habitual parasite of starfishes, living half imbedded in the tissues, from which it sucks the juices. Another gastropod (*Thyca*) is more strictly commensal, and establishes itself near the anal opening of its echinoid host, from whose ejecta it is supposed to obtain sustenance. Very similar species belonging to the same family were semiparasitic on many paleozoic crinoids, growing as their host grew, remaining permanently in the same spot, and frequently inducing distortion in the echinoid thus ridden. A still more extraordinary case is that of *Entoconcha mirabilis*, a degraded mollusk which is an internal parasite of *Synapta*, a worm-like organism found on sand beaches. The *Entoconcha* is found as a sac-shaped mass in the intestine of the *Synapta*, only recognizable as a mollusk by the development of its eggs, which pass through the usual molluscan stages, while the larval animal possesses a small shell, afterward lost, as in the case of many Tectibranchs. The small gastropods which haunt the canals of *Cliona* and other "bread sponges" are probably commensals rather than true parasites, and find shelter in these passages while their food is conveniently brought to them by the ciliary currents kept up by the sponge.

Small mollusks may often be found in the stomachs of starfish as well as other marine animals. In the Arctic regions the walrus, after using his great tusks to rake *Astarte* and *Natica* out of their muddy bed, is in the habit of swallowing them whole. The shells, frequently little injured by their journey through the animal, may be found in large quantities on the rocky beaches where the walrus "haul up" on the shore. The roots of kelp and the branches of sea fans and other corals are the peculiar habitat of a few interesting and often very rare forms.

EGGS AND EGG CASES.

The eggs of bivalve mollusks are usually protected within the valves of the mother, and when the sexes are separate, as in a majority of bivalves, this habit results in the modification of the form of the female shell. In some species the larval mollusks cling to the gills of the parent, in others there are special pouches modified for their use, and these differences occur in most closely related species of one genus. In other groups, as in the cases of *Perna*, *Cardium*, *Poromya*, and *Cuspidaria*, the gills may be so attached to one another and to the mantle, or the siphonal septum may be so produced forward as to form a special chamber serving as a *marsupium* for the protection of the young. In gastropods the whelks deposit their eggs in horny or leathery ovicapsules generally anchored to some stationary body. The prickly coils of the egg cases of *Fulgur* have been already referred to. *Buccinum* deposits its capsules in a heap like grains of corn but so arranged as to admit the sea water to every part. They are commonly placed on or in some dead bivalve. The ovicapsules of *Purpura* stand on end, like little vases in groups upon the rock, usually under the bladder weed. *Chrysodomus* heaps its capsules in a cylindrical tower sometimes six inches high. *Voluta* and *Strombella* have a few large eggs in hemispherical or lenticular capsules an inch across. One species has a large, floating, spherical capsule. There are many gastropods whose eggs are not protected in this way. The nudibranchs lay theirs in a jelly-like mass, string, or coiled ribbon among the marine vegetation. The *Calyptraeidæ* protect their small yellow ova in a jelly-like mass between the muzzle and the front of the foot under the parent shell. At such times a strip or fringe of thin tissue, which runs along each side of the neck, becomes greatly enlarged and is wrapped about the egg mass as a mother would wrap her infant in a blanket. Of the eggs of a great majority of marine mollusks nothing is known, and here there is a most interesting field for study and observation.

ENEMIES AND PARASITES.

Sea mollusks are the prey of marine animals in general, and feed to some extent upon each other. There are no special or peculiar enemies except the boring sponge (*Cliona*), which riddles shells and other limy bodies with a network of small canals and chains of perforations familiar to every collector. Some *Polyzoa* erode the surface of shells to which they are attached and when removed leave marks resembling the pits on a thimble, often regularly arranged and sometimes taken for a normal sculpture by the unwary or inexperienced student.

COMMENSAL ORGANISMS.

Various worms and crustacea are commensal with mollusks, of which the oyster crab (*Pinnotheres*) is a most conspicuous and familiar instance. The shells infested by commensal worms are sometimes abnormally modified by their presence. On the other hand, a curious little mollusk (*Cochliolepis*) has been described by Stimpson, which lives only under the scales of an enormous annelid (*Acoëtes lupinus*) common in the harbor of Charleston, S. C.

The collector whose tastes and opportunities lead him to study the habits of life of mollusks can hardly fail, if patient and accurate, to add greatly to our knowledge. The literature of molluscan biography, if it may be termed so, is meager to an extraordinary degree. No better field for research can be imagined, and with experience it is found that the (apparently) most trifling details may have an important bearing and value.

DREDGING.

THE CONSTRUCTION AND USE OF THE DREDGE.

The dredge has been in use among naturalists since the last century. The form commonly in use for many years was that invented by Otho Frederick Müller, a Danish naturalist, and it is this form which is described in most of the text-books on conchology.* This instrument was composed of a rectangular frame of iron, with two movable arms extending forward, and with two large pieces of rawhide attached by wires to the hinder edges of the rectangle. The sides of these two pieces of rawhide were caught together with wire or twine in such a way as to make a net. This form of dredge is very inconvenient because, when not in service, the hide shrinks, dries, and becomes very hard, requiring to be soaked a long time in order to be fit for use; it is also difficult to turn such a net inside out in order to get at the contents of the dredge.

The modern dredge has been improved by Stimpson, and by the author of this paper. It consists, like the other, of a rectangular frame (Fig. 1), the sides being shorter than the upper and lower portions of the

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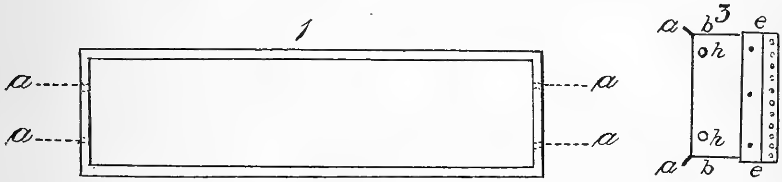
* See Woodward's Manual, edition of 1871, p. 141, figs. 33, 34.

rectangle. The lower and upper edges in front are hammered so as to flare a little, like the edge of a chisel, (*a*, *a*, Fig. 2) thus plowing up the bottom over which the dredge is pulled. The edges of the short vertical sides are left without this bevel. In each side are two holes, (*h*, *h*, Fig. 3) in which are inserted the Y-shaped ends of the arm (Fig. 5) of each side, made of a slender (about three-eighths of an inch) iron rod. The anterior part of each arm ends in a ring formed by turning the end of the rod round. Parallel with and near to the back edges of the frame is punched a row of holes, as many as may be convenient. By means



FIGS. 1 and 3.—Dredge frame.

of rivets through these holes a thin strip of galvanized iron is attached, extending, on the outside, entirely around the back edge of the rectangle. The hinder edge of the galvanized iron extends about an inch behind the hinder edge of the frame. This is perforated with a row of small holes about an inch apart, extending entirely around the edge. To these holes a net (*d*, Fig. 2) and two flaps of stout canvas (*c*, *c*, Fig. 2) are laced with copper or galvanized iron wire. The object of the strip of galvanized iron is to hold the net away from the iron frame, which always rusts. This rust would very soon destroy the net, but if the latter is separated from the iron by the galvanized strip which does not rust, a single net may sometimes be used for a whole season, without need of repair. The

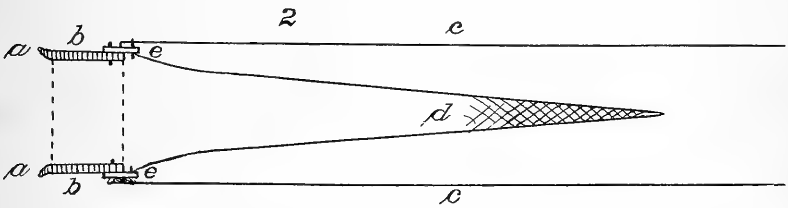
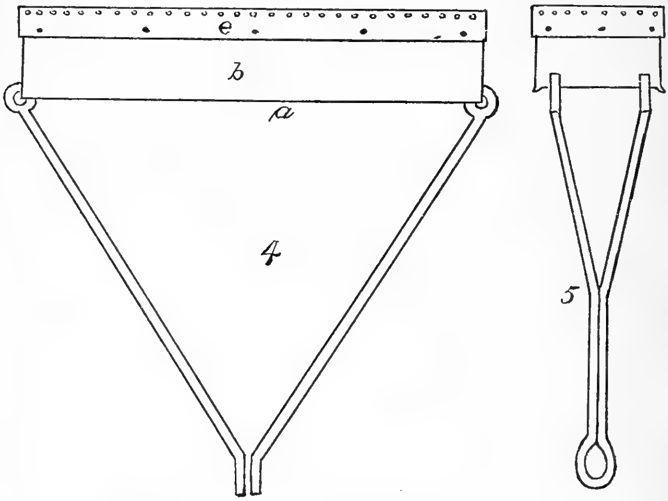


FIG. 2.—Dredge frame with net and canvas.

edge of the net to be laced on is placed inside of the galvanized iron. The front edges of the two strips of canvas are placed outside. These strips of canvas should be a little wider and about a foot longer than the net when it is wet and stretched. The lacing is done by sharpening the ends of a piece of copper wire or well galvanized wire, making holes in the canvas with an awl and passing the wire in and out as if sewing, so that the edges of the canvas, of the net, and the thin strip of galvanized iron are closely and carefully fastened together. The object of the strips of canvas is to receive the friction of the bottom, thereby preventing undue wear upon the net. As in sinking the dredge they are very apt to curl over and get into the mouth of it, it is usually best to tie the lateral edges of the upper and lower flaps to each other, in one or two places with stout twine, which holds them in their place. The net itself can be turned inside out, and the dredge emptied without disturbing the flaps.

To have a dredge constructed, one should go to a blacksmith and not to a machine shop. The size of the rectangle forming the frame will differ according to the necessities of the case. If the dredge is to be used in a small boat in shallow water, it may be smaller and lighter than if it is to be used in a larger vessel, a sail-boat or by the aid of steam. The average dredge, for moderate depths of water to be used in a row boat, should be made of half-inch bar iron. The bar should be about three inches in width, and its length should correspond to the total circumference of the rectangle to be made, with a small allowance



FIGS. 4 and 5.—Dredge frame, showing arrangement of arms.

for welding. The holes for the rivets are to be made and the beveling of the upper and lower edges is to be done by the smith before he bends his bar into a rectangle. After the rivet-holes have been punched, and the edge properly fashioned, two half-inch holes should be made in that portion of the bar intended to form the vertical sides of the frame. These holes are intended for the arms. After all the holes have been punched, the bar may then be bent into the proposed rectangle and the ends welded solidly together. A convenient form is 20 inches from side to side, and 5 inches in height. The arms should be made of nail-rod and inserted in the holes which have been made for them, but the circle which the ends describe through these holes, inclosing the front edge of the frame, should be sufficiently large to allow the arms complete freedom of motion. The form of the arms will be seen from the figure. When in use they should form with the frame an equilateral triangle.

The ring at the front end of each arm should be bent vertically so that when the two arms are brought together in front of the dredge the two rings will be exactly opposite, and lie flat against each other. For the galvanized iron a strip about 2 inches in width is sufficient. This also should have the holes for the lacing punched into it and filed smooth before it is riveted to the frame, as it is much more difficult to do it afterward.

Suitable nets made expressly for dredges can be obtained from the Gloucester Net and Twine Company, Boston, Mass., or from any other manufacturers of nets. The net when dry is usually about 2 feet long; the meshes of the front part of it about half an inch in diameter. The bottom of the bag has smaller meshes, and is usually made double, or with double twines. Various sizes can be had to fit the dredge by mentioning the size of the frame in the order.

In deep-sea dredges, used by steam, it has sometimes been found that when the dredge first reached the bottom it cut so deep into the soft mud as to fill itself full at once, thereby preventing anything else from getting in. This difficulty was remedied by fitting a pair of wooden runners to the sides of the dredge, which would not allow the edge of the dredge to cut into the bottom until it had assumed a horizontal position. In ordinary dredging no precaution of this sort is necessary, since the dredger after a little experience will learn to regulate the length of the line and the position of the dredge for himself.

In attaching the dredge to the line it is usual to have a short piece of rope permanently attached to the frame. This rope may be 10 or 15 feet long. The front end is spliced to form a loop about 6 inches long. Into this loop the long dredge-line can be knotted when it is needed for use. The other end of the short rope is passed through one of the rings at the front end of one of the arms, then along the arm to one of the rings by which the arm is attached to the frame. Here the line is solidly fastened. When in use, the front ring of the other arm is attached to the opposite ring, through which the short rope passes, by means of a piece of ordinary twine, and it will be observed that the rope in no case should pass through both the front rings of the two arms. This is because it frequently happens that a dredge on the bottom may catch upon a bowlder or on other obstructions too heavy to be moved. If the rope passed through both arms of the dredge, the latter could not be raised, and therefore, with the line attached to it, would be lost. But when one of the rings only is tied with twine, by pulling hard upon the line the twine may be broken, and the two arms of the dredge will pull out straight and the latter may be recovered without damage.

In order to prevent the dredge from being raised above the surface of the bottom at its front edge by the inclination of the line to which it is attached, it is usual to attach a weight to the line some distance in front of the dredge, which makes the part of the rope behind that weight assume a more horizontal position. A convenient weight for this purpose is a heavy sash-weight (A, Fig. 6) such as is used for windows by builders. The size to be used will depend upon the depth of water in which work is to be done, but a 10-pound weight is sufficient for ordinary purposes. It will be found convenient to roll the weight up in a strip of old canvas, and have it sewed securely, leaving some of the canvas in front and behind the two ends of the weight. This can then be sewed securely to the line with stout twine and will not require to be taken off. The author has found that in depths not exceeding 20 fathoms it was sufficient to attach the weight to the short line fixed to the dredge, just behind the point where the short line is attached to the long dredge line. For greater depths of water it should be placed further in advance, and in deep-sea dredging at a considerable distance, owing to the great length of the line used. For the latter work a weight of 50 to 100 pounds is sometimes needed.

ON THE USE OF A DREDGE IN A ROW BOAT.

Unless the dredge is very light and the water shallow, it is better to have two hands to pull the boat. The boat should be stout and steady,

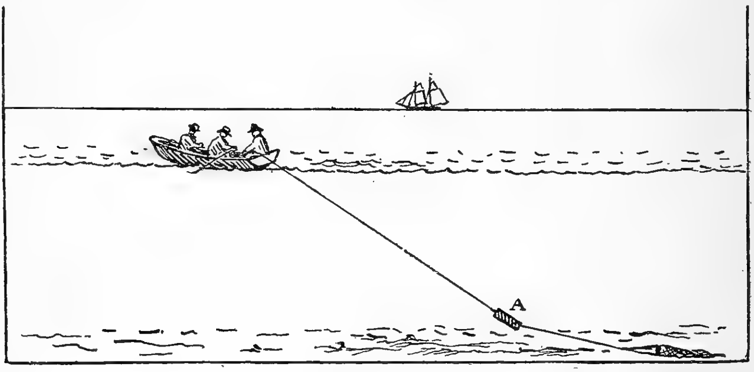


FIG. 6.—Method of using the dredge.

sufficiently large to hold its own well in the water and sufficiently heavy to avoid being anchored by the dredge when it touches the bottom. For most purposes one of those heavy boats used on sailing vessels, known as a ship's dingey, is perhaps the most suitable. The ordinary small light row boat, used for pleasure, is ill-suited for dredging purposes. There should be at the back end of the boat a sufficiently solid seat for the dredger to brace his feet against while standing up in charge of the dredge rope. It is advisable also to have room enough between the stroke oar and the dredger to set a tub for the purpose of holding the dredgings. It will also be found more convenient for each man, if two are employed, to pull a single oar rather than two. On getting to the dredging grounds, the dredger, after making sure that his line is clear, free from knots and twists, and securely fastened to the dredge, that the net in the dredge is not turned inside out, but is in its proper position, and that the canvas strips are straightened out behind the frame, can proceed to do his work. The dredge should be put over the stern, the rudder having been unshipped, and allowed to sink gradually, the line being paid out quickly enough to allow the frame to sink faster than the canvas attached to it. In this way fouling will be avoided. The boat is better stationary while the dredge is being dropped. The long line used for the dredge is best of good soft manila rope, about three quarters of an inch in diameter. It should be coiled two or three times before being used, to take out kinks. Although a smaller line will do for shallow water, it is less convenient to handle. If the depth is considerable and the dredger supplied with only a moderate amount of line, it is perhaps best to fasten the inner end of the long line to one of the thwarts to avoid its being jerked overboard by accident. When the dredge is felt to touch the bottom, the men can begin pulling slowly. The dredger will pay out line enough in shallow water to the amount of at least twice the depth; in deeper water three times the depth may be needed. After some experience the dredger will find that no absolute rule in this matter can be laid down; that he will need a shorter line on muddy bottom than on hard bottom, in shallow water than in deep water, and that he may find it convenient, from time to time, to alter the amount of line paid out to meet the circumstances of the case. After the necessary line has been paid out the dredger will allow it to pass over the stern of the boat in the notch cut for the sculling oar, since, if the line is not amidships, it will be impossible for the men pulling the boat to pull straight forward. A turn may be taken around a cleat with the line, but the dredger should take hold of the line outside of the cleat with his hand, and continue to hold it. He will soon be able to recognize by the feeling of the line whether the dredge is passing over smooth bottom or rough bottom, whether it is biting into the bottom or not, and so on. If, after starting, the line remains quiet in the hand without transmitting any quivering motions, the dredge is probably not on the bottom, and more line requires to be paid out; or, if it is on the bottom, it is possible that it may have become fouled so that nothing is getting into it. When it is doing its duty, the dredger can not fail to perceive the peculiar sensations which are transmitted along the line. If the dredge catches on anything which holds it, one or two quick jerks on the line will probably release it. The length of time that the dredge should be towed varies with the conditions. On gravelly bottom, mixed with mud, a comparatively short time will be necessary to fill the dredge, when it may be hauled in. On sandy bottom, if it be not rich with life, the dredge may be hauled for a long time before it accumulates any considerable amount of material. All these things can be only briefly referred to here, since they are much better learned by experience. When the dredger thinks the time has come for hauling in, the rowers cease pulling, and he hauls in the line until the dredge is on the top of the water; but before taking it over the edge of the boat, it is usually well to look into the mouth of the dredge to see if any very delicate specimens are there. When the dredge is emptied these would naturally be under everything else, and it would be better to take them out, if present, before emptying the dredge. The dredge can be emptied directly into the tub in the boat if it contains material which needs to be carefully examined. If, on the other hand, the contents are chiefly mud, it will be convenient to move it up and down in the water outside of the boat, and thus wash away a portion at least of the mud before taking it in. The dredger should take a note of the depth of the water in which the haul was made, which must necessarily be averaged; of the kind of bottom—muddy, sandy, gravelly, or weedy—and of the date. The writer has found it convenient to go out supplied with a number of nested wooden tubs, such as are sold for household purposes. The contents of the dredge after each haul can be put into a tub by itself. After all of the tubs are filled, it will be well to examine the contents in order to avoid carrying around useless material. If the dredger is near shore the most convenient way is to pull to the beach, provided there is no surf. Being provided with a wire sieve, of about a quarter-inch mesh, mud and fine gravel can be screened and the contents placed in jars, tin pails, or other receptacles, with the memorandum of the haul, so that no mistakes shall afterward be made in regard to the locality.

The proper method of using the sieve is to fill one of the tubs with water, then place some of the mud upon the sieve, which should be about one-half submerged, so that water will enter it to about one-half the height of the rim of the sieve, yet not so deep that the contents of the sieve can be washed over the rim. By using a rotary motion it will soon be found very easy to wash a considerable quantity of mud in a short time. In washing, the dredger will observe whether there are small shells or other objects so small as to go through the meshes. In case he finds this to be so, after he has washed out a certain quantity of mud, he can pour off gently the muddy water in the tub, and replace it by clean water, and by doing this repeatedly before the mud has time to settle he will find the small shells tolerably clean at the bottom of the tub. If foraminifera or other microscopic objects are desired, it will be necessary to preserve some of the mud, either in a wet or dry condition, for examination at home. If the contents of the dredge are not muddy, much less trouble is necessary in handling them. The richest bottom is usually gravelly, and this can be washed in the dredge itself before it is taken into the boat. Usually it will pay the dredger to take his tub of gravel home and examine it at leisure, since the necessary care can rarely be given in the midst of the operations of dredging. If, as sometimes happens, the dredge comes up nearly filled with pieces of kelp, or rolls of seaweed, these should not be hastily thrown overboard, since many animals live in and upon the fronds of weeds, and a careful examination will almost always repay the dredger very well. When the dredge is emptied, the net should be turned inside out before it is returned to the bottom, and thoroughly washed, so that animals obtained at one haul shall not accidentally become mixed with those of the next.

THE USE OF THE DREDGE WITH A SAILBOAT.

In dredging from a sailboat deeper water can be reached than is convenient with a row boat. A person unaccustomed to the use of a sailboat will find it necessary to obtain the services of some one who is, since the management of a boat of this kind hampered by the weight of a dredge and line is no easy matter. If supplied with a competent sailing-master the method of work will differ little from that used in a row boat, except that the direction in which dredging can be done will be limited by the direction of the wind, and, by way of compensation, a much larger space of bottom can be dredged over in the same time.

Use of the trawl net.—In collecting with a sailboat it will often be found advantageous to make use of a trawl. The ordinary trawl consists of an iron frame somewhat like the two runners of a sled, fastened to each other by a heavy bar of iron, to which a large net is attached. The lower edge of the net in front is weighted with oblong leaden sinkers, so as to drag upon the bottom. A trawl of this kind is much used by fishermen, and sometimes in obtaining oysters. Such a trawl, though the coarseness of the meshes renders it unfit to collect minute material, will nevertheless frequently bring up dead shells, stones, and other objects of larger size covered with sessile animal life, together with large-sized mollusks, and in this way specimens may be obtained which it would be difficult to obtain by means of a small dredge. The improved trawl used in deep-sea dredging will be found described in works on deep-sea dredging, to which reference has already been made. In case the collector has an opportunity to accompany a fishing vessel on a trawling expedition he may obtain interesting forms which are brought up with the fish and other commercial products of the sea.

The trawl line.—Line fishermen use the word *trawl* in another sense, applying it to a line buoyed at each end, to which baited hooks are attached at short intervals, and which is set for fish. On this sort of a trawl, or, more properly, trawl line, large carnivorous mollusks frequently attack the bait, and when the fisherman examines his line, are often found sticking to it. A species which can not be dredged, owing to the irregular and rocky character of the bottom, may sometimes be obtained by making arrangements with fishermen to save the shellfish which they find attached to their trawls.

The baited net.—Another mode of collecting, which is available for persons having the use of a boat, over bottom which does not admit the use of the dredge or trawl net on account of its irregularity, is by means of a net such as is ordinarily termed a crab net by fishermen. Such a net is circular and attached to a large wooden hoop from 6 to

10 feet in diameter, according to the size of the net, and stretched with very little slack, so that when the hoop is held horizontally the net will not fall below it more than a foot or two at most. This hoop is attached by four cords, fastened to it and meeting over the center of the net at a distance of 6 or 8 feet from the hoop, to a line of sufficient length to reach the bottom, which is supplied with a small buoy at the surface. In the center of the net a bait is tied, preferably of dead and even partially decayed fish or flesh, since the carnivorous mollusks are apt to be attracted by the odor of any decaying animal matter. The net can be put down and left a convenient length of time and then hauled up. This should be done very carefully, so that the net will keep as nearly as possible in a horizontal position, and if any mollusks have crawled upon it to get at the bait they will be found in the slack of the net when it reaches the surface. If the net is hauled up incautiously, so as to turn it over or tip it sidewise to an inconvenient angle, of course the collector is likely to lose whatever may be upon it. In the writer's experience the most productive time for the use of such nets is at night, and it will be often found advisable to put the net down in the evening and raise it early in the following morning, when the results will be usually found more satisfactory than if the net has been merely allowed to remain on the bottom during the hours of daylight. In northern waters the collector is sometimes disappointed by the voracity of isopod crustacea, which appear in such swarms as to devour the bait in short order.

STEAM DREDGING.

If the collector lives near one of the larger cities, where small tugboats can be had for moderate hire and good dredging grounds are not too far off, it will be found profitable to obtain the use of a tug on some convenient occasion, since dredging by steam is far more effective, more rapid, and more easy than by any other method. The handling of the dredge is practically the same whatever power be used to drag it, but the use of a tugboat reduces the inconveniences to a minimum and enables the collector to go over more ground in the same time than can be covered by any other method. A search for suitable dredging grounds will require some experience and time. Usually grounds found available for ordinary line-fishing, if the water is not too deep, will be profitable for dredging, unless the bottom be very rocky and irregular. Inquiry of fishermen and watermen will often save a collector time and trouble, for such men are familiar with the grounds over which they are accustomed to fish and can designate the particular kind of bottom from long experience.

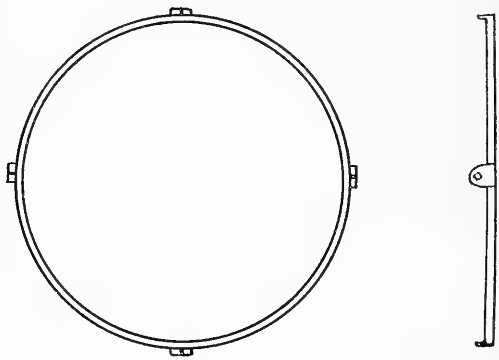
OUTFIT.

Besides the coarse sieve already mentioned the collector may, if he likes, provide himself with a finer sieve for sifting fine sand and mud which has already been passed through the coarse sieve, but in practice the writer has not found this necessary. Most of the text-books direct a collector to have two sieves, one fitting into the other, the one coarser and the other finer; but, in the opinion of the writer, this is not only unnecessary, but objectionable. After trying sieves fitted in this manner he has had no satisfactory results. The motion of the sieve and the friction necessary to pass material through it are injurious to delicate specimens and should be reduced to a minimum. If the material being sifted is shaken and riddled through two sieves at once, without reference to its character, nothing of a delicate nature is likely to survive the process, and it is always better before sifting any of the material to look it over to some extent and to pick out such specimens as may be noted in order to save the injury to which they are liable if they are put into the sieve. Delicate objects, like naked mollusks, would be ruined by being sifted; in fact, if possible, they should be taken out of the dredge or landing-net and put immediately into separate cups of salt water until the collector is ready to prepare them for preservation. Similar care may be needed for other delicate objects, and for this purpose it may be convenient for the collector to provide himself with an ordinary box, like a candle box, to which the lid has been attached with leather or other hinges, and around the sides of which, inside, a strip or two of leather has been nailed, leaving loops large enough to fit a number of wide-mouthed glass bottles. These bottles may be filled with sea water and will serve to preserve temporarily the objects which the collector may desire to protect from injury or to study in a living state. A more troublesome, but perhaps more elegant, manner of reaching the same end is to have a thin drawer or shelf fitting the inside of the box and supported by a ledge on either end at a proper height, in which shelf circular holes have been cut fitting the jars or bottles used for this purpose. A landing net, such as has been previously described, would also be convenient on some occasions, and the outfit of tubs has already been spoken of. A bucket or water pail, especially one with a nozzle, will be found convenient in dipping up and pouring salt water for washing the collections.

When the dredger returns from an outing the dredge should be thoroughly cleaned and hung up where the air can get at it, so that it will dry thoroughly and the net and flaps will not rest anywhere upon the iron frame. By following these simple precautions a single net can be made to last a long time, but if rolled up while moist, or kept in a moist place, the net will often mildew and become worthless. These hints will be sufficient to start a collector in his dredging work. Each man, after some experience, will work out methods of his own or invent labor-saving devices or conveniences for use in his dredging work. All that the writer undertakes to do in the present case is barely to outline the mode of operations.

ON THE USE OF THE TOWING NET.

The towing net is an accessory to the collector's outfit which sometimes produces very desirable results in the way of collections. This can be used but little, except with a sailing vessel. The frame of the towing net is a circle of brass wire with four small loops of wire attached to it solidly, at equal distances apart (Figs. 7 and 8). To the frame is sewed a net made of cheese cloth, mosquito netting, or, preferably, of bobbinet. The border of the net, which is to be sewed over the brass ring, is best made of ordinary cotton cloth doubled and sewed over the wire. Between the doubled hinder edges of the cotton the bobbinet or mosquito netting may be fastened so as to form a conical net of the diameter of the ring and about 2 feet in length. If the netting is sewed directly over the wire it will give way much sooner than if cotton cloth is used for this part of it. To the loops referred to four small cords, ordinary cod line being a desirable size for the purpose, are securely fastened and knotted together in front of the ring, at a distance of about 3 feet.



FIGS. 7 and 8.—Towing net ring.

Care should be taken that they are exactly of the same length, so that when the net is suspended by the knot at that junction the ring will hang perfectly horizontal. In front of the knot is attached a line of suitable length, which may also be cod line, and this is made fast to the rail of the vessel. A sufficient amount of line is paid out to enable the net to drag evenly at the surface, with a small portion of the ring showing above the water. If too little line is paid out the net will jump and will not sink deeply enough to be of much service. If too much line is given to it it will sink too deep and lose those organisms which have the habit of floating on the surface. It is better to attach the towing net to the vessel's quarter rather than directly over the rudder, since refuse thrown overboard is very apt to drift in the ship's wake, and, if the net is towing directly aft, to drift into it. If the vessel is going at a moderate rate of speed there will be no difficulty in using the towing net. A little experience will show whether the circumstances are favorable for its use or not.

The mollusks obtained by use of the net are chiefly larval forms of gastropods, which float on the surface until they reach a more advanced stage of development—*Ianthina*, pteropods, and the so-called heteropods. True pelagic organisms are usually not found very near the shore, unless some ocean current strikes in toward the shore in the vicinity, but on short voyages, or long ones, large numbers of extremely interesting and usually very rare species may be obtained in this way. The length of time the net should be left over will depend upon the weather and upon the region traversed. In the tropics a short time will afford good results. In northern seas the net may sometimes tow for hours without many specimens being obtained. The most favorable time for its use is from a little before sunset to a short time after sunset, since many of these creatures seem to have the habit of coming to the surface at that time of the day and remaining at greater depths during the rest of the twenty-four hours. At the same time it may be noted that towing done at almost any time of day may produce good results, for all of the species do not have the crepuscular habit.

Many of these animals may be obtained alive, put into a tumbler of sea water, and preserved in a living state for a day or two at a time if the water is kept fresh. It is desirable that water-color sketches showing the form and coloration of these pelagic organisms should be made from life, as their tissues are very contractile and when preserved in alcohol shrink irregularly, so that the normal form is difficult to make out. With these mollusks will be obtained many curious crustaceans, and occasionally pelagic fish or fish larvæ and pelagic animals like Salpa and various medusæ, most of which are never found near shore. Several naturalists have experimented with towing nets which were made to be sunk below the surface, closing by a peculiar mechanism, so that at a given depth they could be opened in order to obtain animals proper only to that particular depth. These experiments, however, belong rather to the domain of deep-sea dredging and collecting, for information in regard to which the inquirer is referred to the works previously cited.

PRESERVATION AND PREPARATION OF COLLECTIONS.

After the collector has brought home the spoils of his excursion there is still a good deal to be done before the wet and dirty shells, covered with parasitic growths or inhabited either by the original mollusk or some hermit crab, will be ready to be placed in the cabinet. Some of them, if living, may find a temporary place in an aquarium for the study of their habits, but, for the most part, the collector will wish to prepare his specimens either for anatomical use in the future or as dry specimens for his cabinet. The preparation of mollusks for anatomical purposes has been described in a special chapter of these instructions. For ordinary rough work nothing is better than clean 90 per cent alcohol, diluted with a proper proportion of water. If the specimens are large they should first be put into a jar kept for that special purpose, in which the alcohol is comparatively weak, having, say, 50 per cent of water added to it. After the immersion of specimens in this jar for several days the fluids will have been extracted by the alcohol, and a specimen can then be removed, washed clean of mucus and dirt, which will almost always be found about the aperture of a spiral shell, and placed in its own proper jar of 90 per cent alcohol diluted in the proportion of about 30 per cent with pure water. Specimens to be prepared for the cabinet require the removal of the soft parts if they are still present, the cleaning off of parasitic or incrusting growths, and, in the case of bivalves, securing the valves in a convenient position for the cabinet. The different classes of shells may be treated of under several heads.

LAND AND FRESH-WATER SHELLS.

Land and fresh-water shells are much more easy to deal with than marine shells. In the case of spiral shells, such as *Limnæa*, *Planorbis*, *Paludina*, etc., the shell may first be washed clean of mud or comfervoid growth, which may be conveniently done with the assistance of an old tooth or nail brush. In the case of these forms the easiest way to remove the soft parts is to place the shell for twenty-four hours in weak alcohol, after which those parts can readily be removed; but in any case where the expense of alcohol is an object to be avoided, it will be sufficient to place them in a small tin kettle, or other receptacle suitable for the purpose, and cover them with cold water; which should then be slowly brought to the boiling point. As soon as it has reached the boiling point it may be removed from the fire. The shells should not be put into water already boiling, as it frequently cracks delicate shells, and the sudden change of temperature injures their polish and general appearance.

For removing the soft parts from spiral shells the collector will usually find a crooked pin sufficient. For this purpose one of those long steel pins used by ladies as hat pins is convenient. By heating the pointed end in the flame of a candle or alcohol lamp the temper can be taken out of the steel, so that it can be readily bent into any shape desired. The proper form for reaching the retracted parts in a spiral shell will of course be a spiral. With a small pair of plyers, different forms can be experimented with, and those which are most satisfactory decided upon. After the right form has been obtained, by heating the pin again and plunging it suddenly into cold water the temper of the steel will be measurably restored and the instrument ready for use. Similar pins in their ordinary condition are convenient for cleaning out sand or parasites from the recesses of sculptured shells, and for other purposes. The attachment of a gastropod to its shell is at the central axis or pillar of the shell, usually from half a turn to a turn and a quarter behind the aperture. By applying the pressure of the extractor carefully in this vicinity the attachment will give way and the extractor may be withdrawn, bringing with it the soft portions of the animal. In large and heavy shells, in which the muscular attachments are strong and deep-seated and it is desired to obtain a good hold of the animal in order to extract it from the shell, ordinary steel fish-hooks may be used. These may be softened by heat, straightened out, and twisted into a spiral of the proper form, and retempered. Then they can be securely fastened to small wooden handles by the shank of the hook. In this way the barb of the hook will assist in retaining the soft parts on the extractor when it is withdrawn from the shell. Several German firms advertise sets of implements for cleaning, cooking, and extracting the animals from shells of mollusks, but it would seem to the writer that any person of ordinary intelligence and some little mechanical ingenuity, such as all naturalists are expected to possess, should be able to provide himself with the necessary apparatus without purchasing expensive paraphernalia of this kind. Shells which have no operculum require merely to be cleaned after the animal has been removed, and in the case of land and fresh-water shells this is usually a very simple matter. Shells which possess an operculum should retain it in the cabinet, as it is often of great value in determining the relations of the species, since the operculum is a characteristic feature in the economy of the animal. It should be detached from the body of the animal after the latter has been extracted from the shell, carefully washed and cleaned, and if flat and horny may be dried between two pieces of blotting paper, under a weight. This will prevent it from becoming contorted in the process of drying. For removing the thick incrustation of lime and peroxide of iron which frequently forms upon fresh-water shells, a few tools resembling engraver's tools or the little chisels in use by dentists for excavating teeth are very convenient. A suitable tool, however, can easily be made by softening and grinding down an old file to a triangular point. A little experience will enable the collector to become expert in scaling off the objectionable matter without injury to the surface of the shell.

Naked slugs should be preserved in alcohol, after being sketched in the living state. Some of the older naturalists had a way of skinning slugs, inflating and drying the empty skins for preservation in their collections, much as entomologists sometimes treat caterpillars; but this ingenious device has nothing to recommend it to a scientific collector, even if he has the dexterity to practice it. The internal shell of such slugs as *Limax* may be represented in the collection if desired, but, in any case, specimens should be carefully preserved in spirits.

The bivalve shells, such as *Unio*, if taken alive, may be left in the sun for a short time, when they will usually open, and, the muscle connecting the two valves being cut, the valves may be cleaned. It is desirable for cabinet purposes to preserve the two valves in their natural position, attached to each other by the ligament which holds them together in life. This ligament dries to a very brittle, horny substance. Consequently the shells must be placed in position when fresh, in order to make a success of the operation. After cleaning away the animal matter and thoroughly washing the interior of the shell, it is a good plan to note the locality with a soft lead-pencil upon the shell itself. Then bring the two valves together in their natural position and tie them in that position with a piece of tape or soft twine, which should be allowed to remain until the ligament is thoroughly dry. Specimens prepared in this way are more valuable for exchange and more attractive to the eye than those with which less care has been taken. It is always desirable, however, to have some specimens with separated valves of every bivalve species in the cabinet, in order that the characteristics of the interior may be easily examined.

Fresh-water bivalves are usually covered with a thin and highly polished, often very elegant, greenish or brownish epidermis. Sometimes the shell is so thin that, in drying, the contracting epidermis splits and cracks the shelly portion so that it becomes worthless for the cabinet. This often happens with marine mussels, but is almost characteristic of the thin fresh-water *Unionidæ*. Various methods have been adopted to prevent this unfortunate result. Some collectors have varnished their shells immediately after they were obtained. Others have used sweet oil or other oils in the hope of keeping the epidermis in a soft condition. These applications are all objectionable for one reason or another, as the first endeavor of the collector who desires to make a really scientific collection should be to keep his specimens as nearly as possible in a perfectly natural condition. The most satisfactory substance for application to the shells in question is probably ordinary vaseline, which should be applied in very small quantities, so that the specimen will have no greasy feeling and will absorb the vaseline sufficiently not to become sticky to the touch. Glycerine, which has been recommended by several collectors, like oil, leaves the surface sticky and offensive to the touch, besides rendering it liable to catch everything in the way of dust with which it may come in contact.

Very small gastropod shells need not have the soft parts removed. If they are put into a vial of alcohol for twenty-four hours, then taken out and allowed to dry, the soft parts will become desiccated without any offensive odor, and they may be placed in the cabinet without further preparation. It may be noted, however, that if the cabinet contains many such shells, care should be taken to guard against the access of mice and vermin, which are apt to attack them in the absence of something more attractive in the way of food. For those shells which possess an operculum, after the operculum has been dried and the shell cleaned and ready for the cabinet it is customary to insert a little wad of raw cotton, rolled so as to fit the aperture snugly, the outer surface of it being touched with a drop of mucilage. The operculum can then be laid upon this in its natural position and the mucilage and cotton will retain it so without making it difficult to remove for an examination of the shell, if desired at any time. For the preservation of eggs of mollusks when they have a horny or calcareous shell, small glass tubes securely corked are the best receptacles. Most of these eggs are so small that they may be preserved in a dry state or in alcohol without trouble, but the eggs of some of the tropical land snails are so large that it will be necessary to drill a small hole and extract the fluid contents as if they were bird's eggs in order to preserve them. Such eggs are best preserved in alcohol.

MARINE SHELLS.

The preparation of marine shells for the cabinet does not essentially differ from that required for land or fresh-water shells, except that in the marine shells the muscular system is often much more strongly developed and the creatures themselves much larger than the fresh-water forms, and the manipulation is therefore somewhat more difficult. The marine forms are also more apt to be incrusted with foreign bodies, bored by predatory sponges, like *Cliona*, or even by other mollusks, or perforated by certain annelids which have the power to dissolve the lime of which the shell is composed, and in this way secure a retreat for themselves.

Shells which do not contain the living animal are frequently occupied by hermit crabs or by tubicolous annelids. The latter fill up the larger part of the spire with consolidated sand or mud, in the center of which they have their burrow. The hermit crabs do not add anything to the shells which they occupy, but, on the contrary, by their constant motion are apt to wear away the axis or pillar of the shell, so that often a specimen of this sort may be very fairly preserved and yet on the pillar show characters entirely different from those which one would discover in a specimen which had never been occupied by a crab. A shell which the crab has selected for its home is often taken possession of, as far as the outside is concerned, by a hydractinia, a sort of polype, which produces a horny or chitinous covering which is very difficult to remove from the shell to which it is attached. As the hydractinia grows it finally covers the whole shell, to some extent assumes its form, and then, if the creature has not attained its full growth, this is apt to take place around the edges of the aperture, which are continued by a sort of leathery prolongation which assumes in a rough way the form of a shell. The crab, when he grows too large for the shell in which he has ensconced himself, is usually obliged to abandon it and find a larger one, which is always a difficult and more or less dangerous operation; but if his shell is overgrown by the polype referred to, it often happens that the polype and the crab grow at about an equal rate, so that the latter finds himself protected and does not have to make a change. It is supposed that the polype profits to some extent by the microscopic animals attracted by the food or excrement of the crab, so that this joint housekeeping is mutually beneficial, and, for such cases, since the word *parasite* would not be strictly accurate, the word *commensal* has been adopted. These modified shells often assume very singular shapes. The polype is able in the course of time to entirely dissolve the original calcareous shell upon which its growth began, so that if the spire be cut through it would be found throughout of a horny or chitinous nature. Some of the older naturalists were deceived by forms of this sort and applied names to them, supposing that they were really molluscan shells of a very peculiar sort.

In removing the animal matter from the shell of large gastropods it will often require a good deal of time and care to get out all the animal matter from the spire, but it is well worth while to take the trouble, as the presence of such matter forms a constant attraction for museum pests of all descriptions. A medium-sized syringe is convenient for washing out the spire of such shells. The ordinary marine gastropods may be treated in a general way like the fresh-water gastropods. There are, however, abnormal forms, especially among tropical species, which require particular attention. Some species become affixed to corals and overgrown by them, retaining only a small aperture through which the sea water can reach the prisoner. Such specimens are best exhibited by retaining a part of the coral and cutting the rest away, showing at once the mode of occurrence and the form of the covered shell. Borers are always more difficult to handle and prepare for the cabinet than other mollusks. They are usually more or less modified for their peculiar mode of life, and frequently rely upon their burrow as a protection, so that the shell is reduced, relatively to the animal, to a very small size. Most of these forms are best kept in alcohol. The hard parts may properly be represented in the cabinet by other specimens. Some of the bivalves, such as the American "soft clam," possess very long siphons, covered with a horny epidermis, and it becomes a question as to whether an attempt should be made to preserve this epidermis in the cabinet or not. The writer has seen very nicely prepared specimens in which the fleshy portions had all been taken out and replaced by cotton, so that the epidermis of the siphon retained its original position and form; but such specimens are always very delicate, easily broken, and liable to attack by insects, so that it would seem hardly worth while to go to the trouble, when specimens may be preserved complete in alcohol showing all the features referred to. Boring shellfish, like *Pholas*, frequently have accessory pieces, which are liable to be lost when the soft parts are removed unless care is taken to avoid it. Other bivalves have the internal ligament reinforced by a shelly plate, which is called the ossiculum. This is very easily detached and lost, and, being an object of great interest, special pains should be taken to preserve it, even if it should become detached.

PRESERVATION OF SPECIMENS RESERVED FOR ANATOMICAL STUDY.

In these days the treatment of specimens intended for sectionizing or dissection has become an art in itself, as the wonderful results in morphological work abundantly testify. It would be impossible to go into such matters in detail, but in order that the collector may make the most of his opportunities the following brief directions have been kindly furnished by Prof. John A. Ryder, of the University of Pennsylvania.

DIRECTIONS FOR PRESERVING SOFT PARTS OF MOLLUSCA FOR ANATOMICAL USE.

Soft organisms should never be dropped into strong alcohol at once, as the rapid extraction of the water of organization by the alcohol shrinks the soft parts and distorts them. So, too, a too prolonged stay in too weak alcohol or spirits produces maceration or softening of the soft parts.

Fresh-water gastropods are best treated so as to kill them as quickly as possible by drowning, which can be done by putting them in an air-tight vessel and filling the latter completely with water, so as to shut off all the air. The result of this treatment, after twenty-four hours or so, is that the soft parts after death are often more or less completely extended from the shell; then gradual hardening may be accomplished in alcohol of one part alcohol (95 to 97 per cent) and two parts water, for twenty-four hours, to be followed by further treatment with water and strong alcohol, equal parts, for twenty-four hours more. Final hardening may be accomplished in a mixture of two to four parts of alcoho. (95 to 97 per cent) and water one part, using the last and strongest mixture of alcohol to preserve the animals permanently. Soft organisms thus treated with gradually increasing strengths of alcohol usually give very excellent results, even for histological purposes. The sojourn of soft organisms in weak alcohol, if continued for too long a time, tends to produce maceration and dissociation of the cells. In such cases it is best to keep the jars in which the hardening and fixing is in progress in a refrigerator (if such a convenience is accessible) at a temperature of 45° to 55° for a day or two, or until the hardening has progressed far enough to avoid the chances of injurious maceration.

Paralyzing the larger mollusks with a 1 per cent solution of cocaine gives good results, but is somewhat troublesome. Under its influence gradual paralysis and death follow after one to three hours. The organism after such treatment may be gradually hardened in a fully extended condition in alcohol and water, gradually increasing the strength of the successive alcoholic solutions as recommended above.

A 1 per cent solution of chromic acid is most useful for bringing out surface details for the naked-eye inspection of the surfaces of soft parts, or their examination with low powers of the microscope. Organisms may be subjected for twenty-four hours to its action, after which they should be thoroughly well washed in running water for twenty-four hours, until all the acid is removed. This washing is easily accomplished by putting the organisms in a jar with a wide mouth, over which a piece of coarse, cheap muslin or cheese cloth is tied; a small hole in the cloth may serve to permit passing a rubber hose, from any convenient water tap, into the jar, through which a gentle and constant flow of water may be thus maintained.

The addition of from one to one and one-half parts of acetic acid to every one hundred parts of the chromic-acid solution improves the result for histological purposes in cases where there are no calcareous parts to be injured and acted upon by the acids.

A very cheap and very excellent reagent for fixing and hardening the tissues of large mollusks is Müller's fluid. This may be made up as follows for gallon lots of the fluid: To every gallon of water take 3 ounces of pulverized bichromate of potash and $1\frac{1}{4}$ ounces of sulphate of soda (Glauber's salts). These salts may, in fact, be powdered together in the quantities stated per gallon and put up in packages, each of which would thus contain $4\frac{1}{4}$ ounces of the powdered and mixed salts, sufficient to make 1 gallon of the mixture. The salts should be completely dissolved in the water before using.

The action of this last reagent is slow and requires some attention, as do all of the processes given. Several volumes of the fluid should be used to a single volume of organisms or tissues. The hardening should be done in a cool, dark place. The fluid should be changed the first two or three days every day, then every other day, then twice a week, then once a week, till at the end of three to six weeks the hardening is completed, larger objects taking the longer time. It is also desirable to let the hardening go on in a dark closet or cupboard.

After the hardening in Müller's fluid the objects should be well washed with water, as recommended for chromic acid, under a tap in a jar covered with cheese cloth for twenty-four hours or more, according to the size of the objects. Objects hardened and fixed in Müller's fluid are almost or quite as good for the purpose of studying surface details as those hardened in chromic acid, and are as good for purposes of dissection as objects carefully hardened in alcohol.

After washing the objects hardened in Müller's fluid they should be placed in 70 per cent alcohol for permanent preservation. The 70 per cent alcohol is readily made with a sufficient approximation to accuracy by remembering that by adding nearly four-tenths of its volume of water to the ordinary 95 to 97 per cent alcohol of commerce an alcohol percentage of 70 is reached. Thus with an ordinary foot-rule the operator can mix his alcohols in cylindrical jars, thus:

Stand the jar upon the table, place the rule by the side of it with the scale next the glass, then pour in alcohol till some arbitrarily chosen tenth division of the rule outside is reached by the surface of the spirit, then add water to the spirit to the amount of nearly four more similar divisions of the rule, when the requisite dilution of 70 per cent approximately is reached. Shaking the mixture is all that is now required to mix the spirit and water, and the jar and its contents are ready for the reception of the materials treated with Müller's fluid.

The precautions given in the first paragraph of these directions in regard to the use and abuse of alcohol are vital, and no amount of after treatment of valuable material will atone for the neglect of the precautions recommended for the initial treatment. It is a thousand times better for a collector or a museum to have a little well-preserved material of a given type than bushels of poorly preserved material, literally "trash," of the same thing, that drops or breaks to pieces when the anatomist attempts to remove it from the jar. It is better, therefore, for the collector to take infinite pains with a smaller quantity of material to get it in the right condition with proper preservatives than to endeavor to make up in quantity what his collection may lack in quality.

As a final precaution, it is strenuously advised that too much material should never be packed into one jar or vessel to be fixed by a single bath of any given reagent. The volume of the first fixing and preserving reagent should always exceed by several times that of the objects to be fixed or hardened. This excess of the fixing and hardening reagents should be maintained until the hardening is completed. After the fixing and hardening is properly accomplished and the tissues of the objects have been thoroughly fixed and saturated with the reagents, then, and then only, may objects be packed together tightly with a relatively small amount of strong alcohol round them; otherwise, maceration may occur. In fixing and saturating large objects, especially if they contain large cavities, these should be opened and filled with the first fixing and hardening reagents by means of a cheap syringe made of glass, metal, or rubber.

The permanent preservative to be used after any of the hardening or fixing agents that are commended above should be 70 to 80 per cent alcohol, which is made by diluting ordinary 95 per cent alcohol with from four-tenths to about one-quarter of its own volume of water. Careful washing of the materials fixed and hardened in bichromate of potash or chromic acid is always to be enjoined before the objects are placed in the permanent preservative. This requires from twenty-four to forty-eight hours, according to the size of the specimens. Very small objects can be washed free from chromic acid or bichromate in a few hours by frequent changing or renewing the water over them. For large objects, over an inch in diameter, washing in a gentle current of water for twenty-four to forty-eight hours is advised before placing permanently in alcohol. When large gastropods are preserved in the shell and intended for anatomical examination, it is very necessary to admit the alcohol to the upper part of the spire by making a small hole with a file or other instrument in one of the upper whorls. Otherwise the delicate organs in this region can not be reached by the preservative fluid.

PRESERVATION OF THE RADULA.

The classification of gastropod mollusks has no more fundamental character among those upon which it is based than that of the radula. This is a strip or belt of chitinous or horny material occupying the place in the mouth where in vertebrates the tongue is found. Hence it is sometimes referred to as the tongue. The inner end of the radula is secreted by a glandular surface lining a pouch which lies under and behind the cartilaginous and muscular buccal mass upon which the radula is carried. The front end of the radula is strongly attached to the cuticle. The surface is usually set with teeth disposed in rows, transverse and longitudinal, each transverse row differing from that in front of it merely in maturity. The first few rows are brought into active use; the others form a reserve to come in play when the anterior rows are worn out. The buccal mass with the radula upon it is protrusile, and its action may be easily studied by feeding a snail with soft crumbs of bread or watching a Limnæa mowing away the green confervæ which gather on the glass of aquaria.

Some few gastropods have no teeth on the radula. A few others, like the cones, have isolated barbed teeth, to which a duct conveys poison from a venom-gland. The bite of a cone is extremely painful from this reason. The small round holes common in dead bivalves on the beach are drilled by predaceous gastropods, like *Natica* or *Urosalpinx*, who are able to use their teeth in a rotary manner.

In a few forms like *Acmæa*, *Patella*, and *Chiton* the teeth are less purely chitinous than in the land snails and most marine gastropods. Chitine is a substance very resistant to both acids and alkalies, especially the latter; so that, with few exceptions, such as those above named, the teeth may be boiled in caustic potash without injury. The horny jaw and its lateral appendages which exist in many gastropods will not, as a rule, survive such treatment, and must be dissected out, though in a few cases they are also chitinous.

In large gastropods the buccal mass with the radula upon it is easily recognizable, and can be dissected away without trouble. In rostriferous species it is in the muzzle, just within the mouth. In probocidiferous forms it is to be found at the retracted tip of the inverted proboscis. In the cones and Pleurotomoids, where the teeth are fewer and less compactly set, they are often found only by the exercise of great care.

In small species dissection is often out of the question and another method is to be used, which is, however, available only for such forms as have a decidedly chitinous radula. The radula of chitons and limpets subjected to boiling potash rapidly disintegrates, owing to the solution of the nonchitinous cement which holds the parts together. In such forms the radula must be sought with the aid of a microscope.

In the others the process is as follows: The student provides himself with a microscope with objectives ranging from 1 inch to one-eighth inch, preferably those with a good deal of penetration, showing a large field rather than high magnification; two or three deep, old-fashioned watch glasses and test tubes; some caustic potash, an alcohol lamp, and a pair of spring forceps.

Extracting the animal from its shell, or simply crushing the latter gently, it is dropped into a test tube containing nearly a tablespoonful of caustic potash which has been allowed to attract the atmospheric moisture until it became liquid. Taking the test tube between the arms of the forceps hold it at the side of the flame of the alcohol lamp until it boils, being careful that it shall boil gently and shall not boil over; which, if held over the flame, it is likely to do. Watch that the animal matter is not thrown by ebullition out of the liquid on to the dry side of the tube. If this happens dislodge it by shaking the tube until the fluid washes down the object. Boil slowly and with patience until all the animal matter appears to be dissolved. Then, first shaking the liquid in the tube, pour it out quickly and steadily into a watch glass, replacing it by a little water, with which the tube should be rinsed and then emptied into another watch glass. Take the first watch glass and gently agitate the contents and when they are well stirred up give the glass a rotary motion, but not so violent as to spill the contents. This rotary motion will bring the solid particles in the potash to the center of the watch glass. A sheet of white paper under the watch glasses makes the search for the radula easier. The radula unless it is microscopic can usually be recognized by its curved elongated shape and apparently reticulated surface. It may be picked out on the point of a needle and transferred to a watch glass of clean water and washed clean of the potash. If microscopic the watch glass can be put on the stage of the microscope and examined with the 1-inch objective, when the search will usually reveal it. If it does not turn up examine the rinsings in the other watch glass, and lastly the test tube itself.

Having found the radula it may be laid in a drop of pure water and examined under a cover glass. The live box furnished with most microscopes is most convenient. Transmitted light with a Lieberkuhn reflector, or aided by a bull's-eye lens focussed above the cover, should be used.

After the general form and appearance of the radula has been noted and sketched or described, if an accurate knowledge of the teeth is desired, since they lie over one another like shingles on a roof, it is necessary to tear the radula up so as to get separate teeth, or rows, or parts of rows in full view. The whole can rarely be seen under one focus. The recurved cusp of the tooth being higher than the base both will not come in focus at the same time. Usually there are both small and large teeth in one series so that much caution is needed to make sure that everything has been seen.

Sometimes the teeth are very transparent and it is desirable to stain them. To do this the radula after being carefully cleaned should be put in a drop of strong solution of chromic acid which stains it yellow brown. It will be seen to change color almost at once, and as soon as dark enough should be taken out and washed clean of the acid. If left in too long the acid may destroy the more delicate parts. It may then be treated as before suggested.

For a temporary mount glycerine jelly does very well. If Canada balsam is used it rapidly makes the teeth so transparent as to be invisible, and hence mounts in balsam should be stained. The writer has used hydrosilicon, which makes a very good mounting medium at first but in the course of time it becomes obscured by the formation of crystals.

The teeth are comprised in three principal longitudinal series, which are usually easily distinguished, though in some forms one or the other series may be absent or one lateral series may gradually merge into that next to it.

Normally there is a median longitudinal row of unpaired teeth, one tooth to each transverse row, with the series on either side symmetrical and similar on the two sides with the cusps inclined toward the center of the radula. This central tooth is known as the median or rhachidian tooth. On each side of the median tooth will be found a series of teeth varying in number but separated by their general form, and usually by a toothless space from a set or series of rows nearer the margin of the radula. The teeth of the series near the margin are apt to be small, simple, and similar to one another. In the *Trochidæ* they are very slender and numerous, almost like fur, and are in each row set upon a continuous solid basis which supports them all. These teeth are called the uncini, though other names have been improperly applied to them.

The less numerous but usually larger and more diversely formed teeth between the rhachidian tooth and the uncini, are called admedian or lateral teeth. In many forms one of these is much larger than the others and is known as the major lateral, while the others may be called the minor laterals. The teeth are simple, straight, curved, twisted or compound; in fact, the diversity is remarkable, but the characteristics for each group, especially genera and families or higher groups, are fully as permanent and important as are the teeth of vertebrates.

Any series may be wanting. The median tooth is often absent, and in at least one case the two adjacent laterals are known to have become consolidated, making a false or rather a compound median tooth. There are sometimes congenital deformities in the secreting glands. Such individuals may have an asymmetric or deformed radula. The cusps of the teeth being very brittle are easily broken off by too great pressure from the cover glass. The teeth are usually translucent, amber yellow, or dark brown. The cusps, especially of the major lateral, are sometimes black on a translucent base, as in *Chiton*.

The radula of *Litorina* and of *Patella* is very long and narrow. In the Scaphopods (*Dentalium*) it is very short and broad. In most of the land shells the radula is curved so as to lie flat only under compulsion. In many marine forms the uncini are folded over and lie upon the admedian teeth, except those which are in active use.

The study of the radula is of the greatest interest and importance. Any shell containing the dried animal will probably afford the radula, as the chitine is nearly indestructible. A thorough study of the radula of our common fresh-water shells is still a desideratum and the student remote from the sea will need only to search the nearest ditch to find opportunities for making actual contributions to knowledge.

The work requires great care, patience, and a certain amount of experience. The beginner will do well to lay aside his first drawings and continue to practice. After a year has passed, if he will compare his slides with the drawings first made, he will better appreciate his own progress and the absolute necessity of caution in order to do good work.

In descriptions of the radula it is customary to use a formula called the *dental formula* to express the number and situation of the teeth. Each tooth is regarded as a unit and the different series are separated by a colon or period. Thus a radula with one rhachidian, three admedian, and twelve uncinal teeth would have as its formula 12 : 3 : 1 : 3 : 12. If it is desired to express the number of denticulations on the cusps of the teeth, the unit representing the tooth is written as a numerator and the number corresponding to the denticles as a denominator, while the fractions representing teeth belonging to the same class but differing in detail are connected by a plus sign (+), the series being separated by a colon as before.

$$\text{Thus } \frac{3}{1} : \frac{1}{4} + \frac{2}{2} : \frac{1}{3} : \frac{2}{2} + \frac{1}{4} : \frac{3}{1}$$

would represent the formula of a radula which had three single cusped uncini, a major lateral with four denticles on its cusp and two bicuspid minor laterals, on each side of a tricuspid rhachidian tooth. Since the admedian and uncinal teeth are bilaterally symmetrical, or similar, on each side of the rhachidian tooth, space is sometimes saved by writing the formula for the lateral or admedian teeth and uncini of one side immediately after that representing the rhachidian tooth. Thus 1 : 3 : 3 is the equivalent of 3 : 3 : 1 : 3 : 3. In cases when any of the series are absent their place is represented in the formula by a cipher, so 3 : 3 : 0 : 3 : 3 represents a radula in which the uncini and admedian teeth, to the number of three each, are present and the rhachidian tooth is suppressed, 3 : 0 : 1 : 0 : 3 represents a radula in which there are no admedian teeth and

$$0 : 0 : \frac{1}{3} : 0 : 0$$

one in which the dental armature is reduced to a tricuspid rhachidian series. Further modifications of this principal will suggest themselves with experience.

THE CABINET AND ITS FURNITURE.

CASES, TRAYS, AND TUBES.

The most convenient cabinet for the purposes of the collector of shells is one containing numerous shallow drawers in which the shells can be placed. Very elaborate cabinets of this sort are a luxury on which collectors and ordinary naturalists are seldom able to spend their money. Very convenient and entirely satisfactory cases, however, may be made with but little expense, in the following manner: Having first a plain outside case of suitable dimensions, to prepare it for the drawers let small straps of hard wood the length of the drawers be securely fastened horizontally at about an inch apart from the top to the bottom of the case on each side. These will form the rails upon which the drawers will run. The drawers having been prepared of different depths for the different sizes of shells, similar strips are fastened on them midway along each side. These strips run in the spaces between the strips nailed upon the outer case, and support the drawers. In this manner, all the drawers being of one size, differing only in depth, any drawer can be put into any part of the case. A deeper drawer can be intercalated between two shallow ones and so on, at the pleasure of the collector. The front of the case may be made of an ordinary sash door if the collector can afford it. Otherwise a wooden door may be used, but the edges against which the door shuts should be grooved to the depth of a quarter of an inch all around the doorway. On the door itself, so as to fit into this grooving, should be tacked small rubber tubing which, when the door is shut and securely fastened, will exclude the dust completely, and keep the collection in good order. Such a case as this is quite inexpensive, and if the collector obtains a large box, such as are used for the better class of packing cases, he can make a very satisfactory case for himself with the aid of a few strips of wood, screws, and a screw-driver. In order to exclude dust, which is a great enemy to most collections, if the case is not absolutely tight it will be well to paper it all over outside. This will improve its appearance if neatly done and make it perfectly dust tight. From such rude home-made appliances to the more elegant work of the professional cabinet-maker the collector may proceed as his means allow, but the principle upon which our home-made cabinet just described is constructed is the best one to follow, no matter how elegantly the work may be done. The principle of having all drawers interchangeable and of the same size, all trays multiples of a unit of size, and in general all parts based upon some fundamental unit of measurement or capacity, is that to which the best museums of the present day are universally tending. The convenience of the arrangement for the private collector is almost as great as for the public museum; since it in no way increases the cost it certainly is the best plan to follow.

For the representation of specimens inside the cabinet various plans have been adopted. The specimens may be kept in small trays, unless very small, when they may be put into glass tubes and closed with corks and these tubes into trays, or some system may be adopted by which specimens are mounted with cement on tablets, either of card, hard wood, glass, or even slate. There is no doubt that where space is of no importance and attractiveness in the collection is considered as preëminent, that specimens present a much more inviting appearance if mounted. For study, however, and for all scientific purposes mounted specimens are very undesirable. It is difficult to keep them clean, or if they become soiled to clean them. Glass can be washed, but no cement will adhere to glass for any length of time. Cardboard changes color, or if colored fades and after a time assumes a very shabby appearance. Wood is difficult to keep clean, although better than any of the others. The collector is advised therefore not to attempt to mount his collection. Many firms of paper-box manufacturers are prepared to furnish small paper trays without covers five-eighths of an inch deep and of such length and width as may be desired, at a very cheap rate. Those in most American museums are covered with white glazed paper, from which the dust can be easily brushed, and in width and length proceed on the basis of a unit of size, 1 inch by 2 inches. This is the smallest size of paper tray. All other sizes, except the next larger, which is $1\frac{1}{2}$ by 2 inches, are multiples of the first. In this way when the trays are put into a drawer they will fill it evenly, and if a cabinet is made to order the inside measure of the drawers should bear a suitable relation to the unit adopted for the paper trays to be put into them. For especially delicate specimens small boxes with glass tops are very desirable. These are, however, rather expensive luxuries, needed in most cases for few of the specimens ordinarily acquired by collectors. For small shells the glass tube, which is a sort of homeopathic vial without a neck and without any thickening around the aperture, is most convenient, and one may almost say indispensable. These are closed with corks. The tubes may be had from all dealers in glassware at a low price if specially ordered. As a rule they are not kept on hand. It is well to have them of several sizes. Those in use in the National Museum are of three diameters, three-eighths, five-eighths and 1 inch, and are of the uniform length of $1\frac{5}{8}$ inches. This enables them to be corked and then placed in the smallest size of paper tray, and most shells which require to be tubed will be accommodated by these sizes.

LABELS.

The matter of labels is always of importance to the collector. The appearance of a collection depends very largely upon the neatness and uniformity of its labeling. Blank labels may be printed in sheets at very small expense and afterwards cut apart. They may have a heading, with the name of the collector and his place of residence, with a space between the two items for the number of the particular lot recorded upon the label. Then three or four lines will afford space enough to write the name, locality and collector in most cases. These labels may be printed upon card, but for practical purposes stiff white paper, somewhat like writing paper, only a little thicker, is quite as good as card and much less expensive.

CATALOGUING.

The collector should keep a record or catalogue of his collection. Each specimen or set of specimens placed in it should be numbered and this number should be put upon the label. If the collection is large it would be advisable to number the shells themselves, which may be done with neatness and care in a manner which will not deface the specimens in any way. Small specimens contained in tubes may have a small slip of paper bearing the number included with them. In this way, if a drawer is overturned and the tubes fall out of the paper trays in which they have been placed, the proper locality of each tube can readily be restored, whereas if they were not numbered a certain amount of confusion and delay would result. As the collection grows larger a catalogue will be found to be almost absolutely necessary. The most convenient form for cataloguing comprises the registration book and what is called a card catalogue, which is, however, not necessarily made of cards. Slips of paper cut to a uniform size will do equally well although cards are rather more convenient. In the registration book should be entered as soon as practicable after the collection has been sorted and cleaned, the name of the specimen if known, otherwise its generic name (or in the absence of that a blank may be left to fill up afterwards) the locality, sex and depth, the season or date, and the collector's name. These will be entered in the register in the order of reception or such other as may be most convenient, no classification being admitted in the book. The same items, however, or such of them as is desired to retain, perhaps the name of the species and its registration number may suffice, would be written upon the card or slip which forms part of the card catalogue. These slips can then be arranged in any order, alphabetical or otherwise, which may be selected by the person concerned. By referring to the card the registration number can be easily found and all the details recorded in the register can be turned to without loss of time. These principles carried out to a greater or less extent are those upon which the collections of the best American museums are administered.

PACKING SPECIMENS.

A few hints on modes of packing may be useful for the collector:

Small shells in bulk may be simply put in to a box, such as mustard, tin, or a cigar box, filled so full that the contents can not shake about.

Larger specimens are best wrapped in paper, for which the thin brown paper used for wrapping oranges, or the so-called toilet paper, is excellent. For still larger specimens newspaper will do very well. The southern moss (*Tillandsia*) makes excellent packing material. Sawdust should be especially avoided in packing, as it is really worse than nothing.

In putting up glass jars or bottles containing specimens in alcohol, nothing is better than ordinary damp moss from the woods. The box should be lined with it, the jars set in so as not to touch each other at any point, and moss should then be carefully rammed down between them until the whole space is compactly filled, when a layer may be placed above the bottles and the box cover nailed down. As the moss dries in the box it makes a secure case for each jar, and the writer has shipped hundreds of jars many thousands of miles in this manner without a single breakage.

Boxes of moderate size travel better than very large or small ones.

For alcoholic specimens nothing is better than the screw-topped jars used for preserving fruit. Each jar should be carefully scrutinized to make sure that it it is in perfect order and screwed tight enough to avoid leakage. If the specimens do not fill the jar a handful of crumpled paper will serve as a buffer to prevent injurious friction. Jars should always be filled with alcohol to within an inch of the cover.

For the cabinet, stout vials with rubber corks are best, or jars with ground-glass stoppers for larger specimens. The latter are expensive and really less efficient than the screw-top jars, but of course present a better appearance.

In order that the identification of specimens shall not be lost, it is imperative that a label shall be inclosed in the jar itself. For jars which have to be transported long distances, a label of block tin is often used, upon which a number has been stamped corresponding to the collector's catalogue. Pure block tin in thin sheets can he had of dealers in assayer's supplies, and a set of numbered steel dies for stamping the numbers, of any dealer in hardware. Numbers printed on parchment are also used. Written numbers are apt to get worn off, but, if they must be used, it is best to write them on the best quality of stiff linen paper with a very soft lead pencil, the label being then wrapped up in a piece of clean manila paper to preserve it from wear. Such labels with good luck will last very well, but should, if possible, be supplemented by the tag of block-tin foil. Ordinary "tin," *i. e.*, tinned sheet iron, is entirely unfit for the purpose. Nearly all specimens contain some fatty matter and in cases where the strength of the alcohol is insufficient a chemical change takes place in that part of this fat which is combined with the alcohol, producing several ill-smelling ethers and fatty acids. Therefore nothing in the way of metal, ink, or other substances which may be affected by acid or ether should be inserted in any jar of specimens. Copper tanks with screw tops are sometimes used by collectors, but are soon made leaky by oxidation of the metal unless thoroughly and completely coated inside with pure tin. When the latter, as is often the case, has been adulterated with lead, it is liable to oxidize and is little to be depended upon.

A method of packing identified species for transportation which has many advantages was invented by Dr. Stearns. He took old letters, discarded blank books, and other stiff paper and provided himself with a round stick about half an inch in diameter. Treating one side of the paper with flour paste he proceeded to roll the sheets compactly over his stick, which was then withdrawn, leaving tubes, which, when dry, were extremely solid and could be cut into suitable lengths with a sharp knife without collapsing. A wad of cotton in each end holds the shells safely in the middle of the short tube, while the data can be written on the outside. The economy and efficiency of this method, and its superiority to the average pill-box process have caused it to become popular wherever it has been introduced. The writer has even seen private collections kept in such tubes neatly made of white paper. Except for the larger species, the method is by no means the worst which could be mentioned.

BOOKS OF REFERENCE.

This is not the place for a general bibliography, but, as almost all requests for instructions to collectors are coupled with inquiries as to what books are available for their use, it is thought that a few references to general works may prove of advantage.

The scientific study of mollusks progresses so fast that no manual or text-book long remains up to the times in all particulars. The latest and most extensive general work on the mollusca is by Dr. Paul Fischer,* and is published in the French language. Indispensable for a student, it is somewhat too far advanced for a beginner, and less useful than a more elementary work for the average collector. A work which, notwithstanding deficiencies due to age and the later advances of the science, is still one of the best, if not the very best, English work to put into the hands of a beginner in Conchology is Woodward's Manual of Recent and Fossil Shells,† as it is familiarly called, which for many years has been a classic. Several editions have been published and it has had several publishers, but it is still on sale and can be obtained through any dealer in foreign books. The price is quite moderate, and the work will be found useful and still (apart from changes in classification) reasonably accurate.

A later work, convenient on account of its numerous figures, but

* Manuel de Conchyliologie [etc.]. Paris, F. Savy, 1887. 8°. Pp. 1369, 23 plates, 1,138 figures in the text.

† A Manual of the Mollusca, a Treatise on Recent and Fossil Shells [etc.], by Dr. S. P. Woodward. London, various publishers, 1856 to 1871. 8°, about 500 pp., and 24 plates.

more expensive, is Tryon's Manual of Conchology,* in three volumes, issued by the Conchological section of the Academy of Natural Sciences at Philadelphia.

Publications which were intended to serve the purpose of handbooks for students of our native mollusks have from time to time been issued by the Smithsonian Institution and the U. S. National Museum. The older papers of this class are to some extent out of print, but may be obtained in most cases from dealers in second-hand books. The series has comprised the following memoirs:

Land and Fresh-water Shells of North America, by W. G. Binney and T. Bland. 8°, in three parts.

Part I. Pulmonata Geophila. 316 pp., 544 ill. in the text. 1869.

Part II. Pulmonata Limnophila and Thalassophila. 161 pp., 261 ill. in text. 1865.

Part III. Operculated Land and Fresh-water Species. 120 pp., 232 ill. in text. 1865.

The three parts comprise Smithsonian publication numbers 194, 143, and 144, respectively, and cover all the land and fresh-water gastropods except the melanians.

Researches upon the Hydrobiinæ and Allied Forms [etc.], by Dr. William Stimpson. 59 pp., 29 figures in the text. 1865.

This is chiefly devoted to the fresh-water Rissoidæ, and is No. 201 of the Smithsonian list.

Land and Fresh-water Shells of North America. Part IV. Strepomatidæ (American melanians), by Geo. W. Tryon, jr. 8°, 435 pp., 838 figures in the text. 1873.

This is Smithsonian number 253.

Monograph of American Corbiculadæ, recent and fossil [etc.], by Temple Prime. 80 pp., 86 figures in the text. 1865.

This is Smithsonian number 145, and includes an account of the American *Pisidium, Sphærium, Corbicula,* and *Cyrena.*

A Manual of American Land Shells, by W. G. Binney. Bulletin No. 28, U. S. Nat. Mus. 528 pp., 516 figures in the text. 8°. 1885.

This brings the subject of the Pulmonata, as treated in the "Land and Fresh-water Shells," up to date, though under a different arrangement.

Bibliographies of American Naturalists. II. The published writings of Isaac Lea, LL. D. By Newton Pratt Scudder. Bulletin U. S. Nat. Mus. No. 23. 8°. LX, 278 pp. and portrait. 1885.

In the absence of any general work on the American *Unionidæ,* this bibliographical index to Dr. Lea's works will be of use to students of the group.

A Preliminary Catalogue of the Shell-Bearing Marine Mollusks and Brachiopods of the Southeastern Coast of the United States [etc.]. By William Healey Dall, A. M. Bulletin U. S. Nat. Mus. No. 37. 221 pp., 74 pl. 1889.

This bulletin is devoted to the marine forms, which are illustrated by over 1,000 figures and tabulated so as to show their geographical and bathymetric distribution. The classification is revised and the tables are preceded by a bibliography comprising titles of works bearing on the mollusca of the region.

The nomenclature of the catalogue is extensively reformed over earlier usage, and the collector or student who desires to understand why many names have been changed or have disappeared will in most cases find the reasons fully stated in the following publications.

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*Structural and Systematic Conchology, an introduction to the study of the Mollusca, by Geo. W. Tryon, jr. Philadelphia, 1882–'84. 3 vols. 8°.

Bulletin of the Museum of Comparative Zoölogy at Harvard College. Vol. XII, No. 6. Report on the Mollusca [of the Blake expeditions]. By W. H. Dall. Part I. Brachiopoda and Pelecypoda. Cambridge, the Museum. 1886. 8°. pp. 171–318, pl. I–IX.

The same. Vol. XVIII. Part II. Gastropoda and Scaphopoda. Cambridge, the Museum. 1889. 8°. pp. 1–492, pl. X–XL.

These two publications incidentally review a large proportion of the marine mollusks of our southeastern coast. For a general index to the literature of mollusks for the same region the student may consult—

Bulletin of the U. S. Geological Survey No. 24. List of marine mollusks, comprising quaternary fossils and recent forms from American localities between Cape Hatteras and Cape Roque, including the Bermudas. By W. H. Dall, Washington, the Survey. 1885. 8°. 336 pp.

This bulletin also includes a bibliography.

For information in regard to the mollusks of the Pacific coast of the United States the collector is referred to—

Mollusks of Western North America. By Philip P. Carpenter, B. A., PH. D. Washington. Smithsonian Institution. 1872. 8°. XIV, 325 and 121 pp.

This comprises a bibliography to all papers published on this subject by Dr. Carpenter in foreign countries (but not his papers printed in America), a reprint of many of them and a general index to all, including those not reprinted, always excepting his American papers. It forms No. 252 of the Smithsonian list. A later list, which is, however, a mere list of names and localities, was printed by the State Geological Survey of California, as follows:

Geographical Catalogue of the Mollusca Found West of the Rocky Mountains, between latitudes 33° and 49° north. By J. G. Cooper, M. D. San Francisco. 1867. 4°. 40 pp.

If the student desires a general work in which all the species of mollusks are to be found figured, he is referred to the following publication, still in progress:

Manual of Conchology, Structural and Systematic, with illustrations of the species. By Geo. W. Tryon, jr. Continuation by H. A. Pilsbry. Philadelphia. Conchological section, Academy of Natural Sciences. 1882 to 1891 (*et seq.*).

This work is to be comprised in four series, of which the first and second are in progress, as follows: First series, marine univalves; second series, terrestrial mollusks; third series, marine bivalves; fourth series, fluviatile mollusks.

For reference to the scattered papers of earlier writers on American mollusks the following work will be found convenient, in spite of the want of an index:

Bibliography of North American Conchology previous to the year 1860. By W. G. Binney. Washington. Smithsonian Institution. 1863–4. 8°.

Part I. American authors. 650 pp.

Part II. Foreign authors. 298 pp.

These form numbers 142 and 174 of the Smithsonian list.

In conclusion, it may be added that many of the American recent mollusks, which are also found fossil, and which are not illustrated elsewhere, may be found figured in the Transactions of the Wagner Free Institute of Science, Philadelphia, Pa., Vol. III.

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DIRECTIONS FOR COLLECTING MINERALS.

BY

WIRT TASSIN,

Assistant Curator of the Department of Minerals.

Part H of Bulletin of the United States National Museum, No. 39.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1895.

DIRECTIONS FOR COLLECTING MINERALS.

By Wirt Tassin,
Assistant Curator of the Department of Minerals.

GENERAL REMARKS.

The value of a mineral collection depends largely upon the quality of the specimens and upon the completeness of the information concerning them. A bruised or scratched specimen, or a broken crystal, has little to recommend it, and a mineral of unknown locality or undefined associations can be admitted to a cabinet only under protest. With regard to any given species, the geographical and geological distribution is an important fact; and it is therefore desirable, in each locality, to collect every variety which can be found. Specimens which would be worth little by themselves become valuable when studied in relation to others, and a common mineral, found under unusual circumstances, may have exceptional interest.

WHERE TO LOOK FOR MINERALS.

The best field for a collector is always that which has been well opened, such as a mine, a quarry, a railroad cut, etc. Fresh exposures of unweathered rock yield the best specimens. In prospecting, however, where no work has been previously done it is desirable to get below the weathered rock surface to the fresh material beneath. Sometimes nature assists in this direction, as in ravines and along the bases of cliffs where, in early spring, rock falls leave clean exposures. The recent talus at the foot of a cliff affords a good field for examination.

IMPLEMENTS USED IN COLLECTING.

The tools used in collecting minerals are few in number. The first and most indispensable tool is a hammer (see fig. 1). It should be of well tempered steel, weighing about two pounds, with the striking face square and the cutting edge having the same direction as the handle. The handle should be made of good hickory and wedged into the head with iron wedges. A foot scale, divided into inches, marked on the handle, is desirable.

It often happens that upon specimens brought in from the field there is an unnecessary amount of the gangue adhering, or part of a crystal or crystals may be covered up by the matrix. This can readily be removed and the size of the specimen reduced by means of a few small chisels and cleaning tools (see figs. 3–6) and a trimming hammer (see fig. 2). The trimming hammer should weigh from a quarter to half a pound, and have both faces square. By holding the specimen firmly in the left hand and delivering a sharp blow with the hammer the gangue rock may be removed without injury to the mineral. A pitching tool (fig. 6) is useful in shaping the specimen after trimming. The other tools needed are three steel chisels, one six inches long (fig. 5), the others three inches long, and of similar pattern, for cutting purposes; a set of steel wedges for splitting rocks, and a pickax to remove surface material and for prying.

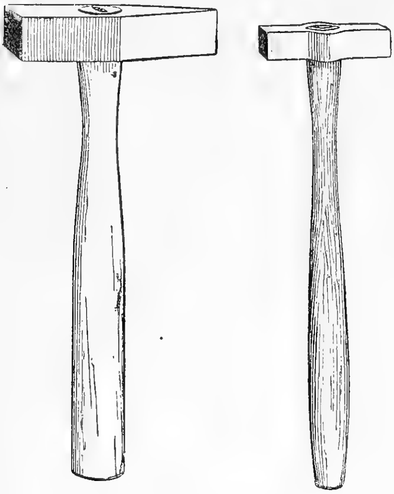


Fig. 1. Fig. 2.

Collecting hammers.

In many cases it is necessary to blast. Blasting powder, drills, sledge hammers, fuses, etc., may sometimes be carried, but they can commonly be borrowed from miners or quarrymen, who can also be hired to assist in the work. Avoid heavy charges of powder, in order that the material sought for may not be excessively shattered. The operation of blasting, regarded from the standpoint of the mineral collector,

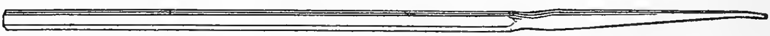


Fig. 3.

Fig. 4.

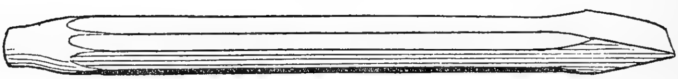


Fig. 5.

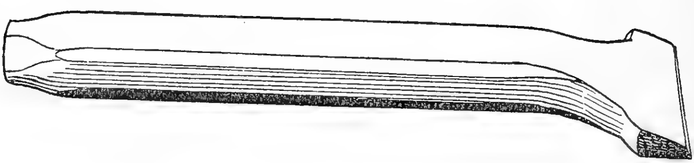


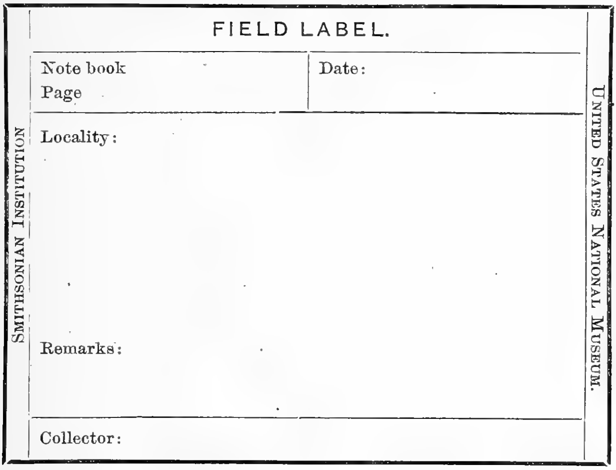
Fig. 6.

Cleaning and pitching tools.

requires the greatest care and judgment. A fine locality may be ruined by the reckless use of dynamite.

METHOD OF LABELING.

In collecting minerals, the labels should be written at once, and wrapped with the specimens. The locality should be stated precisely; for example, "garnet in rhyolite, North Slope, Table Mountain, Gunnison County, Colorado," and not "garnet, Colorado." Unidentified minerals should be marked with full information as to mode of occurrence, in order that they may be properly studied later.


FIELD LABEL.

Note book
Page

Date:

Locality:

Remarks:

Collector:

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FIG. 7.
Museum field label.

It is always wise to preserve a record of the materials in some form of field notebook.

PACKING FOR SHIPMENT.

For the transportation of the material to a place where it can be properly culled and packed a leather bag is convenient. This should be made twelve inches wide, twelve inches deep, and four inches through, of stout leather (fig. 8). It should have a flap over the top and extending fully six inches down the opposite side, and have a strap and buckle to fasten it in position.

The carrying strap should be of strong leather, two inches wide, and long enough to go over the shoulder. This should be provided with a buckle so that its length may be adjusted to the wearer.

This style of bag is of course not a necessity, and any sort of a receptacle may be substituted for it, but some means for the convenient transportation of specimens in the field must be provided.

A supply of paper, preferably of newspaper, is also indispensable for wrapping specimens. Never attempt to carry a specimen unwrapped in the bag. The material collected must not be permitted to chafe or rub.

In packing specimens for transportation, each individual is to be wrapped first in tissue paper, then in raw cotton, and finally in newspaper. This applies only to crystallized and delicate specimens. For massive material newspaper alone is sufficient. With very delicate material such as cuprite, natrolite, etc., the specimens are to be wrapped in tissue paper, then in cotton, and further protected by being boxed separately. In some cases it is advisable to set the specimen in a suitable box and pour plaster of paris around its base, allowing the latter to set, thus insuring solidity. This, however, is a matter that must be left entirely to the judgment of the packer, since no one method is applicable to all cases.

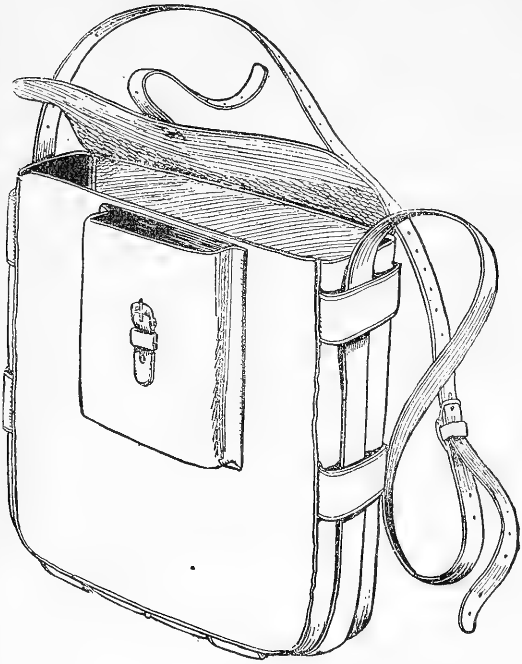

FIG. 8.—Collecting bag or knapsack.

The material is best packed in comparatively small boxes. Large boxes are too heavy for proper handling. A layer of excelsior, straw, or other packing material, about an inch deep, is put on the bottom; then the heaviest and most massive material is packed firmly and closely. Spaces between the specimens should be filled with excelsior; then add another layer of excelsior, a layer of specimens, and so on until the box is filled, and finally a layer of excelsior is put on top and the cover fitted tightly. The box must be absolutely full before fastening. Excelsior is the best packing material, but straw, hay, grass, Spanish moss, or coarse shavings will serve the purpose. *Sawdust should never be used.* Coarse, massive material, collected in bulk to be broken up and trimmed later, may be transported in boxes or barrels without wrapping or other special precautions.

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DIRECTIONS FOR COLLECTING ROCKS AND FOR THE PREPARATION OF THIN SECTIONS.

BY

GEORGE P. MERRILL,
Curator of the Department of Geology.

Part I of Bulletin of the United States National Museum, No. 39.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1895.

DIRECTIONS FOR COLLECTING ROCKS AND FOR THE PREPARATION OF THIN SECTIONS.

By George P. Merrill,
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PART I.—DIRECTIONS FOR COLLECTING ROCKS.

Rock collecting differs from that employed in other branches of natural history mainly in the simplicity of the process.

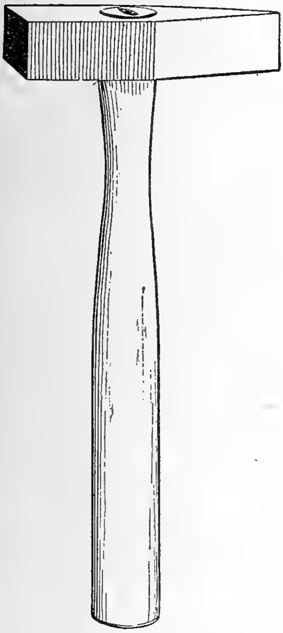

Fig. 1.

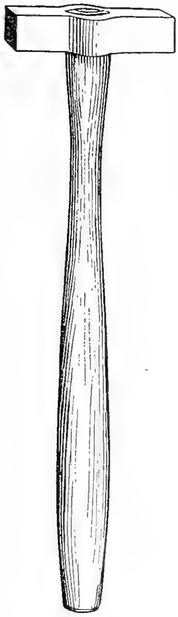

Fig. 2.

Collecting hammers.

TOOLS EMPLOYED.

For purposes of field work, and when the collector is obliged to carry his entire outfit on his person or attached to the saddle, but two hammers are usually employed, the one a square-faced implement of about 2 pounds weight, with the pean (also spelled peen) in a direction parallel with the handle. The proportions found most satisfactory are, head, 5 inches in length; face, $1\frac{1}{4}$ inches square, and handle, some

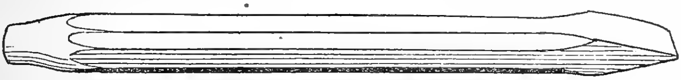

Fig. 3.
Chisel.

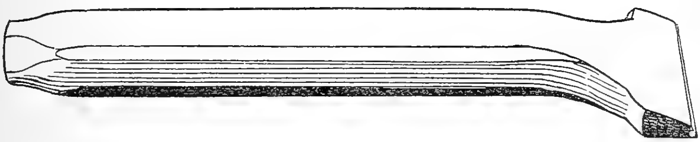

Fig. 4.
Pitching tool.

13 inches in length. This hammer (fig. 1) is used for separating the specimens from the parent mass.

The second hammer (fig. 2), designed for trimming purposes, should weigh about three-fourths of a pound, with head not above $3\frac{1}{2}$ to 4 inches in length and faces three-fourths of an inch square, both faces being alike. The handle must be correspondingly more slender and an inch or so shorter. Handles should be of best hickory, and considerably reduced midway between the head and the portion grasped by the hand in order to impart the desired spring to the blow.

When transportation facilities allow, it is well to have also a 6-pound sledge, as not infrequently the natural weathered forms of rock masses are such as to necessitate the breaking of spalls of considerable size in order to obtain material of the desired freshness. Chisels are rarely of use. Occasionally what is known among stonecutters as a pitching tool becomes of use in breaking off spalls from the larger blocks (see figs. 3 and 4).

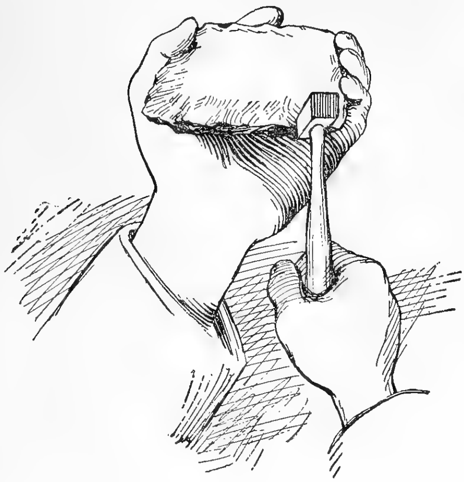

FIG. 5.—Manner of holding specimen.

SELECTION OF MATERIAL.

Always take the specimen from the parent ledge unless absolutely sure that smaller and more accessible masses were derived therefrom. It not infrequently happens that angular blocks fallen from the face of a cliff offer the only satisfactory collecting grounds. Providing there is no glacial or other form of drift in the vicinity such can be utilized with safety. Never collect materials the source of which is not known unless designed for the purpose of studying drift materials or because the specimen presents itself some points of more than ordinary interest. Few objects are of less value than rock specimens the exact source of which is not known.

Collect always fresh material. Many of the collections made by the earlier surveys have been found quite worthless for modern microscopic work, owing to the fact that they were so altered by weathering. The outside weathered surface should always be first broken away until a bright fresh fracture is shown. In some compact, close-grained rocks weathering proceeds so uniformly as to form on the outer surface only a thin crust of oxidation products, so that a single specimen will serve to show both weathered and fresh material. As a rule, however, it will be found best, in case weathered material is also desired, to collect these in separate specimens. Take particular care to secure representative specimens. If any apparently essential variation is shown in the mass of the rock, collect typical materials from each and label so as to show their relations—which is the prevailing type, etc.

METHOD OF COLLECTING AND TRIMMING.

With the heavier hammer knock off from the larger mass, by a single blow if possible, a spall as near the size and shape of the desired hand-

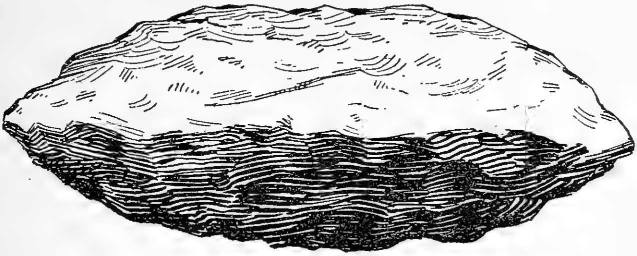

FIG. 6.

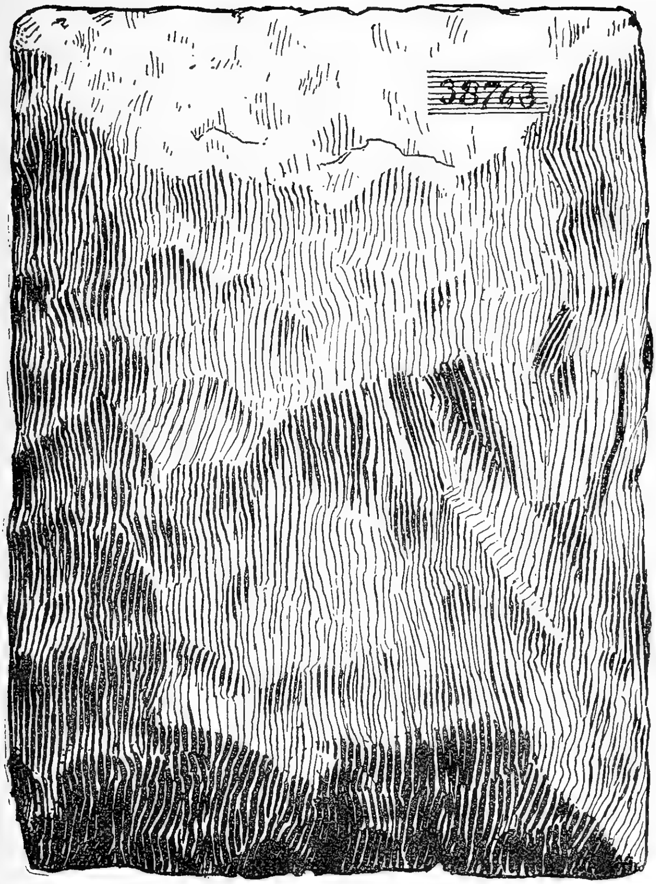

FIG. 7.

Properly trimmed hand specimen. Fig. 6, end view. Fig. 7, face view.

specimen as is possible. About four by five inches with a thickness not above one inch is a very desirable form. The advantage of a single blow over several in succession lies in the less liability to fracture the specimen so that it shall break in trimming. Having secured the spall, hold it in the left hand as indicated in figure 5 and with the small trimming hammer gradually work it down to the desired size and shape.

Favorable dimensions for study series are about three by four inches by not over one inch in thickness. If for exhibition purposes in museums, a half inch more in each dimension adds to the appearance. In trimming a specimen always work from the edge, striking sharp, quick blows obliquely downward, as shown in figure 5, so that the chip separates from the lower edge. Never strike directly across the edge, as, if the specimen is at all thin, it is almost sure to break. Save, when trimming, chips suitable for thin sections and chemical work and wrap with the specimen itself.

Always wrap a trimmed specimen (see figs. 6 and 7) carefully and pack in such a way that abrasion of the surface through rubbing against other

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FIELD LABEL.

Note book Page	Date:
Locality: Remarks:	
Collector:	

UNITED STATES NATIONAL MUSEUM.

FIG. 8.—Museum field label.

specimens is impossible. Almost any kind of paper will answer. Write the label in pencil, fold it, and wrap with the specimen. A sample of the field label used by the National Museum is here reproduced (fig. 8). It is well to first fold the wrapping paper once over the label to prevent its being torn by being pressed too closely against the rough surface of the rock. In packing, remember to pack closely and tightly so that no movement can take place between the specimens themselves such as shall cause one to rub over the face of the next adjoining and scar it. For purposes of study the fresh fracture is always desirable, and, moreover, abrasive marks from the hammer or from rubbing, due to poor packing, are unsightly and suggestive of carelessness. Always label as fully as possible.

Trust nothing to memory. Remember that the exact site of a dike, boss, or ledge of rock is a matter of primary importance since it may be necessary, or at least desirable, to visit the locality again. Moreover, the mode of occurrence of a rock mass is often a matter of primary importance. Do not trust to small labels gummed to the specimen.

If, in the museum or laboratory, it is found desirable to fix a number upon a specimen in order to insure it against loss or displacement, the following method, as pursued in the National Museum installation, may be found advisable: A blue rectangular strip of sufficient size to receive the number is painted upon the specimen in oil colors, the material used being dry ultramarine blue mixed with ordinary white lead and sufficient hard oil finish to thin it for applying with a brush. This dries quickly, giving a firm, glossy surface, upon which the number is then painted in white—Windsor and Newton's flake-white tube paints, thinned with turpentine, having been found best fitted for the purpose. This gives a practically indestructible number, sufficiently conspicuous to be readily found on specimens of any color or texture, and which, if neatly done, does not in the least mar their appearance (fig. 7). The method is of course applicable only to substances of considerable firmness of texture.

FIG. 9.—Collecting bag or knapsack.

In collecting the larger materials illustrative of dynamic phenomena, only very general directions can be given, since each individual case requires separate treatment. The size and shape of the specimen must depend on what it is intended to illustrate, and the means of getting it out and transporting. If blasting must be resorted to, use ordinary slow-burning blasting powder, which lifts but does not shatter; never resort to dynamite. Here, too, care must be taken not to deface by scarring the faces intended for exhibition. Many a fine block has been spoiled through lack of attention to this rule. Never deface a specimen by painting the address upon it for shipment. In these days of dry plates and films it is frequently advisable to photograph an outcrop from which the specimens are selected; this to show other structural features than those brought out by the specimen, as well as to serve as an aid to the future identification of the locality.

For carrying specimens, a stout leather bag, made with separate compartments for compass and notebooks, affords the only feasible means (fig. 9). This can be carried by means of a single strap in the form of a loop over the shoulder or with two straps, like a knapsack. The former is most easily put off and on, and hence has its advantages. The knapsack form can, however, be carried with much less fatigue. One needs to be careful and not let his enthusiasm cause him to get too large a knapsack, or to attempt carrying too much at one time. The remarkable rapidity of increase in weight of a satchel of rocks can be appreciated only by one who has tramped the weary miles homeward after a hard day's field work.

PART II.—THE PREPARATION OF THIN SECTIONS.

Since the study of rocks is now carried on so largely by means of thin sections and the microscope, a few words regarding the methods of preparation of the sections may not be out of place here.

The purpose of the section is to get a certain portion of the rock so thin as to be transparent, without disturbing its structure or the loss of any of its particles. The process of preparation, as now generally employed, has come into general use only within the past twelve or fifteen years, the first monographic work of importance to appear in this country being Professor Zirkel's Microscopical Petrography, which formed Volume VI of the Monographs of the United States Geological Survey of the Fortieth Parallel under Mr. Clarence King, and was published in 1876.[1]

The efficacy of the method is based upon the fact that every crystallized mineral has certain definite optical properties, that is, when cut in such a way as to allow the light to pass through it, will act upon that light in such a way as to enable one working with an instrument combining the properties of a microscope and stauroscope to ascertain at least to what crystalline system it belongs, and, in most cases, by studying crystal outlines and lines of cleavage, the mineral species as well. To enter upon a detailed description of the methods by which this is done would be out of place here, since it involves the polarization of light and other subjects which must be studied elsewhere. The reader

[1]Among the earlier American workers were Dr. G. W. Hawes, who, in 1878, published an important work entitled Mineralogy and Lithology of New Hampshire, forming Part IV (251 pp. and 12 colored plates) of Volume III, Geology of New Hampshire, by C. H. Hitchcock; Prof. R. Pumpelly, of Newport, R. I.; Dr. M. E. Wadsworth, of Cambridge, Mass.; J. H. Caswell, who first described the phonolites of the Black Hills (Geology of the Black Hills of Dakota, 1880); Dr. A. A. Julien, of New York; and Prof. B. J. Harrington, of Montreal. The first systematic attempt at section cutting in the United States was made by Professor Julien, at Columbia College, in New York. In the winter of 1881 apparatus was set in motion for this purpose in the National Musuem, under direction of Dr. G. W. Hawes, and later (1884) by the United States Geological Survey in the Hooe Building, in the same city. See Modern Petrography, by Dr. George H. Williams, D. C. Heath & Co., Boston, 1886, for a brief history of this branch of the science.

is referred to any authoritative work on the subject of light, and to Prof. J. P. Idding's translation of Professor Rosenbusch's work on optical mineralogy.[1]

But to return to the subject of making sections. A thin chip of the size of a nickel 5-cent piece, or at most not over an inch in diameter and as thin as possible, is broken from that portion of the rock selected for study. By means of emery and water on a smooth cast-iron plate, one side is then ground until all inequalities are obliterated. The final grinding must be done with emery so fine as to leave no perceptible scratches. This chip is then cemented, smooth side down, against a small piece of ordinary double-thick window glass, by means of Canada balsam, such as may be procured at almost any drug store, and which, in its liquid form, is best kept in a capped bottle as shown in fig. 10.[2] The glass serves merely as a holder and may be of any convenient size. Rectangular pieces one by two inches have been found most convenient in this laboratory. In cementing the chip a few drops of the liquid balsam are placed upon the center of the glass slip, which is then gently heated until such quantity of the volatile constituents pass off that on cooling the residue is hard but not brittle. Experience is here the only guide; if heated too long it will become brittle and break away; if not long enough it is soft and sticky. Hard enough to be impressed slightly by the thumb nail without sticking or cracking is as definite as can be well stated. In case a large number of sections are to be prepared it is well

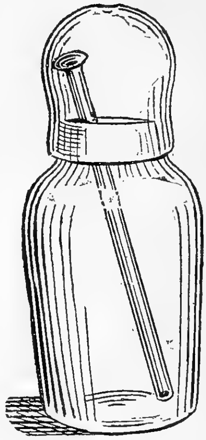

FIG. 10.—Balsam bottle.

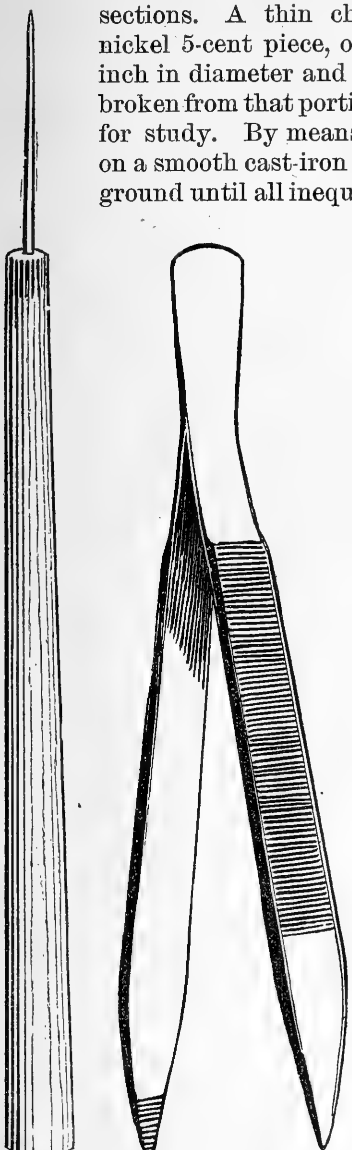

FIG. 11. FIG. 12.

Mounting needle and forceps.

[1]Microscopic Physiography of Rock-Making Minerals. Wiley & Sons, New York.

[2]Some workers profess to prefer a mixture of venetian turpentine and white shellac boiled down to proper consistency.

to have a sufficient quantity of balsam already evaporated and in the form of sticks or lumps.

When the balsam on the glass is of the proper condition and very fluid as well as free from bubbles, the hot chip is placed upon it, one edge first and the other gradually lowered in such a way as to prevent the inclusion of air bubbles. A needle point set in a wood handle (fig. 11) and a small pair of spring forceps (fig. 12) will be found serviceable for this purpose. The chip is then pressed into the balsam and as closely to the glass as possible. It is best to work the chip back and forth a little in order to accomplish this. If too much balsam is allowed to remain between the glass and stone chip the section will be found to remain thick in the center and grind away on the edges, and ultimately become lost or so reduced in size as to be of little value, before the desired

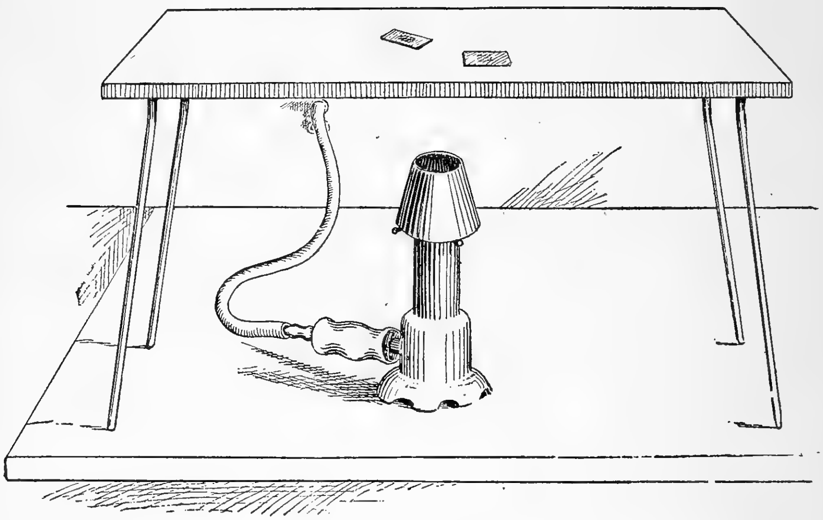

FIG. 13.—Mounting frame.

thinness is reached. This matter of mounting is best carried on by means of an iron plate sufficiently thick to retain a level surface, which is supported at the four corners and heated by means of a lamp beneath (fig 13). After the chip is once in place, the slip is removed from the plate and placed in a horizontal position upon the table to cool.

The grinding now is carried on precisely as before, the glass serving as a holder for the fingers, and, being transparent, allows the worker to observe just the condition of the slide at any moment. Care needs be exercised as the section becomes thinner, and it is well to have two or more plates upon which emery of different degrees of fineness is used. This, however, is not essential, though after the section is well on toward completeness a single coarse grain coming in contact with it may create sad havoc. The final grinding, the writer has found, can be best done on a sloping plate of ground glass (fig.14), using only the finest washed emery. It is not necessary that the section be polished, as the balsam in which it is mounted will correct all inequalities and bring about the same results. When of the proper thinness—and there is no definite rule—say from $\frac{1}{400}$ to $\frac{1}{600}$ inch, it is washed in alcohol or spirits of turpentine to remove all the old balsam and included dirt, as well as such particles of the emery as may have become embedded in the section. This may be done with an ordinary toothbrush and in running water. If the chip is properly secured to the glass there is no fear of injuring it in this work, but it may be brushed over vigorously.

This done, the slip for the final mounting is placed upon the iron plate, not too hot, and the cleaned section still on the thick glass beside it. A drop of liquid balsam is then put both upon the center of the fresh slip and upon the section. Both are allowed to become sufficiently warm to spread out well, but not enough to become, on cooling, so hard as in the first process. A thin cover glass is then laid over the section and pressed down in place as though for a permanent mount. Then taking this slip with the section, by means of forceps, in the left hand, bring it directly over the clean mounting slip, and by means of a needle point in the right hand push the ground section and its cover glass with it off into the balsam on the new slide, in such a way as to exclude air bubbles. The object of first putting the cover on the section is merely to give it support in process of transfer. Otherwise it is liable to become broken. Many rocks, such as sand and limestones, are so friable that in the form of thin films they can not be transferred at all, but must be mounted for grinding on the thin glass on which they are to remain and afterwards covered without removal. In such cases the cover glasses are best cemented on by means of a solution of hard balsam in ether or chloroform. Since in the work of grinding the slide becomes badly scratched and otherwise defaced, it is well, for appearance's sake, to grind the entire surface of the slide before mounting. The index of refraction of the balsam is such as to correct all inequalities in the glass and the resultant slide is very pretty. In case a rock is so friable as to prevent the production of the smooth surface so essential, it can be indurated by boiling in balsam until the latter has so permeated all the pores as to act, on cooling, as a cement. Slides made from such chips can not be transferred, as a matter of course.

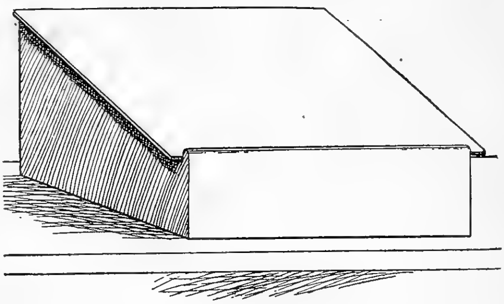

FIG. 14.—Grinding plate.

In the final mounting some care is also necessary in evaporating the balsam to just the right consistency. If left too soft it will continue to exude gradually from under the edge of the cover, rendering the slide sticky and disagreeable to handle. If too hard, on the other hand, it soon crackles, or perhaps allows the cover to spring off on the occasion of any slight jar.

Never mount sections for actual work on the long (3-inch) slides such as are ordinarily used for histological work, as they project beyond the edge of the stage and interfere with its revolution. The sizes mostly used by petrologists are either 28 by 48 mm., or 32 mm. square. The former has been adopted in this department. For ordinary work a 21 mm. square cover glass is sufficient (see fig. 15.)

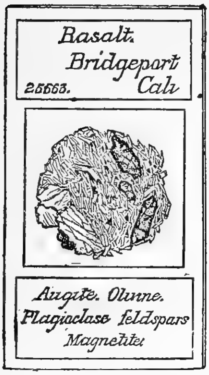

FIG. 15.—Thin section.

Inasmuch as special care must be exercised in the preservation of the sections, the following is given, although not absolutely germane to the subject in hand. The article is reproduced essentially as it first appeared in Science for November 25, 1892.

As it happened, we had in stock a number of paste board boxes some 93 millimeters wide, 143 millimeters long, and 48 millimeters deep, all inside measurements. The dimensions of our standard slide are 48 by 28 millimeters. By means of two wooden partitions, some 3 millimeters thick, running lengthwise, each box was divided into three equal compartments, the partitions being held in place by glue reenforced by two small tacks at each end. Heavy manila wrapping paper, such as we also had in stock, was then cut into strips 25 millimeters wide and as long as the sheet of paper would allow, in this case about 7 feet. These strips were then bent into a series of folds, as shown in the accompanying illustration, the apices being rounded, not pinched flat. If carefully done, the folds when crowded gently together act as a spring. Two of these folded strips were then placed lengthwise in each compartment, and the slides introduced, standing on end, between the folds at the top. A box as thus prepared readily holds three rows of 50 slides in a row, or 150 altogether.

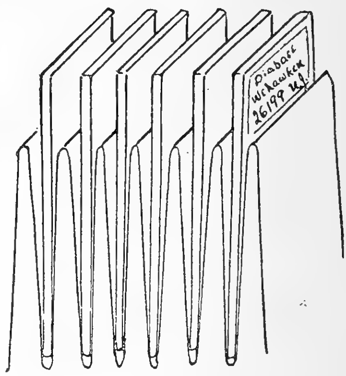

FIG. 16.—Storage frame

Each slide is separated from its neighbor in the same row by a double thickness of manila paper, which, owing to its manner of folding, acts as a spring, and avoids all possible danger of breakage. When all the compartments are filled, the space between the tops of the slides in any row is but about 2 millimeters; but there is, nevertheless, no difficulty in removing a slide or in getting at it to read the label without removal, since, owing to the yielding nature of the paper, the tops may be readily drawn apart. In this respect the box offers a great advantage over those with rigid wooden compartments, such as are commonly in use. The first box was made merely as an experiment. It proved so satisfactory that, for the time being at least, it is the form adopted for storing the several thousand slides forming the museum collections.

I have attempted to show the arrangement as above described in the accompanying drawing. In reality the slides are held much more firmly than indicated, since the paper bulges and comes against both the front and back of the slides, the full length of the fold instead of merely at the bottom. It will very likely strike the reader that a better material than paper might be found. I can only state that after considerable experimenting the paper was, all things considered, found most satisfactory.

The work of grinding the section, although laborious, requires only such skill as almost anyone can shortly acquire. Where but few are to be prepared the grinding may be done entirely by hand, and on any smooth piece of cast iron, such as the circular covers used on cooking stoves and ranges. This process is necessarily slow, and whenever possible it is best to have a simple machine consisting of one or more horizontally revolving iron plates some ten to twelve inches in diameter, driven by foot or other power. This plate, or lap as it is not infrequently called, should be made to revolve in a zinc or lead lined box, the sides of which are elevated an inch or so above the level of the plate. This not merely to prevent the mud from the wheel from flying over the workman, but for the purpose of preserving the mud, which may be used over many times to advantage. It is essential that the lap be driven by means of a belt rather than cogwheels, and that the shaft have a balance wheel sufficiently large to give a uniform rate of revolution. How fast the plate should revolve depends on the individual. If too rapidly the emery flies off without doing its work. About 1,000 revolutions to the minute has been found quite satisfactory in this department.

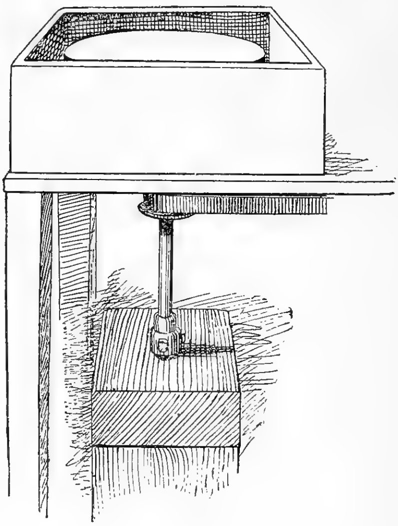

FIG. 17.—Grinding wheel.

Such a machine may be made at small cost by any intelligent machinist (see fig. 17). The demand has as yet been scarcely sufficient to cause them to be kept ready-made. In the Johns Hopkins University Circulars (Vol. XII, No. 103, 1893), and also in the American Journal of Science for February, 1893, was described and figured a machine built under the direction of the late Dr. George H. Williams.

When the nature of the material is such as to necessitate sawing instead of breaking with the hammer, in order to get the desired chip for grinding, a horizontally revolving tin or soft iron plate some 10 inches in diameter may be used, the cutting material being fine emery or carborundum mud applied with a brush in one hand while the object to be cut is pressed against the edge of the plate with the other. A better though from necessity more expensive method is afforded by the small diamond saws made by W. C. Kerr, of 292 Westminster street, Providence, R. I., at $12 per dozen. These are simply tin disks charged for a width of an eighth of an inch or so on the edge with diamond dust. Some workers prefer to make their own saws. The following is the method advocated by Prof. J. E. Wolff, of Harvard College, in the American Journal of Science:[1]

From a tinsmith are procured disks of ordinary sheet tin, 6 inches in diameter, with a central hole five-eighths of an inch in diameter, to fit the arbor of the lathe. Two round wooden blocks are turned out from board, about 5½ inches in diameter, and a central hole of the same size as that of the disk bored in one, while a corresponding round wooden stick is set into the center of the other. The tin disk is then placed between the two blocks, the round stick holding it central, and the whole fastened in a vise. The edge of the disk projecting beyond the wood is then notched by a shoemaker's knife, which is held against it and struck a sharp blow with a light stick, but the plane of the knife is held slanting or oblique to the plane of the disk and not transverse, and, moreover, is inclined on opposite sides in adjacent quadrants. The notches are made as close together as possible without breaking the tin, and about one-tenth of an inch deep. The bort (preferably the so-called scrap carbon left as waste from diamond drills) is pulverized in a diamond mortar to a fine sand, corresponding nearly to grade 100 in corundum or emery powder, mixed with a little oil to form a stiff paste, and inserted between the teeth of the saw by a pointed match. The edge is then gently hammered back to a plane, using a light hammer on an anvil, and the saw then turned over and hammered smooth on the other side. It requires 1 carat of bort to charge a saw properly.

By this method, which has been perfected in the laboratory by Mr. C. L. Whittle, the bort is forced into the tin and held fast by the teeth, which, owing to the oblique cutting of the notches, press tightly together when hammered back to place. The teeth are cut obliquely on opposite sides in adjoining quadrants, in order to distribute the bort equally on both sides of the saw. A refinement on the notching process described above consists in the use of a brass disk with guide notches cut into its edge, by which the knife can be guided and the notches made evenly. Saws thus made will do a surprising amount of work before wearing out. In two cases, where a record was kept, the saws cut respectively 300 and 400 square inches of rock, mainly of crystalline varieties.

Carborundum will, in many cases, be found to serve as a cutting medium, and is much less expensive than diamond dust.

Saws of this nature cut with a very smooth scarf and can be utilized for a variety of purposes. They are particularly serviceable in cutting shells designed for exhibition in museums, the thinnest septa rarely becoming broken in the process. For cutting large massive specimens for exhibition several forms of saws are available. One in use for several years in the Museum laboratories is what is known as a reciprocating saw, built on the same general plan as the larger saws in general use in stone yards throughout the country. The saw blades are of soft iron, with a few obscure notches in the lower edge, the cutting material being quartz sand, emery, corundum, or chilled iron, according to the hardness or toughness of the material to be cut. Any number of saw blades from one to ten, making a corresponding number of cuts, can be used at once. Other workers prefer saws in the form of large steel, copper, or sheet-iron disks, like the circular saws used in cutting lumber, but without teeth, revolving vertically, the cutting material being of the same nature as with the reciprocating saw.

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[1] Am. Jour. of Science, May, 1894, p. 335.

A form of cutting machine employed for some years in the laboratory of the United States Geological Survey, and in favor of which much can be said, consists merely of an endless soft iron wire running like a belt or band saw over two grooved pulleys. These pulleys, which are some 18 inches in diameter, revolve in the same vertical plane. The lower, to which the power is imparted by means of a small pulley and belt, revolves in stationary bearings, while the upper, by means of two upright standards, is free to move a distance of several inches in a vertical direction. This permits the ready replacement of the cutting wire when necessary, while at the same time it permits, by means of weights, a constant tension to be brought upon the wire, otherwise likely to become loose through stretching. At the Survey laboratory a No. 16 soft iron wire is used mainly. After being cut to the right length the ends are beveled and bound with fine wire, such as is used by florists, and then soldered with hard solder. After cooling the excess of solder is removed by filing. The pulleys are made to revolve at about the rate of 400 revolutions per minute, and wet emery applied either by the hand or a brush, while the object to be cut is held immediately below. A table, through which the wire runs like a mechanic's band saw, serves to support and steady the object. Such a saw has the advantage of the reciprocating saw above described, in that the pressure may be made constant and steady, there being no blow such as is imparted by the constant lifting and dropping of the saw frame in order to allow the cutting material to be washed into the scarf.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR COLLECTING SPECIMENS AND INFORMATION ILLUSTRATING THE ABORIGINAL USES OF PLANTS.

BY

FREDERICK V. COVILLE,
Honorary Curator of the Department of Botany.

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1895.

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GENERAL REMARKS.

Information on the subject of aboriginal botany may, of course, be best obtained by actual observation and by conversation with individuals of those tribes among whom primitive uses of plants are still in vogue. In the United States at the present time nearly all of the native tribes are assembled on reservations, and are in charge of public agents who attend to their relations with the Government. In addition, most tribes are supplied with Government schools, in charge of teachers and subject to the inspection of a superintendent. In each tribe there are prominent men, either chiefs or medicine men, from whom, under favorable circumstances, better information may be obtained than from the average individual. This is particularly true of the medicine men and women who are themselves expert in the practice of medicine, according to the Indian ideas, and are usually persons of exceptional keenness and knowledge, not only of the materials with which they work, but of the aboriginal products and usages as well. It is through these and other prominent individuals, Indian teachers and superintendents, and occasionally agents, that information is ordinarily most easily accessible. In the absence, however, of such favorable opportunities the average Indian will be found capable of communicating a great deal of useful information. It must be borne in mind by the observer that actual observation conscientiously made, so as to reduce the possibility of error, is far more valuable than any amount of second-hand information, and that a single positive detailed record, accompanied by good specimens of the products under discussion, is of permanent and almost inestimable value to the history of aboriginal botany. It is such facts and materials that the observer should secure. Hearsay evidence is principally useful in suggesting to others lines of investigation.

MATERIAL TO BE COLLECTED.

Material for identification.—Probably the most important fact to be learned about a vegetable product of aboriginal use is the scientific name of the plant from which it was derived. To obtain material, therefore, upon which a positive identification can be made should be the first object of the observer. If he is a botanist, and consequently in the habit of making herbarium specimens, he will be able to forward material in that form, which is wholly satisfactory for the purpose. To those not familiar with the preparation of herbarium specimens the following brief statement will be found useful: A herbarium specimen should consist of a flowering or fruiting plant, including not merely the portion above ground, but such an amount of the root, rootstock, tuber, or other underground parts as will indicate clearly their characteristics. It is often impossible to secure all these portions of a plant on a single specimen, but two or more should be collected when necessary. The specimen should be placed in a folded sheet of bibulous paper, such as the cheaper grades upon which common daily newspapers are printed. These sheets containing the plants are placed in a pile alternating with two or three sheets of common carpet paper, or blotting paper, and subjected, between two boards of the same size as the sheets, to a pressure of 15 to 30 pounds, applied by straps or by a weight, and so regulated as neither to crush the tender parts of the green specimens nor to allow the leaves to wrinkle in drying. Stems, roots, or other parts exceeding a quarter of an inch in thickness should be thinned on the back with a knife before pressing. Specimens of fleshy fruits, additional to the plant itself, may be dried in the open air, inclosed in envelopes, and placed in the folded sheets with the specimens of the plant. The specimens in their containing sheets should be removed from the pile of moist carpet paper each day to a similar pile of well-dried ones, and in most cases they will be found thoroughly pressed and dried within three to seven days. The sheets upon which specimens are mounted in most herbaria are of a standard size, 11½ by 16½ inches, and all the specimens dried should come within this limit. It is best, therefore, to use carpet paper and containers no larger than the herbarium sheets. If a plant is too large to be preserved entire in its normal position it may be bent in the form of an inverted V or an N and brought within the proper dimensions, or, if still too large, as in the case of trees and some herbaceous plants, branches and other portions of suitable size, illustrative of the whole plant, should be secured.

If it is impracticable for the observer to prepare herbarium specimens, he should collect a specimen of the entire plant, or, in the case of very large plants, representative portions, wrap them up securely in paper while still fresh, using preferably a glazed or oiled paper, and forward immediately, so that they may reach their destination in a fresh state. Herbarium specimens may be preserved indefinitely, and when ready for shipment should be packed between two sheets of stiff pasteboard, tightly wrapped, and tied.

In labeling specimens the directions given below should be followed.

Materials illustrating manufacture and use.—Next in importance to the identification of the plant, in our observations, comes the question of its manufacture. This should be illustrated by specimens of the crude materials in all the different stages through which they pass, together, when possible, with specimens of the completed product. In the case, for example, of a plant whose roots are used for food, specimens of the root should be obtained, preferably those dug by the Indians themselves; other specimens of the root after cooking; still others after the material is ground or otherwise prepared for its ultimate use; and if the ground product is made into cakes or bread, samples of these also. The methods of preparation are so varied in the case of different seeds, fresh fruits, roots, textile products, etc., that no single rule can be given except to secure specimens illustrating every stage in the process of preparation. Paper envelopes or cloth bags are convenient receptacles for these materials, labeled according to the directions given below. On account of their liability to injury from moisture, insects, or other causes, it is preferable to forward specimens to their destination at once. But if this is impossible, they should be kept in a dry place, and, if they become infested by insects, should be subjected to the vapor of carbon bisulphide (a poisonous and highly inflammable substance), naphthaline, or any of the commercial products commonly employed to prevent the ravages of moths and other insects.

DESCRIPTION OF SPECIMENS, AND NOTES.

Specimens forwarded to the Smithsonian Institution should be carefully labeled, as in the absence of proper data they are almost worthless. Notes are always of interest, even when not illustrated by specimens, but they become especially important when well-labeled specimens accompany them. Descriptions of such articles are then capable of verification at any time in the future.

Labeling of specimens.—Each specimen should be marked by a number, the numbers arranged chronologically in the order of collecting. These numbers should be entered in a blank book, or on separate sheets suitable for ultimate binding, and with each number the requisite data should be written, whether the specimen is a plant collected for the purpose of identification or is a derivative product. These sheets, preferably about 5¼ by 8¼ inches in size, should accompany the specimens to their destination, duplicates being retained by the sender if he desires. A blank space should be left for the insertion of the technical name, and below should be given the common and aboriginal names, when known, the date and place of collecting, the name of the collector, the object for which it is used, the name of the tribe, and the part used. These facts may, for convenience, be arranged in the following order:

1. Number.
2. Common name.
3. Aboriginal name of plant.
4. Aboriginal name of derived product.
5. Tribe.
6. Place.
7. Uses.
8. Part used.
9. Date of collecting.
10. Collector.
11. General remarks.

Descriptive matter.—Specimens labeled as described above do not furnish complete information on the uses of the particular plants that they represent, but they constitute the basis upon which detailed descriptions may be made. Often no one is better able to furnish these descriptions than the observer himself, and this should always be done whenever any additional information can thus be conveyed. The descriptive matter should cover especially the method of manufacture and the method of use, but it is not desired under that heading to enter largely into the customs of the Indians, at least not into their ethnological features. The following will serve to indicate the nature of the descriptive matter desired:

One of the prickly pears, *Opuntia basilaris*, is used by the Indians, prepared in a peculiar manner. In May and early June the flat, fleshy joints of the season's growth, as well as the buds, blossoms, and immature fruit are fully distended with sweet sap. They are broken off with sticks, and collected in large baskets. Each joint, having been carefully rubbed with grass to remove the fine, barbed prickles, is exposed to the heat of the sun. When they are thoroughly dry they will keep indefinitely, and are prepared for eating by boiling and adding salt. Instead of the drying process another more elaborate is sometimes adopted. A hole, about 10 inches in depth and 3 feet in diameter, is dug in the ground and lined with stones. Upon this a fire is built and other stones thrown in. When they are all thoroughly heated, the ashes, coals, and all but one layer of stones are scraped away, and some fresh or moistened grass spread in the hole. Next a layer of cactus joints is added, then more hot stones, and so on, till the pile is well rounded. The whole is then covered with sacking (originally with a mat of sedges), and lastly with moist earth. After about twelve hours of steaming the pile is opened and the nä′-vō, as the cooked cactus is called, is salted and eaten. Prepared as it is, in larger quantities than can be disposed of at once, a portion is dried and preserved. It is then in texture and appearance similar to unpeeled dried peaches.[1]

Fiber materials, Rhus trilobata and Salix lasiandra.—Sumac and willow are prepared for use in the same way. The bark is removed from the fresh shoots by biting it loose at the end and tearing it off. The woody portion is scraped to remove bud protuberances and other inequalities of the surface, and is then allowed to dry. These slender pieces of wood, that they may be distinguished from the other elements of basket materials, will be called withes. The second element is prepared from the same plants. A squaw selects a fresh shoot, breaks off the too slender upper portion, and bites one end so that it starts to split into three nearly equal parts. Holding one of these parts in her teeth and one in either hand, she pulls them apart, guiding the split with her fingers so dexterously that the whole shoot is divided into three equal even portions. Taking one of these, by a similar process she splits off the pith and the adjacent less flexible tissue from the inner face and the bark from the outer,

[1] Amer. Anthrop., V, p. 354, 1892.

leaving a pliant, flat strip of young willow or sumac wood. This is here designated a strand. Both withes and strands may be dried and kept for months and probably even for several years, but before being used they are always soaked in water.[1]

It is hardly possible to go too much into detail in description when the detail is based upon actual observation. Finally, the observer should always remember that a single positive fact or series of facts derived from actual observation among the aborigines themselves has a greater and more permanent value than an indefinite amount of information made unauthentic by the uncertainty of its origin or by carelessness on the part of the one who records it.

ABORIGINAL USES OF PLANTS.

The following list will suggest to the collector the principal uses to which plants are applied by aboriginal races in North America:

Food:
- Foods proper—
  - Farinaceous—Seeds, nuts, starchy roots, tubers, bulbs.
  - Saccharine—Sugar-pine exudates, maple sugar.
  - Herbaceous—Pot herbs, mescals.
  - Fleshy fruits—Berries, plums, cherries.
  - Condiments—Red pepper, sassafras.
- Drinks—
  - Simple aqueous drinks.
  - Acid drinks.
  - Fermented drinks.
  - Distilled drinks.
  - Narcotic drinks.

Clothing:
- For protection and use—Hats, bark dresses, moccasin thread.
- For ornament—Necklaces, hair ornaments, paints, dyes.

House and furnishings:
- House building—
  - House frames—Timber, poles.
  - House coverings—Bark, mats, thatch.
- House furniture—
  - Beds—Blankets, mats.
  - Domestic utensils—
    - Food utensils—Baskets, sieves, mortars.
    - Water-holding utensils—Baskets.
    - Washing utensils—Soap.
    - Child-rearing utensils—
      - Cradles—Frames, coverings, stuffing materials.

Heating, cooking, and lighting:
- Matches—Fire sticks.
- Tinder—Punk, moss, cottony substances.
- Fuel—Ordinary wood, resinous woods and bark, vegetable oils.
- Fire receptacles—Stoves, candlesticks, lamps, lamp wicks.

Manufacture:
- General tools—Drills, mallets, ax and hammer handles.
- Special tools—Sewing tools, arrow-making tools, net-making tools; in short, the tool chest or outfit of any craft whatever.

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[1]Amer. Anthrop., V, p. 358, 1892.

Field industries:
- Hunting—
  - Killing—Clubs, spears, bows, bowstrings, arrow shafts, arrow points, quivers, air guns.
  - Trapping—Traps, snares, nets.
- Fishing—Fish nets, weirs, pounds; fishhooks, lines, poles; fish poisons.
- Harvesting—Baskets, paddles, granaries.

Travel and transportation:
- Boats—Bark canoes, dugouts, wicker boats.
- Land vehicles—Sledges, drag poles.
- Packing utensils—Pack baskets, fastening cords.
- Snowshoes—Rims, wickerwork.

Language communication:
- Paper, ink, pens.

War:
- Killing—Clubs, bows, arrows, arrow poisons, quivers.
- Painting.
- Truce—Smoking.

Amusement:
- Outdoor games—Lacrosse sticks, hoops for rolling; hoops, balls, and sticks for throwing.
- Indoor games—Dice, stick throwing, other gambling games.

Ceremonial and religion:
- Music—String instruments, drums, wind instruments, rattles.
- Dancing—Special ornaments, masks.
- Smoking—Pipes, tobacco.

Medicinal plants:
- External use—Poultices, ointments.
- Internal use—Narcotics, astringents, and other medicines.

SMITHSONIAN INSTITUTION.

UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR COLLECTING AND PREPARING FOSSILS.

BY

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Assistant Curator of the Department of Paleontology.

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CONTENTS.

DIRECTIONS FOR COLLECTING AND PREPARING FOSSILS.

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INTRODUCTION.

The object of this treatise is to instruct beginners in the study of paleontology in regard to the best methods of collecting and preserving fossils. It should be borne in mind, however, that there are no laws governing the formation of a collection of fossils. Each individual will have his own way of working out details, and all that is here attempted is to lay before the reader some methods which in the experience of many have proved most advantageous.

PART I.—FOSSILS AND THEIR MANNER OF OCCURRENCE.

DEFINITIONS.

According to a definition proposed by Charles Lyell, a fossil is "any body, or the traces of the existence of any body, whether animal or vegetable, which has been buried in the earth by natural causes."

Fossils, or "petrifactions," as they are sometimes termed, may also be defined as parts of plants and animals once living in the water, on the land, or in the air. Fossils are never more than parts of organisms, since the soft structure of the later can not be preserved, though impressions or casts of them are sometimes retained in fine sediments or muds. It follows, therefore, that fossils are usually the relics of the hard parts of organisms, such as the shells of mollusks, the skeletons of sponges and corals, the bones of fishes, birds, or mammals, and the wood, bark, or leaves of plants. These ancient organisms were buried by the accumulating sediments of oceans, lakes, or marshes. Fossils may preserve much of their original mineral matter, or may have it greatly altered or entirely replaced, subsequent to their burial, by other mineral substances. Footprints, trails, or burrows left by animals upon sand or mud are also included under the term fossils, though these objects were at no time parts of animals.

CONDITIONS IN WHICH FOSSILS OCCUR.

The conditions in which fossils occur in nature are various, and it is important that the collector of extinct plants and animals should be familiar with them. This subject has received much attention from Dr. Charles A. White, an honorary curator of the National Museum, and his observations are given in his valuable essay on "The relation of biology to geological investigation," which because of its completeness is here quoted at length. He writes:[1]

There are seven different natural conditions in which fossil remains are recognizable, three of which relate to substance, three to form, and one to both. To those relating to substance I have applied the terms permineralization, histometabasis [substitution], and carbonization; to those relating to form, the terms molds, imprints, and casts; and to the one relating to both form and substance, the term pseudomorphism.

Permineralized fossils.—The term permineralization applies to that condition of fossil remains of animals which differs least from their original condition as parts of living animals, such, for example, as bones of vertebrates, shells of mollusks, tests of crustaceans, etc. It is in this condition that the greater part of all fossil remains are found. In their original condition they were all composed of both mineral and animal matter. Mineral matter greatly preponderated in nearly all of them, but the proportions differed much in the case of different branches of the animal kingdom. For example, the proportion of animal matter is much greater in bones, even in their most solid portions, than in shells of mollusks or tests of most crustaceans. In all cases, however, the proportion of mineral matter was sufficient to perfectly preserve the original form of each specimen during the process of fossilization. Their only material change in this process was the removal by decomposition of the animal matter and its replacement by mineral matter, the latter having been added as a precipitate from its solution in the waters in which the fossilization took place. This having been continued until all the minute interstices originally occupied by the animal matter were filled, the fossils became wholly mineralized and as indestructible as are other minerals of like composition. Indestructibility of these fully mineralized fossils, however, is not in all cases absolute, as will appear by remarks in following paragraphs.

Fossils in which the original mineral substance is exchanged for another.—The term histometabasis is applied to that condition of fossilization in which an entire exchange of the original substance for another has occurred in such a manner as to retain or reproduce the minute and even the microscopic texture of the original. It is especially applicable to silicified wood. In such cases of fossilization the exchange has been made by destructive decomposition, molecule by molecule, of the woody tissues and their immediate replacement by precipitated molecules of the silex held in solution in the water in which the wood was immersed. By this remarkable process not only the original cell structure of various kinds of wood, but the characteristic cell markings of each kind are often found to have been so perfectly preserved in the solid agate-like mass that it may be as completely studied as if the specimens were taken from living trees.

Fossil pseudomorphs.—Pseudomorphism of fossils is so nearly like that of mineral crystals that this term is equally applicable to both. It consists in the replacement of the original substance of the fossil by a crystallizable or crystallized mineral, such, for example, as calcite, pyrite, quartz in the form of chalcedony, etc., the original form of the fossil being perfectly retained. It is evident that at least a part of the crystallized pseudomorphs were formed by the precipitation of the component mineral from its solution within such cavities as are described as molds in

[1] Proc. U. S. Nat. Mus., xv, 1892, pp. 264–267.

another paragraph. In such cases they differ from casts as described on the next page only in being crystallized, but crystallization is one of the distinguishing characteristics of pseudomorphs. In many cases pseudomorphs were evidently formed by molecular replacement. All those chalcedonic pseudomorphs of shells which sometimes occur in limestone, and from which they often may be freed in a complete condition by acids, have doubtless been produced by molecular replacement.

Carbonized fossils.—The term carbonization is applied in this connection only or mainly to such masses of vegetable remains as coal, lignite, and peat. While such remains are of great economic value and often of great importance in structural geology, they are of little paleontological importance, because the organic structure of the plants from which they were derived has usually been so completely obliterated as to render them useless for such a purpose. Occasionally, however, fruits and other separate parts of plants are found to have acquired a carbonized condition in which their botanical character may be approximately determined.

Fossil molds.—Molds are cavities in sedimentary rocks which were originally occupied by fossils, the latter having been subsequently removed by the percolation of water containing a solvent of the fossils but not of the rocks. Such solvents, while completely removing certain kinds of fossils, sometimes left others unaffected, and sometimes they acted equally upon fossils of essentially the same chemical composition. For example, the shells of the Ostreidæ almost always have resisted such solvents more than have most other shells. The original surface features and markings of fossils are often minutely preserved in molds, but they are frequently obscured in different ways; for example, by compression of the mold after it was formed, or by its having received a drusy lining.

Imprints of fossils.—Imprints do not differ materially in character from molds, the former term being usually applied to impressions left in the rock by thin substances like leaves of plants, wings of insects, etc., after their removal by decomposition. Sometimes, however, the molds of shells and other fossils have been reduced to the character of imprints by the extreme pressure to which the strata containing them have been subjected. The details of imprints have often been obscured by pressure, as in the case of molds, but they are often preserved with the greatest degree of minuteness.

Natural casts of fossils.—Casts are counterparts of fossils, having been produced by the filling of molds with a substance other than that of the original fossil. It may have been by the injection, caused by pressure or otherwise, of substance derived from the matrix or inclosing rock, or by the precipitation of substances brought into the cavity suspended in percolating water. If, in the latter case, the cast is composed of a crystallized mineral, the term pseudomorph is applied to it, as already stated. Natural stony casts of the interior of shells and other fossils are often found within the molds which were formed by the solution and removal of the fossil itself, and they are also often found filling permineralized shells. The student of fossils often finds it desirable to take artificial casts of natural molds, especially in case he can obtain no other representation of the species he desires to study. By such a cast the original form and surface features are often reproduced with the greatest accuracy. * * * Although the soft parts of animals could never have become really fossilized, cases have occurred of the preservation in fine sediments of their form and even parts of their structure, in the condition of imprints or casts. A most remarkable and exceptional case of this kind is that of the jelly-fishes of the Jurassic slates of Solenhofen [and Middle Cambrian of Alabama], where, in the fine sediments of which the slates were originally composed, not only their shape but the essential parts of their structure are preserved.

Adipocere bodies.—Fossilization or petrefaction of human bodies is often popularly reported to have occurred, but these are only cases of the change of the adipose and muscular tissues of the body to the wax-like substance adipocere, which process only delays but does not prevent final and complete decomposition. This change frequently occurs in other animal bodies that have become buried in wet or constantly damp earth, and packages of pork recovered from old river wrecks have often been found to have undergone the same change.

Every specimen of fossilized man is really only a skeleton, but the wonderful cases of preservation of the human form in the partially hardened volcanic ash of Pompeii are worthy of mention in this connection as illustrating more than one of the facts that have been stated in the foregoing paragraphs. While excavating the buried city the workmen came upon molds of the bodies of persons who were suffocated by, and buried beneath, the shower of ashes from Vesuvius. The body, even including the bones, long ago decomposed and removed by the percolation of water which fell from the clouds. Casts of these molds, when discovered, were made by pouring them full of plaster, and when the comparatively soft inclosing matrix was removed an exact counterpart of the body was disclosed just as it fell in death well-nigh two thousand years ago.

PART II.—APPARATUS AND METHODS OF COLLECTING INVERTEBRATES AND PLANTS.

KINDS OF ROCK AND SITUATIONS IN WHICH FOSSILS MAY BE FOUND.

Sedimentary rocks.—Fossils are never found in granite or in any originally molten rock, while sedimentary or stratified rocks usually contain such remains. All such rocks should therefore be examined for fossils. "A little practice," says Geikie, "will teach the learner that some kinds of sedimentary rocks are much more likely than others to yield organic remains. Limestones, calcareous shales, and clays are often fossiliferous; coarse sandstones and conglomerates are seldom so. Yet it will not infrequently be found that rocks which might be expected to contain fossils are barren, while even coarse conglomerates may, in rare cases, yield the teeth and bones of vertebrates or other durable relics of once living things. The peculiarities of the rocks of each district must, in this respect be discovered by actual careful scrutiny."[1]

Metamorphosed sedimentary rocks.—In mountain ranges sedimentary rocks are often subjected to enormous pressure or to heat in the proximity of volcanoes or their outflows of lava. In such places sedimentary rocks are more or less altered or metamorphosed, and the fossils are much changed or distorted, or may be entirely obliterated. "Metamorphism is a crystalline (usually also a chemical) rearrangement of the constituent materials of a rock. In its production the following conditions have been mainly operative: (1) Temperature, from the lowest at which any change is possible up to that of complete fusion; (2) pressure, the potency of the action of heat being, within certain limits, increased with increase of pressure; (3) mechanical movements, which so often have induced molecular rearrangements in rocks; (4) presence of water, usually containing various mineral solutions, whereby chemical changes would be effected which would not be possible in dry heat; (5) nature of the materials operated upon, some being much more

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[1] SIR ARCHIBALD GEIKIE, Text-Book of Geology, 3d ed., p. 669, 1893. Macmillan & Co.

susceptible of change than others.[1]" In such regions, look over the old weather-worn rock surfaces, since the chances of finding fossils there are usually far more favorable than on fresh fractures. Localities of this kind usually yield few and poor fossils, but these are of the greatest interest to the geologist for determining the age of the strata in question.

Localities new to the collector.—In searching for localities new to the collector, one way is to begin by asking local school-teachers or druggists if there are any collectors of fossils in the vicinity. If such a person can be found, directions to localities will generally be given. As a rule, however, one has to depend upon himself in this matter, and it is advisable to begin by looking over the refuse piles of quarries and the cuttings along railroads and turnpikes, or to search the banks of streams and hillsides for natural rock exposures. If organic remains occur, these are, as a rule, most easily seen on weathered surfaces, since the fossils are nearly always of a mineral composition different from the matrix in which they are buried, and therefore weathered differently. Friable sandstones, however, often fail to show traces of fossils on weathered surfaces, even when they are quite abundant within. Loose drifted rocks in the beds of streams generally will indicate, on breaking them, whether fossils abound in the vicinity, and the amount of wear will afford some clew as to the distance they were transported. These "lost rocks" often serve as leaders to fossiliferous strata. Externally they are of no value as specimens, but when broken may yield an abundance of good fossils.

A list of some important North American localities for fossils is given in an appendix to this paper.

Stone walls.—In many regions stone walls furnish excellent fossils, the rock being usually derived from strata in the immediate vicinity of the wall. Examine the fields around these walls, particularly after the spring rains, as such localities are occasionally productive of free fossils.

Rock ballast.—Broken rocks on which railroads are laid are sometimes good places in which to collect, but caution is required lest several geologic horizons become mixed. Trackmen usually give the sources of such rocks.

Gravel pits.—Sometimes fossils are found in gravel pits, but are usually very much worn. In certain regions, however, notably in Michigan, very good fossils are found in such places. These transported fossils may have an interesting tale of travel to tell. In Minnesota it is not rare to find fossils in the drift from Manitoba, while in the Ohio Valley pieces of native copper are sometimes picked up which were transported from the Lake Superior copper region by the great glaciers from the north. The value of drift fossils, however, is

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[1] GEIKIE, Text-Book of Geology, 3d ed., p. 319. See also JAMES D. DANA'S Text-Book of Geology, 4th ed., p. 309, 1895.

greater to the glacial geologist than to the paleontologist. As a rule, fossils not found in place, whether they have been transported by human or other agencies, are much less valuable than those collected from their original beds. The collector should therefore always try to trace all fossils found in walls, stream beds, drift, etc., to their source, and make his principal collection there.

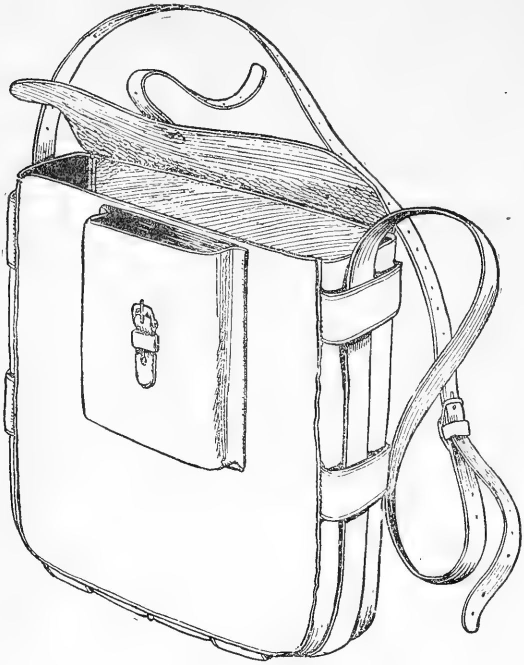

FIG. 1.—Collecting bag or knapsack.

GENERAL COLLECTING OUTFIT.

1. *Collecting bag.*—The leather collecting bag illustrated above (see fig. 1) is one in general use among geologists and paleontologists. It has a width and length of 13 inches and a depth of 4 inches. Flat-bottomed baskets are also useful to pack fossils in, but are more tiresome to carry on long journeys than leather bags, which may be carried over the shoulders.

2. *Hammers.*—Two hammers are required, the "paleontologist's" hammer and a "trimming" hammer. The former (see fig. 2) is most convenient for collecting fossils and for prying up thin ledges of rock. The peen end is longest, tapering, with the cutting edge transverse to the handle; the striking end has a flat, square face. The trimming hammer (see fig. 3) should be small and light, to enable the user to strike a quick, sharp blow. To avoid shattering a specimen, direct the blows near the margin and never near the center.

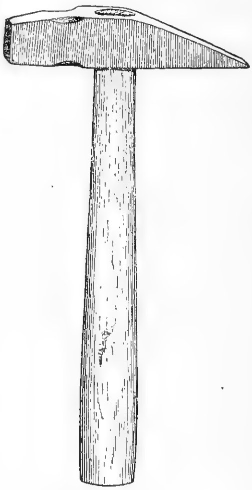

FIG. 2.

FIG. 3.

Collecting hammers.

3. *Chisel.*—A small stonecutter's chisel is useful in freeing fossils from large blocks of rock or from the face of cliffs.

4. *Magnifying glass.*—For field use this need not be expensive. An ordinary pocket glass having lenses seven-eighths and one inch in diameter, bound in rubber, and worth about 80 cents, will serve. For study purposes a "Codding'on magnifier" of three-fourths of an inch focus is serviceable, but a better glass is the "achromatic triplet" of three-fourths of an inch focus. In the former the field is limited but of good definition; the glass is worth $2. The "achromatic triplet" has a large field, great depth of focus, with perfect definition, and is sold for $6.

5. *Field label.*—It is always desirable to record the locality of specimens at the time of collecting. The field label used by the National Museum is shown on page 19.

6. *Notebook.*—A notebook in which the paper is bound on the end instead of the side is the most convenient kind.

7. *Newspaper for wrapping.*—A supply of newspapers should invariably be taken for wrapping the specimens.

8. *Tissue paper.*—Delicate fossils are best protected by wrapping in tissue paper before using newspapers or coarser packing.

9. *Wrapping twine.*—The collector should carry a supply of twine for tying small lots of fossils together in bundles.

DIRECTIONS FOR COLLECTING FOSSIL PLANTS.[1]

Fossil plants are rarely found in perfect condition, and usually occur as impressions in rocks of different kinds, particularly in shales. They are not often found loose, weathered out, and lying on the surface, as is frequently the case with invertebrates. Good collections of fossil plants are usually obtained by quarrying and splitting large masses of rock. While the oldest plants are inhabitants of marine waters, and are found sparingly associated with marine faunas in the older systems of the Paleozoic era, yet the majority of known ancient plants are from coastal, marsh, or lowland deposits, or have been blown or washed from high lands into the water, and finally buried in sediment. Because of the usual imperfection of fossil plants, it follows that the value of any specimen will largely depend on the relative abundance and perfection of the parts, in connection with the geologic age. All plants are of value, particularly those from the land of pre-Devonian times, and should be carefully gathered, no matter how fragmentary. Coal-measure plants are usually found in good condition in the shale layers above coal seams. In the fresh-water Mesozoic formations the sandstones often contain numerous well-preserved leaves.

When fossil plants are abundant and the flora is extensive, it is advisable to make large collections and to retain all those specimens which present important or diagnostic characters. These are "the tips of a leaf, a petiole [footstalk of a leaf] with a small part of the leaf

[1] If the collector desires more detailed directions for collecting fossil plants, he is referred to Part B of this bulletin (by Prof. F. H. Knowlton) from which the quotations here given have been taken.

attached, a good perfect base of a leaf, or a well-preserved portion of the margin. In collecting ferns the most valuable specimens are those found in fruit [the small brown clusters of spore-cases on the underside of ferns] and nothing, no matter how fragmentary, that shows the slightest tendency to fruit-bearing should be discarded." Tree trunks are always important.

Counterparts, or reverse impressions, should be preserved and kept together, but wrapped separately. Remove with the trimming hammer as much superfluous rock from the specimen as is possible without endangering the safety of the specimen, but never trim closer than to within one inch of the plant nor get the pieces so thin that the jarring of transportation will cause them to break. If a good specimen is accidentally broken do not throw it away, but retain all the pieces, wrapping them separately and bringing them together in one bundle.

Plant-bearing clay should be sent to the Museum in bulk, to be broken in the laboratory.

DIRECTIONS FOR COLLECTING FOSSIL INVERTEBRATES.

Make large collections.—The first important principle for a collector to observe is to gather large collections from the localities visited. The extent of a collection, of course, will depend upon the abundance of the individuals and species present. Never restrict yourself to six or a dozen specimens of a common species when hundreds can easily be had. These duplicates assist in studying the local variation of species, and are also useful in making exchanges.

Keen eyesight and the expenditure of an abundance of intelligent labor are requisite for the gathering of a valuable collection. It may be the work of many days or weeks to exhaust one locality, and many local collectors have spent a few hours a week for ten, twenty, or even more years in bringing together their unique collections.

Collecting in hard rock.—To make a collection from limestone, dolomite, sandstone, quartzite, or slate, usually involves considerable work in the breaking and examining of the rock. When such rocks are found in large masses it is well to use a sledge hammer first to reduce the rock to sizes which may be easily broken with the smaller hammers. Rocks which never have been subjected to great pressure usually break most readily along the lines of bedding, where fossils are most abundant, therefore the collector should try as much as possible to split the rock along these lines of natural weakness. The peen end of the hammer is best for splitting soft or slaty material, such as shales, slates, or shelly limestones.

It is bad practice to select a representative collection in the field. Laboratory work nearly always discloses the want of more material for the study of specific variation. The rarer species are also often thrown away by this method of collecting. It is far safer and less expensive to reject specimens in the laboratory than it is to go back to a locality for more material. Collectors should always bear in mind that circumstances may prevent the revisiting of a locality, and should therefore make the best use of present opportunities.

In the field the first duty is to collect, and it is inadvisable, therefore, to try to become familiar with the details of species. The appropriate place for study is the laboratory. The fossils should be examined only far enough to ascertain whether they are good or bad specimens. Notice should be taken of rare species which are often fairly abundant along narrow zones or are found in more or less separated clusters. When such are met with, it is desirable to search carefully along the zone of occurrences for more.

Rock trimming.—Do not trim the rock surrounding fossils too closely, since much of the specimen may be covered; moreover, specimens when not obtained free look far better with a little rock around them. The final trimming should be done after the fossil is developed in the laboratory.

Hasty collecting.—It is unwise to collect hastily or to try to cover much territory in a short time unless conditions demand it. One large and well-gathered collection is worth far more than two or three small ones.

Collecting free fossils.—When fossils are found free, lying in the soil, it always pays to get down on the hands and knees and crawl over the ground in search of them, rejecting only poorly preserved or badly broken specimens. In so doing the smaller specimens are more likely to be seen, and at the same time collections will not be made hastily. Picking of this kind affords much pleasure and involves less labor than collecting from limestones or sandstones. The collector should remain in such locality until all good material that is visible has been picked up.

Molds and casts of fossils.—Rocks having cavities in them, which are the molds of organisms, should always be collected if the cavities are not too much filled with crystals. These molds are of course broken before discovered, but all the pieces should invariably be saved. Do not gum the parts together in the field, but wrap each separately in paper, and put all the parts of one specimen into a single package. The fastening together can be done much better in the laboratory, and the necessity of having a gum bottle in the collecting outfit will be avoided.

Internal casts of gastropods (snails) and pelecypods (clams, oysters, etc.) are often of little value when collected alone, but if the surrounding matrix preserving the exterior form and ornamentation of the shell is also carefully saved they are more instructive than those showing only exterior characters. Casts of single valves of pelecypods should always be saved. Do not trim these too closely, as they may show impressions of the hinge teeth. Every fragment of a bivalve showing any part of the hinge should be saved.

In gastropods the form of the aperture is one of the most important features, but one that is most frequently imperfect in specimens collected from hard rocks. In species with long canals and expanded outer lips, carefully save every fragment of these parts.

Siliceous fossils.—Fossils of a siliceous nature, partially weathered out of limestone, should be gathered in bulk, to be treated in the Museum with muriatic acid. Material which will bear this treatment is readily tested with a pocketknife. If the knife does not scratch the fossil, but leaves a black mark, it will be well to make an experiment. Of course, where the fossils are in cherts or are more or less surrounded with amorphous silica nothing can be done to free them. Limestone with fossils changed into iron pyrite or of a carbonaceous or phosphatic composition can also be submitted to the acid process of developing. The structure and young stages of graptolites, linguloids, goniatites, etc., are sometimes only obtained by this method.

Fossiliferous shales.—Where fossils are found free and abundantly weathered out of clay or shale, it is always advisable to take a small quantity of the weathered shale and wash in a pan until the water is no longer colored by the residuum. If this is found to contain an abundance of fossils, a box of clay unwashed should be gathered. The object of such collecting is to obtain the young stages of mature forms and also microscopic organisms, such as ostracods, bryozoa, etc.

Calcareous fossils.—Fossils of this nature taken from shale banks and much covered with firmly adhering shale, if otherwise good and solid, should not be thrown away, since many of these can be cleaned with caustic potash. This is particularly true of corals and the interior of brachiopods.

Fossil-yielding marls.—Marls having an abundance of small fossils, which frequently occur in Tertiary deposits, should be dug up and shoveled into barrels or boxes, to be picked over in the laboratory. This plan, however, is only feasible when the fossils are reasonably hard. Mr. T. W. Stanton suggests the following plan of operation:

In sandy marls like those of the Cretaceous in the Southern States the animal matter has nearly all been removed from the more delicate shells, leaving them in a very soft condition that will not permit rough handling. In such cases the marl should be carefully dug up and the pieces showing edges or surfaces of fossils trimmed with knife and hammer to a convenient size for packing. When the marl is compact and not too wet good results have been obtained by blasting, using an inch and a half auger with a shank about 4 feet long for making the hole. No attempt should be made to expose the fossils in the field nor to free them from the matrix, as they would then be broken in transit. It is a good plan to have at hand a hot solution of common furniture glue and to apply a coat of it to all exposed surfaces of shells, otherwise they are likely to crack and fall to pieces on drying. The glue is to be used in preference to other hardening materials, because it can be easily washed off with a wet sponge and does not interfere with the subsequent cleaning of the fossils. Collections of this kind should be packed in cotton or other soft material in small boxes, which may then be packed in a larger box. If this is not done the fossils are likely to be crushed and ruined by their own weight.

Such fossils are cleaned and hardened in the manner described on page 24 as soon as practicable after they reach the laboratory.

Limestone or ironstone nodules.—Nodules of limestone or ironstone often have very fine fossils in the center. They should be broken and examined, but sometimes it is not easy to split them so as to expose the fossil. If the nodules promise well, a quantity of them should be collected and treated in the laboratory "by putting the nodule into a fire, and dropping it, when quite hot into cold water."[1]

Importance of noting the exact location of fossils.—The second important principle in collecting fossils is to determine accurately the geographical position of the locality and the horizon from which the fossils have been taken. This information should be recorded while in the field in a notebook. It is of great importance not only to the geologist, but to the paleontologist as well. Fossils without locality have, as a rule, little value and generally are thrown away by careful students. If a species is common and scattered over an entire hillside, it is well to determine whether all the specimens are in place or derived from a stratum near the top of the hill. The strata of a hill may represent a very long period of deposition.

At a locality where more than one fossiliferous zone occurs, never collect promiscuously from all, but gather the fossils from one horizon at a time. Pack each lot separately, with a field label.

When collecting in loose rock or talus at the base of a cliff, note this fact on the field label, but when conditions are favorable never neglect to ascertain the horizon or horizons from which this rock has fallen.

If collections are made from many localities within a geologic basin where certain common species constantly recur, do not fail to gather these from all the places, since by such collections local faunal or floral changes and geographic distribution are ascertained.

"The theory that all the existing forms of life have been derived from other forms by a natural process of descent with modification, and that this same process has been in action during past geological time, should enable us to give a rational account not only of the peculiarities of form and structure presented by animals and plants, but also of their grouping together in certain areas, and their general distribution over the earth's surface."[2]

Fossils from the drift are sometimes very valuable, but when collecting them the fact that they are from the drift should be noted. A drift fossil may lead to the discovery of important outcrops, or give other valuable information.

PACKING INVERTEBRATES AND PLANTS FOR SHIPMENT.

Wrap each specimen separately in paper, preferably in old newspaper, or, if delicate, in cotton or tissue paper. When the fossils are small

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[1] GEIKIE, Text-book of Geology, p. 673, 1893.

[2] WALLACE, Darwinism an Exposition of the Theory of Natural Selection, p. 338, 1890.

several can be wrapped together, but separate each one so as not to rub, adding others as the package is rolled up. Another good method, which in some cases is the only successful one, is to select the smaller and more delicate fossils and lay them between cotton in cigar boxes. When the collection is wrapped, set the packages vertically in the box, one against the other, in rows and layers, until filled up. Never lay thin slabs horizontally in the box, as the jarring during transportation is apt to break quite a number. If a vacant space is left on the top, fill up with excelsior, hay, straw, or paper, and force this loose material gently but firmly down with the lid.

Boxes are conveniently and cheaply purchased in grocery or dry goods stores. Soap, starch, or canned-fruit boxes will answer for invertebrates, or if stronger and larger boxes are needed these can be had in hardware or stove stores.

Number the boxes and keep a list of the contents, especially a list of the localities from which the fossils in each box have been derived.

PART III.—METHOD OF COLLECTING FOSSIL VERTEBRATES.[1]

OUTFITS.

To the invertebrate outfit described on a previous page it is necessary, when collecting fossil vertebrates, to add a pick and shovel for digging, some large stone mason's chisels for use in freeing bones from a hard matrix, a large bag of flour, plenty of gunny cloth, several cans of prepared glue, and some gum arabic for saturating soft bones. Rough boards, an inch thick, for making boxes should be included in the outfit when lumber yards or suitable boxes are not accessible.

DISCOVERY AND REMOVAL OF SKELETONS.

Bones, as a rule, are not nearly as easily gathered as invertebrates or plants. Of course loose specimens are easily collected, but it is not common to find such in good preservation. The difficulties encountered in successfully collecting bones are numerous, beginning with the finding of a skeleton and increasing as the work of digging up a monster progresses. Persons without experience in taking up vertebrates and finding large specimens should begin the exhuming cautiously and slowly, or, better still, leave the skeleton alone, cover the exposed parts with earth, and call the attention of this Museum to the find. However, make some examination of the specimen, as to the extent of the parts and their condition, so that an intelligent description of it may be given.

In some regions, if "the explorer searches the bottoms of the rain washes and ravines, he will doubtless come upon the fragment of a tooth or jaw, and will generally find a line of such pieces leading to an elevated position on the bank or bluff where lies the skeleton of some

[1] To Prof. O. C. Marsh, honorary curator of fossil vertebrates in the National Museum, the writer gratefully acknowledges valuable suggestions in relation to this work.

monster of the ancient sea. He may find the vertebral column running far into the limestone that locks him in his last prison; or a paddle extended on the slope, as though entreating aid; or a pair of jaws lined with horrid teeth, which grin despair on enemies they are helpless to resist; or he may find a conic mound, on whose apex glisten in the sun the bleached bones of one whose last office has been to preserve from destruction the friendly soil on which he reposed. Sometimes a pile of huge remains will be discovered, which the dissolution of the rock has deposited on the lower level; the force of rain and wash having been insufficient to carry them away."[1]

Complete skeletons are rare, since these remains, unless the animals were mired in swamps, have been more or less broken up by the action of the waters or scattered by predaceous animals. Good skeletons are often lost through lack of knowledge of proper methods in collecting. Of the American elephant and mastodon many skeletons are found annually in the United States, and yet there are few fine skeletons of these animals extant in the museums of this country. Teeth are often seen, but other parts are commonly lost. Persons who find the bones of these monsters usually dig them up and lay them on the ground to dry, where their complete ruin is but a matter of a few days, since, if unprepared by gum or glue solutions, the bones will crumble in the sun and air.

The skull of a mastodon or elephant falling into the hands of an unskilled person is usually destroyed, because of its size, weight, and soft condition in the ground in which it occurs. When the great molar teeth are seen, considerable curiosity is aroused, and then it has happened that sledge hammers or any other instrument which would break the skull have been brought into action so that the teeth may be taken out. These may eventually be seen by somebody having a knowledge of their scientific value, but only after the valuable skull has been ruined. The teeth may be worth several dollars, whereas if the skull had been left entire it would have brought a far greater price.

The bones of each individual animal should be kept together, and separate from all others. Gather all the loose bones and fragments on the surface before digging out the rest of the skeleton. Single bones, if one end is perfect, are worth saving. If freshly broken all the pieces should be sought for and preserved.

Small more or less complete skeletons are not so difficult to handle as large ones. When complete, or when parts are in their natural position, do not remove them piece by piece, but leave the skeleton together. Specimens in their natural position are of great importance to anatomists. Having secured such a specimen, dig away enough of the rock on top to ascertain its position and extent. If in solid rock, all that should be done is to free the block, leaving sufficient rock around the skeleton to give it firmness. When in a soft matrix, expose

[1]Cope, E. D.—The Vertebrata of the Cretaceous Formation of the West. Rept. U. S. Geol. Survey Terr., II, p. 43, 1875.

the skeleton in a general way, soak the exposed bones well with gum water, cover completely with one layer of thin oiled paper, lay across the entire length of the specimen two or more iron rods or sticks of wood, and then prepare enough thick plaster of paris to make a solid mass several inches thick over the top of the specimen. After the plaster has set, the undermining can begin, but leave enough rock to give stability to the block. If the skeleton lies in mud and is not large, it will be well to pour plaster around the entire mass. Wherever plaster is used for bedding or stability do not forget to first lay iron rods or sticks of wood lengthwise on the specimen before pouring and smearing the plaster. The plaster when dry is brittle, and these rods are inserted to keep all the pieces in place in case of breakage.

The limbs of large skeletons should also, if possible, be kept together. Never separate the toe bones when found in their natural position. If in a soft matrix, pour plaster around each foot as described above for small skeletons.

To dig out skeletons embedded in a more or less solid matrix is a matter of skillful quarrying. Do not separate the bones of skeletons more than is necessary even though the blocks may weigh a few tons. Mr. J. B. Hatcher succeeded in quarrying out in Wyoming, for the United States Geological Survey, a mass of rock weighing about three tons and containing an enormous skull of Triceratops nearly eight feet in length. Moreover, it was necessary to haul the specimen forty miles over rough trails to the railroad.

Hard bones, even when badly shattered, should never be rejected nor shoveled into a box, as is sometimes done. These can be taken up successfully by a method long in use by Professor Marsh and Mr. J. B. Hatcher. After the bones have been exposed, fill all the large cavities with thin fluid plaster of paris. Next stick short pieces of gunny cloth with thick flour paste over the loose pieces. Lengthwise along the bone lay strips of gunny cloth 2 to 4 inches wide, each slightly overlapping the other, fastening them with flour paste. When dry, undermine the bone and turn it over, pasting also on this side a longitudinal layer of gunny cloth, followed by another wound around the specimen from one end to the other. Use plenty of flour paste, since when dry this gives great stiffness to the gunny cloth and therefore supports the bone. In the laboratory, this protection is readily taken off by moistening with a sponge as the work of hardening and solidifying the bone progresses.

PACKING FOR SHIPMENT.

When specimens are very large the boxes should be made of two courses of lumber nailed to each other crosswise. Apply as many stays inside as are necessary to hold the block firmly in place, for if it should move about not only the box may be broken, but the specimen will in all probability be damaged beyond repair.

Never pack large and small bones in the same box, since the weight of the larger will crush the smaller.

FIELD LABELS AND NOTES.

It is not necessary to place a field label with every fossil unless the specimens are large and packed in different boxes, or when there is some important geologic fact connected with a specimen. The usual way is to pack one or two field labels together with the fossils of one locality and geologic horizon in each package or box.

In the note-book the geographic position of the locality and the horizon of the fossils should be carefully noted. Also draw a profile or "section" of the rocks as seen, giving the thickness of the beds. Note also the dip of the rocks when determinable, and the strike, which is at right angles to the prevailing dip of the strata. Each locality can be given a number and the beds of each section letters. If this is

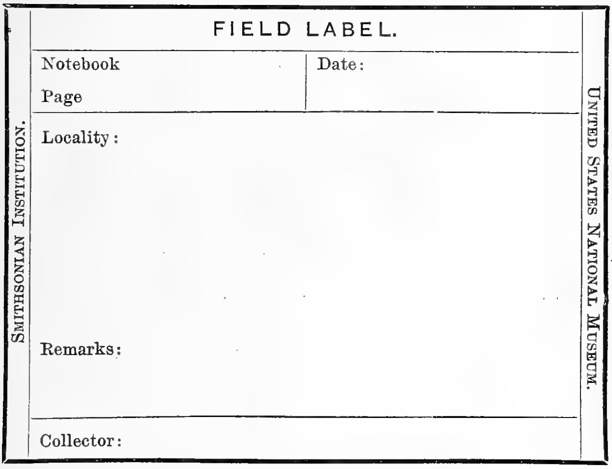
SMITHSONIAN INSTITUTION.
FIELD LABEL.
Notebook
Page
Date:
Locality:
Remarks:
Collector:
UNITED STATES NATIONAL MUSEUM.

FIG. 4.—Museum field label.

done, it will simplify the writing of field labels, since the number of the locality and the letter of the zone from which the fossils came is all that is required. Another way is to write out this detailed information on the field label. The number of the book, and the page on which the information relating to the fossil in question is given, should be on the field label, also the date when collected and the name of the collector. A copy of the field label in use by the National Museum is given above.

PART IV.—PREPARATION OF FOSSILS FOR STUDY.

SEPARATING FOSSILS.

Having received the boxes in the laboratory, they are to be unpacked and distributed into drawers or trays, each lot of fossils being kept separate with its proper field label. The fossils are next to be washed thoroughly with a stiff brush and water to rid them of all loose mud. This, however, can not be done with a great number of fossils, because of the soft condition of many sediments, such as friable sandstones, soft shales, chalks, and marls. In general, fossil plants can not be washed, since these are usually preserved in soft materials. Vertebrates, also, do not need this preliminary treatment, as most specimens will first require the work of a "stone mason" or a preparator.

Clay and marl washing.—Paleozoic fossiliferous clays which are to be washed for small and young fossils should be first dried in an oven or in the sun and then well soaked in water for a day or more before washing. A deep pan or bucket serves well for this purpose, using the hands to stir the mass around, but do not get too much mud in suspension, since in pouring off the muddy water many of the smaller organisms are liable to be carried away. The writer has tried nests of sieves of various size meshes, placing the soaked mud in the upper coarse one, and using a stream of running water as the cleanser. But to catch all the smaller fossils, which is the main object, the lower sieve must be very fine (a bolting cloth), and this is soon clogged with mud, preventing further washing. The contents of the lower sieve must be washed alone, and in the end a pan is more productive for rapid work, with equally good results. After the washed earth has been dried it should be sifted, to facilitate picking, into three grades, using sieves of 6, 18, and 38 meshes to the inch. The coarser material can be assorted with the unaided eye, but the finer grades will have to be selected under a low-power lens. A moistened camel's-hair brush is the best tool with which to pick up these smaller organisms. If the brush is held in the end of a small vial a twirl of the fingers will readily remove the attached fossil.

The material derived from washing slabs and the residuum from etching by the muriatic-acid process should be washed in the same way as described above for clay. Great care, however, must be taken in washing etched fossils, since quite often these consist of but a thin outer and inner layer, the intermediate space being hollow and therefore very delicate. The surface detail of such fossils is preserved better than on fossils weathered out in nature.

Washing Paleozoic fossiliferous clay for mature or large fossils is sometimes resorted to on a large scale. In England, Mr. Maw prepared for Thomas Davidson several tons of Dudley clay (Upper Silurian) in tubs beside a stream. His results were remarkable.

Marls frequently yield good fossils when carefully washed. It is often the case, however, that marl fossils are quite soft or chalky. Such, of course, can not be washed, and must be picked out and cleaned dry. If hard, the marl is laid in a coarse sieve, and washed in a stream of running water until clean. Some of the fine material thus carried away should be caught and washed separately for foraminifera or other microscopic organisms by the method described beyond.

Washing unweathered shale.—Dry the shale well in an oven, and then soak it in water till it crumbles. The larger fragments can be dried and soaked again and again until all are well reduced, but some unbroken pieces will always remain. Wash away all the mud as described above for clay. Then boil in a dish "over a brisk fire for about half an hour, the boiling being continued with occasional changes of water till little or no mud appears." Gray shales usually boil down completely.

The black shales, on the other hand, containing considerable proportion of bituminous cement, will not thoroughly break up even after prolonged boiling.

The drying and steeping here described may be regarded as processes of rapid artificial weathering. The effects of the heat of a fire upon shale resemble those of the sun's rays, and the soaking in water is a counterpart of the action of rain. It is surprising how easily hard, compact shale, which can with difficulty be broken or split with a hammer, may, by the method above specified, be reduced to dust or to fine granular débris, from which even delicate shells may easily be picked out entire.[1]

Washing for microscopic organisms.—One of the first essentials is that all glassware, pipettes, etc., designed for this use be absolutely clean, and that only river or rain water, recently filtered, be used; otherwise you will probably find on your slides many beautiful organisms that do not belong to the substance under examination.

Clay.—In preparing most of the samples of clay, we would put about 1 ounce of the material, and the same amount of common washing soda, into a druggist's two-quart clear-glass packing bottle, not over one-fourth filled with water, and let it remain twelve to twenty-four hours, frequently shaking the bottle, so as to thoroughly break up the clay. Now fill the bottle with water, and after twenty-five minutes carefully pour off the upper three-fourths of it. Again fill with water, and in twenty-five minutes decant as before; repeating this at twenty-five minute intervals until the upper three-fourths of the water in the bottle, after a twenty-five minute rest, will be nearly clear. A large amount of the fine sand, clay and the soda, has by this process been washed away, and the action of the soda has broken up the clay and removed most of the adhering material from the fossils. Now mount a few microscope slides from the residuary sand, etc., at the bottom of the bottle, by taking up with a pipette (a piece of small glass tubing makes the best pipette) a small amount of the material; scatter very thinly over the middle of the slides; dry them thoroughly over an alcohol lamp, or in some better way, and while hot, cover the dry material with a few drops of Canada balsam, keeping the slides quite warm until the balsam will be hard when cold. As these "trial slides" are seldom of any value, it is not necessary to use cover glasses if the balsam is hardened, as above directed. A careful examination of these slides under the microscope with a good quarter or half inch objective will decide as to the value of the material under observation, and if it proves to be only sand, pour it all out, wash the bottle, and again try the same process with another sample of clay. But if the slides show a few good fossils, the next step is to separate them as much as possible from the mass of sand, etc., with which they are associated. In this, as in the first washing, specific gravity will do most of the work. Pour off most of the water and put the shells, sand, etc., into a 4-ounce beaker (or glass tumbler), wash out the bottle, fill the beaker about three-fourths full of water, and after it has rested ten minutes, pour three-fourths off the top through a glass funnel into the bottle, repeating this five or six times. As in the first washing, mount and examine a few slides from the material at the bottom of the bottle, mounting and preserving slides, if found to be of value. If nothing of value is found pour out the contents of the bottle, and fill up again as before from the beaker, after five minutes rest repeating these washings and examinations at shorter resting intervals, of, say, three, two, and one minute, or less, until nothing but the coarsest sand remains in the beaker. In that there

[1] Sir Archibald Geikie, Text-Book of Geology, pp. 671, 672, 1893.

may be a few good specimens of *Polycystina*. Each layer of clay, as deposited by its specific gravity, has now been examined, and most of the fossils are contained in some or possibly two of them. Nineteen-twentieths of the original sample of clay have been washed away, and in the selected one-twentieth that remains there may be one fair fossil to 100 grains of sand.

Shale.—The fossil contents of most of the softer shales can be secured by breaking up the specimen with a pair of strong pliers, crushing the shale while under water and edgewise of its laminæ. This will free many of the fossils without breaking them. Then boil the firmer parts of it for a few minutes (or longer if the material requires) in a rather strong solution of washing soda, and wash and separate fossils from the fine shale, sand, etc., by repeated decantations, as directed in the treatment of clay.

Chalk.—Foraminifera, coccoliths, rhabdoliths, with an occasional radiolarian (*Polycystina*), of which the "farmer's chalk," or soft limestone, is largely composed, can be freed from the rock by washing the surface of a clean piece of it with a rather stiff brush while under the surface of the water in a bowl or basin. The water will soon become as white as milk. The specific gravity of the foraminifera and radiolaria will promptly carry them to the bottom, and they can be partly separated from the sand, etc., by repeated washings, decantations, etc., as directed in the treatment of clay; but unless great care be taken in this washing, the coccoliths and rhabdoliths, which largely give to the water its milky appearance, will be lost. They are very fine and very light, and some of them will remain suspended in a 4 ounce beaker of water for several hours. They can be separated from the other material by repeated washings and decantations, so as to make almost pure mountings, but the resting time between decantings must be from one-half to three-quarters of an hour.[1]

Limestones.—Entomostraca, and other small organisms in which the valves are united, may also be obtained in a perfect condition from this class of rocks, by pounding fragments of the fossiliferous material with a hammer within the circle of a small iron ring or "washer," one-eighth of an inch in thickness. As the rock is crushed by the blows of the hammer the organisms jump out of the matrix, but are retained within the bounds of the ring, which also answers as a gauge, preventing the material from being broken too small. The pounded rock is afterwards washed free from dust, dried and searched as above directed.[2]

DIRECTIONS FOR HARDENING SOFT FOSSILS.

Fossils from friable sandstone, ferruginous sandstone, soft clays, or marls, if not hardened, will usually soon be ruined. One method of hardening is to warm the fossils, then dip them into hot, thin glue water. The glue water must not be too thick, otherwise the specimens will have a decided gloss and stick to the trays in moist atmospheres. Warming the fossils before dipping assists the glue water in penetrating deeper into the rock, and it also guards somewhat against the glue gloss. However, a more desirable and quicker, though somewhat more expensive, method is the shellac process. All that is here required is to have a very thin solution of white shellac, in which fossils are well soaked and then laid aside to dry. Such hardened fossils will never stick to moist fingers, as is the case with glue-soaked specimens. Dr. W. H. Dall, of the National Museum, employs the shellac process entirely to harden all soft Tertiary marl fossils.

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[1] WOODWARD and THOMAS, The Microscopical Fauna of the Cretaceous in Minnesota, Final Report Geol. Nat. Hist. Survey Minnesota, Chap. II, pp. 25–27, 1893.

[2] GEIKIE, p. 673, 1893.

Mr. T. W. Stanton recommends the following process for soft fossils:

In soft fossils that are too fragile to remove from the matrix, such as those from the Cretaceous marls, the process of cleaning and hardening must be carried on at the same time. As soon as a small portion of the surface has been cleaned by means of lithographers' needles or dental tools, it is brushed with the shellac solution and set aside to dry. This process is repeated until the entire surface has been exposed, and afterwards in many cases the shell can be entirely removed from the matrix. If this is not practicable, the marl on which it rests should be trimmed and the whole mass dipped in the shellac solution.

METHODS OF RECORDING FOSSILS.

In all large collections the most desirable feature is that each fossil shall bear its systematic name, formation, locality, when and by whom collected. These facts can not, for obvious reasons, be written on each specimen, therefore more simple and less expensive methods are resorted to to accomplish this purpose. There are two methods in use by various large institutions, one of which is preliminary and the other of a permanent nature. Quite often both systems are applied to the same specimen for reasons explained below.

Preliminary record.—After the fossils have been washed and hardened, the preliminary recording should be taken up, since the fossils are as yet unstudied and unassorted, and may remain in this condition for many years, during which time it may happen that the field label, containing the most important information, is lost. To guard against such accidents and the additional one of getting fossils mixed during the work of separation and study of extended faunas and floras, Prof. James Hall adopted the plan of giving the field label a record number. Each label is carefully copied opposite a given number in the "locality record book." In it should be entered for each lot the detailed position of the locality, formation, date when collected, and the name of the collector. Never enter two lots under the same number, if derived at different times, even though from the same locality. As they come in the lots can be entered and numbered under continuous numbers, or certain series of numbers may be allotted to each system. Differently colored "tickets" can be used to differentiate Paleozoic from Mesozoic and Cenozoic fossils. However, such details will vary with the needs or tastes of each individual worker or institution, but each lot must invariably have its own register number.

Now punch out of paper having a prepared colored surface (green, orange, etc.,) circular tickets five-sixteenths of an inch in diameter. Upon these write very plainly with waterproof india ink the locality number given in the register to the lot in question. Stick these with liquid gum arabic or a prepared glue on each fossil in places where nothing of importance structurally will be covered, or in any out of the way places. If this "ticketing" is carefully done, specimens from many localities, without any labels, can be gathered for study into a single tray, and yet these little tickets will preserve the history of each individual specimen. When the fossils are smaller than the tickets put them into vials and stick a ticket on top of the cork, placing one or two loose ones inside the vial.

Permanent records.—After the collections have been studied and determined, the series of each species selected for permanent preservation is to be entered in the museum catalogue and given a permanent number. It should make no difference how many individuals are reserved to illustrate a species. All from one locality should receive the same number, but if from different localities each lot should have a distinct number. The museum catalogue number should be written or painted upon each fossil with materials of a permanent nature, since these numbers are to guard the museum against all mixing and loss of once acquired information. Black, green, red, or vermilion oil colors, thinned with turpentine and some japan or drier or indelible inks, are probably the best to use for this work. Some museums apply definite values to certain colors or desire that the numbers stand out conspicuously, but as rocks have many colors it becomes necessary to first paint on the specimen either a blue, white, or black base, on which is written the catalogue number. This method is very good for mineral, petrographic, or rock collections, but it is not necessary to go to so much labor with fossils. All that is required is a permanent number on each and every specimen in the collections. Duplicates need not receive such numbers, since they have locality tickets for their identification, but should be removed from the reserve-study collections.

TRIMMING AND CLEANING.[1]

With tools and brushes.—The cleaning of fossils is entirely mechanical, and the degree of success will depend largely upon the amount of patience and originality possessed rather than on the kinds of tools. For heavy cutting the ordinary tools of stonecutters are used, but for light work more delicate tools are employed.

All fossils for study and exhibition should be well cleaned. Remove the rock or clay from all parts, either by brushing or cutting. Hard, calcareous fossils are sometimes easily cleaned of all clay with a brush made of thin brass wire (see fig. 5). These brushes were first thus employed by Dr. C. E. Beecher, of Yale University. They have been used to great advantage on Waldron (Indiana) fossils, and even on such delicate organisms as crinoids from Crawfordsville (Indiana). However, care must be exercised, since the brushes are quite stiff and cut the dirt rapidly, compared with bristle brushes.

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[1]The possibilities of cleaning and removing fossils from hard rocks, and methods for securing minute fossils, or the young stages of adult species, has but begun. In America this tendency had its origin in Albany, N. Y., with Dr. Charles E. Beecher and Prof. John M. Clarke. To the former gentleman the writer is particularly grateful for many of the directions for cleaning fossils detailed in this paper, and as well for the reading of this manuscript.

All of the marks left by cutting tools should be removed. The white scratches can all be removed with very dilute muriatic acid and brushing, but be careful that the acid is not strong, otherwise calcareous fossils will take on a gloss which is objectionable.

The best way to trim slabs is to cut them with thin tin circular saws edged with diamond dust, operated by either foot or steam power, or by breaking between two sharp-edged jaws, the upper one of which is made to descend by whirling a large wheel working on a slow gradient screw. A number of forms of pincers and cutting tools are used in cutting and trimming specimens. The more important of these are here reproduced (see figs. 6–12). Small hammers are useful, but great care must be taken to prevent shattering or breaking the fossil.

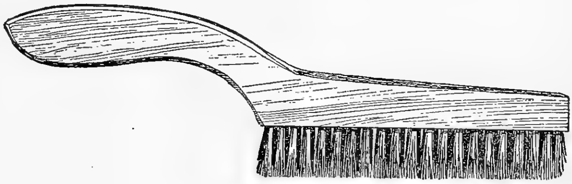

Fig. 5.—Wire brush.

Broken fossils, if small, are best mended with fish glue; when large enough plaster of paris should be added to give the glue greater body.

Sand bags are very serviceable in working slabs and large fossils, particularly when chisels and hammers are to be used. In removing rock from skeletons, sand bags are of the greatest service to block up and remove pressure from weak spots or to ease strains when turning specimens.

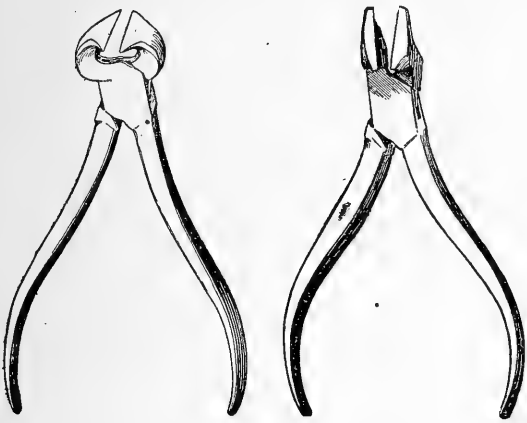

Fig. 6. Fig. 7.

Cutting forceps.

Cleaning with acids and potash.—Calcareous rocks with siliceous fossils can be etched in a solution of about one part of commercial muriatic acid to two parts of water. Use dishes of various sizes and set these out in the air, otherwise the escaping fumes will corrode all metallic surfaces in the room. Once or twice each day the rock can be subjected to fresh dilute acid, but first wash away the dead acid under a stream of running water. Also transfer the loose material at the bottom of the dish to another with clear water, in which it is best to leave the material for a few days to soak out all of the acid, otherwise your fossils may always have a wet and greasy appearance. A very little caustic potash added to the water will also assist in removing the acid. After the material has dried, sift it through the three sieves described under "Clay and marl washing."

Phosphatic shells, such as thick-shelled or very small linguloids or graptolites of a half-carbonized, chitinous substance, can also be etched out of limestone, but here the acid solution must be very weak. Final or delicate etching can be done with vinegar more or less diluted.

Siliceous fossils from red soils can be bleached with oxalic acid dissolved in water, to which action subject them for a day or two; then soak them in water for a few days more, changing frequently to get rid of all acid.

To remove hard clay from the calyxes of corals or the interior of

FIG. 8.

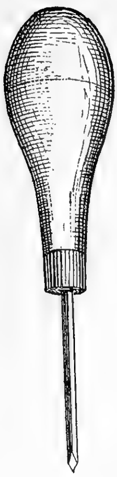

FIG. 9.

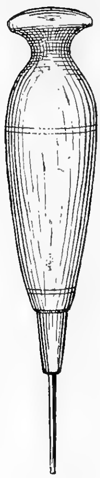

FIG. 10.

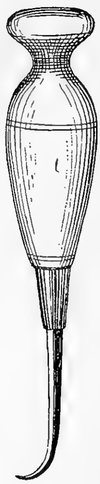

FIG. 11.

FIG. 12.

Cutting tools.

shells and other objects, caustic potash is often very serviceable. Fossils cleaned in this way, however, must be solid and without cracks, for the potash will penetrate into the minutest fracture and force the parts asunder. "Caustic potassa" comes in round, slender sticks sealed in one-half and one-pound bottles. Keep the potash sealed in the bottles with paraffin and cork stoppers. Handle the pieces with iron forceps, not with the fingers. In cleaning fossils have the parts to be acted on uppermost, and on these lay small pieces of solid caustic potash. After the potash has acted for a day or so wash the dirt away which rises in puffed masses, and continue the application of fresh potash until the parts are cleaned. To get rid of all potash, which if not removed will for years after come to the surface in a white film, soak the fossils in many changes of water to which has been added a few drops of muriatic acid, and brush repeatedly. Sometimes the white film is a product of decomposition and can not be wholly removed. It can then be darkened with india ink or some suitable color.

Preparing skeletons.—The cleaning of vertebrate skeletons when embedded in rock is at best very difficult work. Since none but large institutions attempt to prepare such bones, there will be no necessity to describe here the various manipulations such specimens undergo before they are placed on exhibition. However, all bones found in marshes should at once be well soaked in gum water after exhuming, and then dried slowly in a protected place. Bones found loose on the surface should also be treated in the same way. Boiling in oil, shellacking, or varnishing should be avoided.

ARTIFICIAL CASTS AND SQUEEZES FROM NATURAL MOLDS.

When the specimen is large and flat, as large Cambrian trilobites, for instance, dental plaster of paris will make good casts. If the specimen is in a hard slate or limestone, moisten it well with water or apply a thin solution of "green soap" before pouring on the liquid plaster of paris, which is to prevent the cast from adhering to the fossil.

To obtain a squeeze of the dentition of shells or delicate surface ornamentation from not too deep natural molds, gutta-percha is very good. This comes in small, thin sheets of a reddish color. Cut off a piece about twice the size of the mold. Heat this in hot water and then press it into the moistened mold with the thumb, which must be wet to prevent sticking. Considerable pressure is required to make a fine squeeze. Keep folding back into the middle that squeezed out, otherwise there will not be enough gutta-percha in the deep parts to take on the form of the mold.

Where the mold is very deep or has slight "undercuts," a very good substance to use for making casts is "modeling composition for dental purposes, No. 2, medium." This comes in cakes packed in half-pound boxes, and can be purchased at any dental supply store. This also is made pliable by hot water. Modeling composition is used for making squeezes in the same manner as the former, and since it is softer when heated and remains so longer than gutta-percha, it can be more readily pressed into deep cavities and bent out of undercut places.

Casts of gutta-percha and modeling composition in the course of years become very brittle and are then very easily broken. If permanency is required, molds and casts in plaster of paris should be made.

METHODS OF PREVENTING DECOMPOSITION.

About the only fossils which are liable to decompose in the air are those changed into iron pyrite. As yet no process is known which will entirely stop decomposition and leave the specimen with its natural color. Boiling in hot paraffin or melting this over the fossil with a blowpipe sometimes will stop decomposition entirely. Soaking in vaseline sometimes will do the same. Another good method, which seems to promise fair results, since the natural color of the specimen is not changed, is one recently adopted in the department of minerals of the National Museum by Mr. Wirt Tassin. This consists in varnishing the specimen with a coat or two of "retouching varnish," a fluid used by artists in fixing crayon pictures.

PERMANENT LABELS AND PAPER TRAYS.

The label and paper tray figured below is one in use in the National Museum study collections. It will at once be seen that this label is never covered by the fossils, but is always readily seen, while the label on which the fossils rest gives additional space for short remarks when such are deemed necessary. Paper trays, in sizes which are multiples of each other, are the best for holding fossils for study and for private collections. These should be of the following sizes, in inches: 2 by 3, 3 by 4, 4 by 6, 6 by 8; sides five-eighths of an inch high, with the corners bound together with linen; the inside of trays should be covered with smooth, glossy, white paper to prevent the dust from adhering.

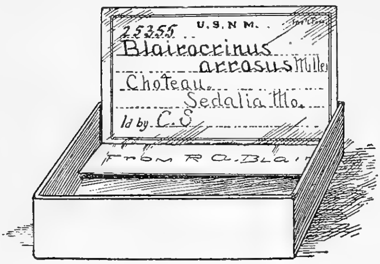

FIG. 13.—Paper tray.

APPENDIX.

LIST OF SOME IMPORTANT LOCALITIES FOR FOSSILS IN NORTH AMERICA.

Only such localities as are known to yield well-preserved fossils in comparative abundance are given. Historic or important geologic localities are not noted unless yielding good fossils. The exact position of localities is not indicated, only the nearest town; but the outcropping rocks will be easily found if directions, given under the heading "*Localities new to the collector*" (page 9), are followed. Localities are arranged geologically under systems, beginning with the oldest (Cambrian) and ending with the Post-Pliocene.

CAMBRIAN.

Lower Cambrian.—Troy, Schodack Landing, Washington County, N. Y.; Parker's Quarry, near Georgia, east of Swanton, Vt.; York, Pa.; Coosa valley, Ala.; Eureka district and Pioche, Nev.

Middle Cambrian.—St. Johns, New Brunswick; Coosa valley, Ala.; Mount Stephan, British Columbia; Eureka district, Nev.; Antelope springs, House range, Utah.

Upper Cambrian (*in places also Middle Cambrian*).—Near Saratoga, N. Y.; Prairie du Sac, Trempealeau, Menomonie, Eau Claire, Hudson, St. Croix falls, Wis.; Red Wing, Winona, Franconia, Marine Mills, Dresbach, Minn.; San Saba river, Texas; Eureka district, Nev.; Deadwood, S. Dak.

LOWER SILURIAN OR ORDOVICIAN.

Calciferous.—Philipsburg, Point Levis, Quebec; Mingan islands; Mills creek basin, Tenn.; Armstrong mines and Swan creek, Christian county, Mo.

Chazy.—Chazy, N. Y.; Fort Cassin, Vt.

Trenton and subdivisions.—Trenton falls, Watertown, and Middleville, N.Y.; Ottawa and Montreal, Canada; Blue grass region of central Kentucky; Nashville, Lebanon, and Clarksville, Tenn.; Dixon, Ill.; Beloit, Janesville, and Platteville, Wis.; Decorah, Iowa; Minneapolis. St. Paul, and Cannon Falls, Minn.; Cañon City, Colo.

For fishes.—Cañon City, Colo.

Lorraine or Cincinnati.—Anticosti island, Gulf of St. Lawrence; Salmon river, N. Y.; Cincinnati, Oxford, Waynesville, Ohio; Versailles, Richmond, Madison, Ind.; Wilmington, Sterling, Ill.; Spring Valley, Minn.

UPPER SILURIAN OR SILURIAN.

Lower and Middle Silurian.—Anticosti island, Gulf of St. Lawrence; Lockport, Rochester, N. Y.; Gault, Guelph, Ontario; Dayton, Eaton, Ohio; Waldron, Ind.; Louisville, Ky.; Chicago, Joliet, Ill.; Wauwatosa, Racine, Milwaukee, Wis.; Perry County, Tenn.

Lower Helderberg.—Albany and Schoharie counties, Becrafts Mountain, near Hudson, N. Y.; Square lake, Me.; Perry and Decatur counties, Tenn.

DEVONIAN.

Lower Devonian.—Oriskany falls, Albany and Schoharie counties, Becrafts Mountain, near Hudson, Port Jervis, N. Y.; Cumberland, Md.; De Cewsville, Ontario.

Middle Devonian.—Schoharie, Leroy, Pratts falls, Moscow, Eighteen Mile creek, Canandaigua, N. Y.; De Cewsville, Ontario; Columbus, Sandusky, Ohio; Louisville, Moreland, Lebanon, Ky.; Cumberland, Md.; Fulton, Mo.; Davenport, Iowa; Rock Island, Ill.; Milwaukee, Wis.; Thedford, Ontario; Petoskey, Alpena, Mich.; Eureka district, Nev.

For fishes.—Sandusky, Delaware, Milford, north of Columbus, Ohio; North Vernon, Ind.

Upper Devonian.—Ithaca, Steubenville, N. Y.; Warren, Pa.; Rockford, Independence, Iowa; Eureka and White Pine districts, Nev.

CARBONIFEROUS.

Waverly.—Warren, Pa.; Granville, Bedford, Sciotoville, Ohio; knobs south of Louisville, Ky.; Louisiana, Choteau Springs, Mo.; LeGrand, Iowa; Marshall, Mich.

For fishes.—Sheffield, Lorain county, Rocky river, near Berea, Ohio.

Lower Carboniferous.—Burlington, Keokuk, Ottumwa, Iowa; Warsaw, Nauvoo, St. Louis, Alton, Chester, Kaskaskia, Ill., Spergen Hill, Bloomington, Crawfordsville, Ind.; Princeton, Ky.; Huntsville, Ala.

For fishes.—Quincy, Hamilton, Warsaw, Nauvoo, Chester, Ill.; Augusta, Iowa.

Upper Carboniferous or Coal Measures.—Flint Ridge, near Newark, Ohio; Springfield, La Salle, Danville, Mazon creek, Ill.; Kansas City, Mo.; Des Moines, Ottumwa, Iowa; Oswego, Leavenworth, Kans.; Giddings, Tex.; Plattsmouth, Bellevue, Nebraska City, Nebr.; Santa Fe, N. Mex.

Plant localities are generally associated with coal mines.[1]

For fishes and batrachia.—Linton, Columbiana county, Ohio; Morris, Belleville, Carlinville, Ill.; Nova Scotia coal fields.

TRIASSIC.

Durham, Middlefield, Southbury, Conn.; Sunderland, Mass.; Phœnixville, Pa.; Humboldt Mountains, Nev.; southeastern Idaho; Pitt river region, Shasta and Plumas counties, Cal.

For Dinosaur tracks.—Greenfield, Turners Falls, Mass.; Portland, Conn.

For fishes.—Boonton, N. J.; Durham, Conn.; Turners Falls, Mass.

For Dinosaurs.—Springfield, Mass.; Windsor, Manchester, Conn.

JURASSIC.

Black Hills, Dak.; 8 miles north of Cañon City, Colo. (fresh water invertebrates); Pitt river region, Shasta county and Taylorville, Cal.

For mammals.—Near Lake Como, Wyo.; near Cañon City, Colo.

For Dinosaurs.—Black Hills, Dak.; Lake Como, Wyo.; Morrison, Cañon City, Colo.

CRETACEOUS.

Lower Cretaceous.—Leon Springs, Austin, Denison, Fredericksburg Glen Rose, Tex.; Shasta and Tehama counties, Cal.; Riddles, Oreg.

For plants.—Vicinity of Dutch Gap, 9 miles north of Fredericksburg, near Brooke station, Va.; Baltimore, Md.; new reservoir, District of Columbia; Glen Rose, Tex.

Upper Cretaceous.—New Egypt, Blackwoodstown, near Marlboro, Morristown, N. J.; Eufaula, Prairie Bluff, Ala.; Ripley, Houston, Miss.; near Fort Worth, New Braunfels, Kaufman, Corsicana, Chatfield, Tex.; Black Hills, Dak.; Fossil creek, Larime county, Cañon City, Huerfano Park, Boulder, Colo.; Coalville, Utah; Fort Benton, Mont.; Redding and Cow creek, in Shasta county, Pence's ranch in Butte county, Cal.

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[1]A complete catalogue of American fossil plant localities, up to 1889, will be found on pages 848–931 of the "Eighth Annual Report of the Director of the United States Geological Survey, 1889." The work is by Lester F. Ward and is a part of "The Geographical Distribution of Fossil Plants."

Dakota group plant localities.—Near Fort Harker, 10 miles northeast of Delphos, Ellsworth county, Pipe creek, in Cloud county, Kans.; north side of Big Cottonwood river, near New Ulm, Minn.

Laramie group plant localities.—Vicinity of Golden, Erie, Mount Carbon, near Morrison, Colo.; Black Buttes, Hodges Pass, Point of Rocks, Wyo.

For Cretaceous Dinosaurs and other vertebrates.—Marlboro, Hornerstown, Birmingham, Barnsboro, N. J.; in the marl and iron-ore beds near Baltimore, Md.; Smoky Hill and Solomon rivers, Kans.; near Denver, Colo.; Converse county, Wyo.; Judith river, Montana.

EOCENE.

Upper Marlboro, Piscataway creek, Glymont, Md.; Acquia creek, Va.; Claiborne, Wood's Bluff, on Tombigbee river, Ala.; Vicksburg, Enterprise, Shubuta, Jackson, Miss.

Plant localities.—Florissant, Colo.; Green River Station, Wyo. The last-named locality is also famous for its well-preserved fishes.

Vertebrate localities.—For Zeuglodon, Clarke county, Miss.; Clarke and Choctaw counties, Ala.; Farmingdale, N. J.; Evanston, Fort Bridger, Wind River, Wyo.; White river, Utah; Animas river, New Mexico.

MIOCENE.

Yorktown, Va.; Jericho, N. J.; St. Marys river, Plum Point, 5 miles southeast of Easton, Md.; Wilmington, Natural Well, N. C.; Darlington Courthouse, S. C.; Alum Bluff, Tampa, Chipola River, Fla.

Plant localities.—Independence Hill, Spanish Peak, Cal.; John Day valley, Oregon; Cook inlet, Unga island, Alaska. The Alaska localities may be either Miocene or Pliocene.

Vertebrate localities.—Squankum, Shiloh, N. J.; Bad Lands, Nebr., and S. Dak.; John Day valley, Oreg.

PLIOCENE.

Caloosahatchie river, Fla.; Loup Fork, Niobara river, Nebr.

POSTPLIOCENE.

Cornfield harbor, Federalsburg, Md.; Wadmalan sound, S. C.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR COLLECTING AND PRESERVING SCALE INSECTS (COCCIDÆ).

T. D. A. COCKERELL,
Entomologist of the New Mexico Agricultural Experiment Station.

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DIRECTIONS FOR COLLECTING AND PRESERVING SCALE INSECTS (COCCIDÆ).

By T. D. A. Cockerell.

Entomologist of the New Mexico Agricultural Experiment Station.

General directions for collecting and preserving insects have been given in such admirable form by Doctor Charles V. Riley, that any further contribution to the subject might seem superfluous. But Coccidæ are so different from other insects that they can not be treated in the same way. Ordinary insect collectors, even when attempting to obtain material in all orders, almost invariably ignore the Coccidæ. Thus, for example, innumerable collections have been made in Brazil, South Africa, and the Malay Archipelago, some of them very extensive and varied; yet the Coccidæ of these regions are almost entirely unknown. The writer has not the least doubt that he could find in a single day in Rio Janeiro, Cape Town, or Batavia, more species of Coccidæ than are at present known from either of the regions mentioned, with the possible exception of Brazil, whence several forms have lately been sent by Doctor Von Jhering. He knows, in fact, single gardens in Kingston, Jamaica, which contain more coccid species than are recorded from either of these three regions.

We are accustomed to pride ourselves on the scientific spirit exhibited by the English-speaking races of the present day; yet Jamaica, one of the oldest of English colonies, has not produced naturalists like Poey and Gundlach, of Cuba. Considering our opportunities all over the world, it is surprising, not that we have accomplished so much, but that we have in so many directions failed to even see what was before us. What we have seriously set ourselves to do has in almost every case been done not only successfully but brilliantly; but our capacity for ignoring whole classes of facts, so far from being peculiar to strictly official circles, has manifested itself on every side. Thus it is that the Coccidæ, everywhere abundant in the Tropics, everywhere conspicuous on, and injurious to, cultivated plants, have been regarded almost as if they had no existence.

Yet there is no group of insects so easily collected as the Coccidæ. None are more easily packed in a small space or sent through the mails. A complete collection of the known neotropical species could easily be put in a hand bag of very moderate size.

COLLECTING COCCIDÆ.

I. *Localities.*—It may be taken as a general rule that Coccidæ are not abundant north or south of the fortieth parallels, although (as I learn from Mr. Bergroth) *Orthezia cataphracta* has been found even in Greenland and Arctic Siberia. At all events, in the colder portions of the temperate zones it will not pay anyone to search for Coccidæ alone, although if he has them in mind when looking for other things he will be sure, in the course of time, to run across many interesting forms. In the tropics, however, and even in the warmer parts of the temperate regions, searches directed to Coccidæ alone will yield excellent harvests. A tour around any tropical garden, especially if it be at or near sea level, will be almost certain to furnish much interesting material. Going southward on the American mainland, no species are known from the whole western coast of Mexico south of Guaymas, except an *Aspidiotus* from Mazatlan.* The little collecting that has been done in Tampico and Vera Cruz on the east coast does but give us a glimpse of an undoubtedly rich coccid fauna. From Yucatan we know nothing,† nor is anything known from Lower California. From Guatemala to Panama we have just two records! From the mainland of South America we know practically nothing except from British Guiana, São Paulo in Brazil, and the neighborhood of Santiago in Chile. Here and there, elsewhere, a single species has been obtained, or possibly two or three, but no serious collecting has been done, or if it has, we have no published information regarding it.

In the West Indies, Jamaica, Antigua, Trinidad, and lately Grenada have furnished collections of coccids; the Jamaica list is the best, and stands at about seventy; next comes Trinidad, with about forty. That we know four species from Cuba, two from Haiti, and one from Porto Rico merely shows that no one has seriously looked for Coccidæ in these islands. Martinique has just one record, Guadeloupe and St. Lucia none.

Passing westward to the Pacific Islands, collections have been made in the Hawaiian Islands and a few species have come from Fiji. But otherwise we know hardly anything. From Tahiti three, New Caledonia one, Tonga one, Samoa one, the Marquesas one. From the Galapagos, Low Islands, Cook Islands, New Hebrides Islands, etc., none at all.

New Zealand and the eastern parts of Australia have been pretty well searched, and very many interesting species described; but the whole of the East Indian Archipelago is practically virgin ground. China, Siam, the Malay Peninsula, Burmah—all are unexplored for

* Since this was written, three or four more species have come to hand from the west coast of Mexico.

† Since the above was written, Professor Townsend has sent a new species of *Lecanium* from Yucatan.

Coccidæ. Even India has received but the most meager attention, although the Ceylonese species have just lately been carefully studied by E. E. Green. We know nothing of the scale insects of Arabia, Persia, Afghanistan, Turkestan, etc., Japan, until lately, had no coccid records, but some collecting recently done there has yielded excellent results, the majority of the species being new.

The islands of the Indian Ocean, Madagascar, and the whole of tropical Africa are practically unexplored for Coccidæ.

Thus, to sum up, it may be said, in the first place, that the Coccidæ are by far the most abundant in the Tropics; and in the second, that no part of the Tropics has been anything like carefully examined for them, except Jamaica, Antigua, Trinidad, and Ceylon.* There is thus a vast field left for investigation, compared to which the investigated portions of the earth are utterly insignificant.

II. *Plants on which Coccidæ are found.*—Coccidæ are found principally on trees and shrubs. Herbaceous plants in temperate regions, which die down in winter, support Aphididæ and Aleyrodidæ, but very rarely Coccidæ. The reason of this is obvious, since the stationary females would perish when the infested parts of the plant died. Nevertheless, there are some root-inhabiting coccids of great interest, and others which occur on perennial grasses and similar plants. Some, also, are found in the nests of ants. Mr. Newstead has lately taken the trouble to examine such situations in England, with the result of finding several entirely new and very interesting species. Mr. G. B. King, collecting in Massachusetts, has been even more successful.

Of temperate-region trees and shrubs there are many which have yielded Coccidæ. The various species of oaks are especially worth examination, while mention must be made of the willows, poplars, roses, ashes, elms, birches, pines, spruces, and all the rosaceous trees cultivated for fruit. While in the Tropics the leaves of trees are much infested, in temperate regions the smaller branches and twigs will be found to bear most of the scale insects. Evergreens, however, will exhibit species of Diaspinæ on the leaves.

Going somewhat farther south, the native shrubs and perennial herbaceous plants will show a fair coccid fauna. In the Mesilla Valley the *Atriplex canescens* is extraordinarily prolific in coccids, presenting six species, all of different genera. I have come to regard it as a probable rule in this region that every native shrubby plant will show at least one coccid, though there are several on which none have yet been found. The mesquite, *Prosopis*, has yielded good coccids in New Mexico, Arizona, and Jamaica, but in each region the species are different. Thus it is evident that collecting should be carefully done at various points in the range of a likely plant; even the Mesilla Valley, New Mexico, and Tucson, Arizona, have very different coccid

* Professor Townsend has lately collected with care in Tabasco, Mexico, but the collection has not yet been studied.

faunæ, though in the same general region. The same species of plants in these localities are not infested by the same coccids at all. In the Tropics almost everything may be examined, but especially cultivated plants at sea level. Palms, particularly the cocoanut, are excellent. Crotons, orange trees, cotton, guava, mango, olive, *Hibiscus*, *Acalypha*, akee, capsicum, *Lantana*, sugar cane, ferns, orchids, cacti, etc., have proved worth examination. Even the underground tubers of yams and sweet potatoes have their peculiar species.

In Australia wonderful coccid faunæ inhabit the species of *Eucalyptus* and *Casuarina*, including many gall-making forms. It is, however, of little use to examine these trees in parts of the Tropics where they are not native but have been raised from seed. It is useful to look under the bark of such trees as have loose bark, like the lignum-vitæ of the West Indies.

A great deal of excellent work may be done by those who receive plants from the Tropics. It is, of course, extremely desirable to prevent the introduction of fresh coccids into our hothouses and gardens; but if, in addition to destroying the species found on plants received, the owners would save some specimens for the coccidologist, it would be an excellent thing. Much has already been accomplished in this way, but there is a great deal of useful work still to be done; in fact, considering the opportunities that importers have, the results are nothing to be proud of. Nor is it any satisfaction to contemplate the careless manner in which infested plants are taken from hothouse to hothouse, bought and sold, without any serious attempt to clean them of scale insects. It is not merely a question for the hothouses, either, since it is through hothouse plants that several coccids have already been transferred from the Tropics of one hemisphere to those of the other. Witness *Orthezia insignis*, for example.

III. *How to recognize Coccidæ.*—Coccidæ are degraded homopterous insects with apterous and usually stationary females and two-winged (rarely apterous or subapterous) males. This definition, however, will not much assist the casual observer. Attention should be directed to any stationary insect with a soft body and more or less mealy powder or cottony secretion; also to any hard, naked species resembling somewhat half of a split pea, or to any oblong or rounded, flat, or convex object, hard or soft, from the size of a pin's head to that of a waistcoat button. Likewise to any whitish or grayish scurfy substance, and to any small masses of wax. All such are nearly sure to be Coccidæ.

Unskilled observers always manage to gather in, along with the coccids, some miscellaneous material such as Aleyrodidæ, Psyllidæ, and even fungi. But there is no harm in this. On the contrary, new species of both Aleyrodidæ and fungi have been found among coccid material sent to me, proving quite as interesting as the coccids themselves.

IV. *How to collect.*—Simply gather portions of the plants with the insects in situ. If the specimens are on the bark of large trees, portions of the bark or epidermis may be removed with a knife. When possible, always get plenty of material. Well-known species can usually be recognized from very little material—even single scales; but new species, or species in difficult groups, require, as a rule, a fair number of specimens, in order to be properly studied. This is in order that some may be prepared for the microscope and others left in the natural state, and also that the normal amount of variation may be ascertained, and, if possible, both sexes described. Very often I receive one or two scales only of species of *Eulecanium*—an extremely difficult group. It may as well be understood that such material, in the present state of our knowledge, is practically worthless.

In the case of new species, it is very desirable to have enough to distribute cotypes to the various workers in Coccidæ and some of the museums.

Care should be taken to obtain both sexes whenever possible. Often the male scales will be conspicuous and the females very inconspicuous, as in some Diaspinæ, or, vice versa, as in many Lecaniinæ. The male scales may occur on the leaves, while the females are on the twigs; hence various parts of the plant should be examined.

PRESERVING COCCIDÆ.

I. *Treatment in the field.*—As a general rule, Coccidæ should be preserved dry in situ on the plants. With the softer species, alcoholic material is often useful, but it can not be too strongly insisted that this should only supplement dry specimens. The mealy bugs, for example, can hardly be determined from alcoholic material alone, because the characters of the cottony secretion are lost, whereas they can frequently be described quite accurately from dried examples.* I have had collections of alcoholic Coccidæ sent to me at considerable trouble and expense, which would have been much more valuable if simply sent in paper envelopes at a minimum of cost and inconvenience.

It is an excellent plan for the collector to have a number of fairly large envelopes, or better, flat card boxes, and place each gathering in one of them, writing on the outside the locality, date, name of plant, name of collector, and any remarks that seem desirable. The envelopes have the advantage of occupying a very small space, and are very convenient for mailing; their disadvantages are two, first they may crush some scales, particularly *Lecanium* and *Ceroplastes;* and second, they may not retain any parasites which happen to issue from the coccids. Card boxes about 6 inches long, 3 wide, and 1 high, would probably serve as well as anything that could be devised, provided that the collector could afford to take with him such bulky objects; failing these, however, it is to be understood that in nine cases out of ten the material placed in envelopes is perfectly satisfactory.

Nothing air-tight, as tin boxes or glass tubes, should be used for fresh material, as it will almost invariably mold.

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* It may be added, that alcoholic material is often hard to clear for the microscope.

Pill boxes are sometimes used with fair success, but they are too small to contain a good quantity of material. In working over a collection in pill boxes, one is almost sure to find some interesting forms too scantily represented for description.

II. *Drawings.*—As stated above, soft coccids can frequently be described from dried material; but a sketch of their appearance when alive, with a note on their color, very much facilitates correct identification. For example, with the mealy bugs, we want to know whether they have cottony filaments along the sides, or only at the tail, or any at all, and so forth. A rough sketch may be made in a few moments on the box or envelope at the time of collecting. The male coccids should always be described when alive, if possible.

III. *Collecting food plants.*—Collectors are begged not to guess at the names of the plants. If they know, it is very necessary to record the information, but in more than one case even the fragments of the plants sent have belied the identification. It is excellent, when possible, to put in a little bit of the flower, so that the name of the plant may be ascertained or confirmed. Lately I received a new neotropical *Pulvinaria* on a plant unknown, but a few withered flowers were in the package, and from them it was possible to learn at least the probable order of the plant.

IV. *Treatment in the cabinet.*—The plan of pinning coccid specimens seems to me very unsatisfactory. Material can not conveniently be pinned in quantity, or if it is, it is troublesome to label each specimen. Furthermore, the scales will frequently come off the leaves and twigs, especially when such specimens are sent in the mails. The envelopes or card boxes are unsuitable for permanent preservation of coccids for several reasons, the principal of which is that they do not exclude *Anthrenus.* I have now in use nothing but glass tubes with rubber stoppers, and find them entirely satisfactory. Various sizes of tubes may be used, according to the specimens. The data are written on slips of paper placed inside the tubes. Parasites may be put in small pieces of glass tubing, stopped with cotton at each end, and these placed inside the tubes containing the coccids whence the parasites were bred. One caution is necessary: never put material in a stoppered tube until it is perfectly dry. The material, if not dry, may be placed in the tube, but a wad of cotton temporarily used in place of the rubber stopper.

V. *Microscopical preparations.*—Coccidæ make good transparent objects in Canada balsam, but they have to be clarified first by boiling in a strong solution of caustic soda or caustic potash. They may be boiled in a test tube or small dish over a lamp, washed in water, and then examined in the ordinary way. Sometimes it is necessary to puncture the skin in order to allow the reagent free access to the body cavity. I have quite successfully treated Diaspinæ by placing the females in a little caustic potash solution on a slide, covering them with a cover glass, and then boiling for a few moments over a gas jet.

CONCLUDING REMARKS.

The present short article is intended to emphasize the fact that a great deal of useful work can be done by those who are not coccidologists, but happen to reside in or visit unexamined localities. Material obtained by such persons, if sent to the United States National Museum or Department of Agriculture, will be thankfully received, fully reported upon as time permits, and proper credit will be given to the collectors. Assistance of this kind is not asked as a favor; it is rather supposed that there are many persons who would themselves take a pride in adding to the knowledge of an interesting group of insects, while at the same time indirectly conferring a benefit upon horticulture.

It is to be remarked, however, that there is a pressing need for new students as well as new collectors. The small band of coccidologists now at work will welcome any addition to their ranks, and (I am sure I may speak in this for all) will only too gladly assist any student who shows a serious intention to elucidate any branch of the subject.

LITERATURE.

The student will find the following literature especially useful.

V. SIGNORET. Essai sur les cochenilles. 1868–1876. (A complete monograph to date of publication.)

J. H. COMSTOCK. Report on scale insects, in Rep. U. S. Dept. Agriculture for 1880. Second report on scale insects, in 2d Rep. Dep. Entomology, Cornell Univ. Exp. Sta. 1883. (Includes all Diaspinæ to date.)

W. M. MASKELL. Scale insects of New Zealand, 1887.

E. E. GREEN. The Coccidæ of Ceylon. (In course of publication.)

A general summary of what is known about coccid faunæ will be found in Proceedings United States National Museum, Vol. XVII, pp. 615–625. In the same Proceedings, Vol. XIX, pp. 725–785, is a detailed article on the food-plants of Coccidæ, the insects being arranged under the names of the plants infested. A check list of all known coccidæ has been published in Bulletin Illinois State Laboratory of Natural History, 1896. The yearly bibliography of coccid writings given in the Zoological Record should be consulted by every student.

MESILLA, NEW MEXICO, *August, 1897.*

THE ZOOLOGICAL STATION AT NAPLES.
From a photograph by G. Sommer.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

THE METHODS EMPLOYED AT THE NAPLES ZOOLOGICAL STATION FOR THE PRESERVATION OF MARINE ANIMALS.

BY

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Translated from the original Italian
BY
EDMUND OTIS HOVEY.

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1899.

INTRODUCTION.

In April, 1897, the zoologists of the world united in honoring Dr. Anton Dohrn on the completion of the first quarter century of the existence and work of the zoological station in Naples.[1] This period has seen wonderful advances in all lines of scientific work, and the Naples station has been such a prominent factor in the line of biology that a brief account of it will not be without interest as an introduction to the detailed description of the methods employed there. The city of Naples has peculiar advantages for the location of an aquarium and zoological station, because its bay is remarkably rich in animal life, many semitropical and even tropical forms being found in its waters, and storms driving in many of those which otherwise are to be obtained only in the broad expanses of the Mediterranean Sea. In 1870 Dr. Dohrn went there, filled with the idea of establishing an institution partly for the purpose of exhibiting in glass tanks the beautiful and strange forms of animals to be found in the sea, but mainly for the study of these animals under the best conditions possible, not only as to their anatomy and their physiological relations to other animals, but also as to their habits, food, etc. After two years of disheartening delays and hindrances, Dr. Dohrn, who was a man of pecuniary means as well as of great scientific attainments and indomitable energy, succeeded in starting the zoological station which for years has been the principal place in the world for the study of marine animal life, and the influence of which upon the science of zoology has been world-wide and of incalculable value.

The home of the station is a three-story and attic structure, built of stone and stuccoed, and consisting of two parts separated by a courtyard but communicating overhead by means of bridges. The ground floor of the larger part of the building is devoted to the aquarium, the second, third, and attic floors to offices, the library, laboratories, and

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[1] For brief accounts of the Naples station, published in this country, reference may be made to—

The Marine Biological Stations of Europe, by Bashford Dean; Biological lectures delivered at the Marine Biological Laboratory of Woods Hole in the summer season of 1893, Tenth lecture, p. 224. Also, Smithsonian Report, 1893, p. 513.

Some unwritten history of the Naples Zoological Station, The American Naturalist, XXXI, 1897, p. 960. This is a report of an address delivered by Dr. Anton Dohrn at the Woods Hole station in August, 1897.

The Zoological Station at Naples, by E. O. Hovey, Scientific American, LXXVIII, May, 1898, p. 314.

An excellent and very complete popular account of the station and its history appeared in the four numbers of "Die Kölnische Zeitung" for March 28 and April 4, 11, and 14, 1897.

work rooms. The smaller building is used for receiving, preserving, and storing the material brought in from day to day, and for laboratories and study rooms for some of the officials and others. The aquarium proper contains twenty-six tanks having glass fronts and lighted from above in such a manner that, as a person gazes into them, he can readily imagine himself standing on the bottom of the sea with the animals at home about him. There are no open tanks and no light enters the room except that which comes through the water.

The stocking of the aquarium and the supply of material for the naturalists at work in the station is cared for in a very complete way. The station owns two steam launches, which are used for dredging and other heavy or distant work, and two or more small rowboats, which are kept constantly busy collecting jelly-fish and other surface forms of life which are driven into the harbor from the open sea. Furthermore, all the fishermen in the bay regularly bring to the station all the animals that come up in their nets that are known to be desired. These objects are paid for as they are brought in. Every day the naturalists state what they need for the next day's work, and every evening corresponding orders are given to the crews of the boats belonging to the station. One naturalist may want fifty sea-urchins of a kind, another twenty-five starfish, another a large or small number of jelly-fish or crustaceans or what not, and each finds his wants supplied the next morning, if the weather has been favorable. It is very interesting to observe the pride which the rough fishermen of the bay now take in bringing to the station all rarities and other forms of life which they know to be desired there.

Although the aquarium is the most popular portion of the institution and the public sees only that and the preserved animals which are sent out to museums, the chief mission of the station, in the eyes of the director, Dr. Dohrn, and of all other scientists as well, is to provide a place for the investigation of marine life under the best conditions attainable on land, and most of the station building is given up to provisions for this purpose. The regular scientific corps consists of nine men, including the director, each of whom makes a special study of some form of animal life. The average number of naturalists not connected with the institution who study there is about forty in each year, though not more than from twenty-five to thirty may be there at one time. Each of these is an independent worker along some particular line of study, no elementary instruction being given by the officers. Each student is provided with a table or desk, drawers, racks, book-shelves, microscope, glassware, alcohol, and other reagents, drawing materials, glass tanks with running and stationary water, and, in fact, with everything needed to carry on his investigations, and with animals to work upon.

The library is very full on all subjects bearing upon zoology, a specialty being made of periodicals. Furthermore, fully equipped laboratories are provided for the investigation of the chemical and physical questions which arise, and there are optical and photographic rooms, and a machine shop fitted up for doing all ordinary grades of work. More than a thousand naturalists have availed themselves of these opportunities for study. Of this number 375 have been Germans, 240 Italians, 85 Russians, 80 Englishmen, 40 Dutchmen, 40 Americans (from the United States), 36 Swiss, 35 Austrians, 22 Belgians, 17 Spaniards, 17 Hungarians, the remainder being Scandinavians, Greeks, Roumanians, Bulgarians, Japanese, and Hindoos. Truly an international array!

The activity of the investigators at the station does not expend itself wholly or even largely upon the description and naming of new species. It seeks rather to discover the innermost secrets of life, and to learn all the comparisons that can be made between one set of animals and another. The results of the work are published in three ways and appear periodically. The description of the Fauna and Flora of the Gulf of Naples began to be published in 1880, and up to the end of 1897 twenty-four quarto volumes of these exhaustive memoirs had been issued, magnificently illustrated with numerous text fixures and colored and plain plates. The Contributions from the Zoological Stations are the shorter articles brought out by the workers at the station, and thirteen volumes of these have appeared. The Zoological Yearbook is now in its twenty-first volume, and seeks to give not only a list of all articles and books of the current year pertaining to the science, but also brief abstracts of their contents.

To inaugurate the station in 1872 required about $100,000, besides the land in the beautiful Villa Nazionale donated by the city of Naples. Friends of science in Germany and England contributed about $40,000 of this amount, but the remainder came from Dr. Dohrn's own fortune. The money necessary to meet the running expenses of the institution comes from several sources. Each contributor of £100 annually to the station supports a "table," and has the right to name a person to receive the benefits thereof. At present 30 tables are thus provided for, the Italian Government paying for 7, different institutions in Germany for 11, England for 3, Russia, Austria, and the United States[1] for 2 each, and Belgium, Holland, and Switzerland for 1 each. The tables are paid for year by year, and there is no endowment fund, though Dr. Dohrn is striving now to establish one. The German Government appropriates £2,000 for the station; the fees of visitors to the aquarium amount to about £1,000; the sale of preserved animals to about £700, and the sale of old material of various kinds to about £100. The expenses, however, always manage to keep pace with

[1] The Smithsonian Institution has supported a table at the Station regularly since 1893. The Collegiate Alumnæ have begun supporting a "woman's table" in commemmoration of the twenty-fifth anniversary of the Station. During some years Columbia University has had a table, and one has been paid for at intervals by a few of the leading American universities alone or in conjunction with the American Society of Naturalists.

the income, or exceed it, although the officers of the institution work for almost nothing, the highest salary paid being less than $1,100 a year.

The branch of activity at the station which appeals more strongly to the public than do the scientific investigations is the preservation of marine animals, particularly invertebrates, for exhibition in museums and for purposes of study. To Cav. Dr. Salvatore Lo Bianco is due the major part of the credit for the success which the station has had in this line of work. Beginning work for the station as an attendant, he soon showed peculiar ability in handling the animals which were obtained. He studied their habits, anatomy, and composition carefully, and made many experiments to determine the best method of killing and preparing each species, so that it would present a lifelike appearance in the exhibition jar, until he succeeded in obtaining the beautiful results which have been distributed to museums and colleges all over the world. The animals which are intended for dissection and study must often be preserved in a different manner from those which are intended for exhibition, and in this line of work, also, the Naples station stands preeminent. An investigator may even send word to have specimens prepared in special ways of his own devising, and thus save himself the trouble of making a trip to Naples.

One reason for the beautiful appearance of the material sent out by the station is that it is properly caught in the first place; another is that, for the most part, the animals are alive when the process of preservation begins. With many forms it is indispensable that they be alive at the beginning of operations; with some it is not so necessary, but with all it is highly desirable. A fish which has been put into alcohol after death looks entirely different from another specimen of the same species which has been put into the fluid when still alive. The best methods have been determined for each species by itself, different species of the same genus often requiring different handling, hence it is necessary that the operator should be able to recognize the species with which he has to deal in order to obtain the best results. When new species are encountered, the best mode of precedure must be determined by experiment. The experience of the Naples station has been so long and varied, however, that a knowledge of the methods pursued there will be of value to naturalists all over the world. For this reason the writer, with the consent of Professor Dohrn and the consent and cooperation of Dr. Lo Bianco, has undertaken the translation of the latter's "Metodi usati nella Stazione Zoologica per la conservazione degli animali marini,"[1] incorporating therewith the notes made during a stay of five weeks at the station in the autumn of 1897 for the express purpose of studying those methods for the benefit of the American Museum of Natural History. It is to be understood that the methods have all been devised by Dr. Lo Bianco, unless otherwise stated.

EDMUND OTIS HOVEY.

NEW YORK, *March, 1899.*

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[1] Mittheilungen a. d. Zoologischen Station zu Neapel, Pt. 3, IX, 1890, pp. 435–474.

THE METHODS EMPLOYED AT THE NAPLES ZOOLOGICAL STATION FOR THE PRESERVATION OF MARINE ANIMALS.

By Dr. Salvatore Lo Bianco.

[Translated from the original Italian by Edmund Otis Hovey.]

UTENSILS.

The laboratory of the station is provided with large tanks containing running and stationary sea water, a table covered with sheet lead and furnished with a drain, a great variety of glass and earthenware dishes, and tools of different kinds and materials.

Cylindrical glass jars, with glass stoppers ground to fit, are used for exhibition purposes and for storage. Those with necks are employed for the most part, but those without necks and with a flat top are preferred for elegant installation. Cylindrical jars are the most economical of fluid and are the cheapest to get.[1] Since glass jars are expensive, earthenware jars and basins are used for many laboratory manipulations. The small, globular vessels which have the bottom formed by a glass stopper, concave within, are recommended for small spherical animals. Round-bottomed glass tubes are very useful, but care must be exercised to see that the walls are not too thin. The edge of the orifice should be smoothed in the Bunsen flame. When the tubes are more than 30 mm. (1.2 inches) in diameter, the lip should be flared out so that a piece of bladder can be readily tied over the opening.

Corks should be selected from the best stock, should be as compact as possible, and should be without cracks or other defects. In form they should be cylindrical, so as to make a good joint with the sides of the tube. The ends must be flat, with clean cut edges, so that no fragments can get into the alcohol. With large tubes it is desirable to put a plug of cotton inside the tube next to the cork, since the alcohol extracts the tannic acid from the cork and is stained brown thereby.

[1] For convenience in suspending objects in the liquid, those having a glass hook in the under side of the stopper should be obtained. E. O. H.

To preserve small, delicate animals, such as eggs and larvæ, it is well to place the small tube containing the objects in alcohol, closed with a cotton plug, inside a larger vessel, which is likewise filled with alcohol. This arrangement prevents danger from evaporation and minimizes the liability to breakage. One must see, however, that the cotton contains no acids and does not stain the alcohol. Absorbent cotton is the most suitable, of course, but the best quality of ordinary cotton will answer every purpose.

For large, flat objects, such as Asterids, Pleuronectids, and the like, rectangular jars with flat sides are recommended. These jars are made to be closed with a plate of glass, cemented on. Gutta-percha cement is generally used. Such receptacles have the great advantage that they do not distort the view of the object within them. For delicate forms, which are long and stiff, like *Funiculina*, glass tubing of proper size, cut off at the right length, is used, one end being closed in the Bunsen flame and the other with a cork.

For preliminary manipulations much use is made of glass crystallizing dishes with flat bases and perpendicular sides, in which many specimens can be placed in little liquid without touching or interfering with one another. They are especially advantageous for keeping animals alive in sea water, letting them remain at rest until thoroughly distended; for killing by different methods, either slowly or quickly, and for hardening objects in different solutions until they are transferred to permanent receptacles. These crystallizing dishes have ground edges so that they may be tightly covered with disks of glass, when desirable. For hardening worms and other elongated animals use may be made of long rectangular vessels covered with a sheet of glass, or of the zinc trays to be described later.

It is also necessary to have a number of ordinary beakers (or battery jars) of different sizes, which serve for the preserving of animals alive, tubes for the reception of small animals, pipettes for the extraction of minute forms from jars of water, glass rods, reagent bottles, graduated cylinders, etc.

For preserving animals, especially fish, of a size too great for such glass receptacles as have been mentioned, a rectangular case or box of zinc with a shallow trough around the margin is very useful. The cover, likewise of zinc, has its edge made to fit into the trough. To prevent evaporation the trough may be filled with water and a layer of oil. The cover has an opening in the middle to permit the escape of the air which is compressed under it by closing the box. This opening is provided with a cork. It must be acknowledged that these boxes have the disadvantage that, after a time, the zinc becomes corroded, probably by some acid formed in the alcohol through the action of dead animal matter. It is a good plan to protect the metal box by an exterior wooden case.

In place of the rectangular vessels of glass for hardening animals of elongated form, the station uses some made of zinc with a layer of wax in the bottom. The wax bottom is for the purpose of holding the wooden pins used in straightening out worms while they are hardening. Pins of orange or other hard wood are preferable to those of metal, because the fixing fluids attack metals. A convenient size for such a tray is 60 by 6 by 6 cm. (24 by 2½ by 2½ inches) with about 1 cm. (one-half inch) of wax in the bottom.

For the transfer of objects from one receptacle to another spatulas are largely used. These are made preferably of horn, because that material is not attacked by the reagents in use. They range in size from 6 mm. (one-fourth inch) to 10 cm. (4 inches) in width, and are of a convenient length, say 17.5 to 20 cm. (7 or 8 inches).

A pair of soft iron forceps 30 cm. (12 inches) long is very convenient for taking objects out of deep receptacles. Iron is both cheaper and just as good as brass for that purpose. Small forceps, wire cutters, syringes, and so on are used at times.

The apparatus for narcotizing certain Actinians is constructed as follows: The nose of a pair of bellows is provided with a metallic bowl which fits over the metal bowl of a tobacco pipe. The latter is provided with a peg which fits into a slot in the bowl on the bellows and fastens the two together. The tube of the tobacco pipe is continued with a piece of flexible rubber tubing which terminates in a U-shaped piece of glass tubing, the distal end of which has been drawn out to a point. With this apparatus one can easily force smoke into a receptacle.

REAGENTS.

Alcohol.—Without doubt the most indispensable liquid is alcohol. For the preparation and preservation of delicate, transparent animals it is necessary to use purified spirit which has been filtered and diluted with distilled water. For coarser animals ordinary alcohol may be used, if desired, even that which has been obtained by redistilling what has once been used being available, care being exercised to see that acids and alkalies have been neutralized. The station always has on hand a quantity of alcohol of 70 per cent strength, which is what is ordinarily used for preserving animals, that of 90 per cent being used only in special cases. By mixing the alcohol and water somewhat in advance of actual need one avoids the innumerable bubbles of air which form on the surface of an animal when immersed in freshly diluted alcohol. Soft or gelatinous animals must be allowed to remain from two to six hours in alcohol of 35 to 50 per cent, according to their consistency, and then be transferred to that of 60 per cent, and afterwards to that of 70 per cent. If the preparations are too delicate to bear handling, the transfer may be made by pouring off the liquid and adding the proper amount of alcohol to make a 35 per cent solution, continuing the process until the standard strength is attained. When necessary to avoid disturbing the animal at all a siphon may be used in effecting the transfer. Frequently it is necessary to change the alcohol after a few days, on account of discoloration. Some forms are immersed directly in 70 per cent alcohol, the liquid being changed after a few days. Changes should be made until the alcohol remains colorless. When an animal which has been in alcohol is transferred to that which is stronger, it is necessary to agitate the jar from time to time to avoid the formation of a layer of weaker alcohol on the bottom.

Many liquids have been tried at the station in search for a possible substitute for alcohol, but always with poor results. Some liquids, like those of Goadby and of Owen, when used on gelatinous forms, eventually produce contraction and consequent distortion. Wickersheimer's solution, which was highly praised when first brought out, distorts or macerates marine animals. Alcohol of 70 per cent is preferable for the permanent preservation of animals for the reason that it is sufficiently absorbed by the tissues after repeated changes. A stronger solution not only is unnecessary for good preservation in the majority of cases, but it is even harmful in some, because it eventually hardens the objects too much and renders them brittle. Alcohol is useful, furthermore, for narcotizing animals and for killing them slowly or quickly.

Formalin or formaldehyde.—Formalin is a very useful liquid for keeping animals temporarily, but not for preserving them permanently. Some pelagic animals—for example, certain Medusæ, Pterotrachaidæ, and Salpidæ—may remain in it for even two or three years without serious detriment, but if they are not transferred to alcohol by that time they begin to disintegrate or decompose. Formalin therefore may be used on a voyage or a long journey when alcohol is scarce or not to be had. As a provisional fluid it is useful for many other animals which are not contractile, and especially for those which contain no lime spicules, skeleton, or shells. Shell-bearing mollusks, echinoderms, and such things can not be preserved in formalin on account of the free acid[1] in the fluid, which attacks the calcareous portions and causes them to lose form or brilliancy, or both. In the case of large animals, such as fish, one must make an injection through the anus of a solution of at least 5 per cent strength. With formalin, as with other preservatives, only one, or at any rate only a very few, objects should be put into the same receptacle at the same time, and there must be a good amount of fluid in proportion to the animal matter present. For gelatinous animals the solution should be of 1 to 4 per cent strength. *Carmarina* and similar things may be killed and hardened at the same time by the use of formalin of the right strength and chromic acid of 1 per cent in equal parts. For animals of some consistency, like ascidians and fish, one should use a 2 to 6 per cent formalin solution, the general rule being that the softer the animal the weaker the formalin. Either fresh or salt water may be used in making the solutions, as may be convenient. The sea-water solution, indeed, preserves the transparency of gelatinous bodies better than the

[1] It is said by the advocates of the use of formalin that this free acid may be neutralized by sodium carbonate and many of the objections to the fluid thus removed. E. O. H.

other. It is not necessary to wash objects which have been in formalin before transferring them to alcohol. For killing and hardening *Rhizostoma*, *Tima*, and some other animals formalin is excellent, and the objects may remain in the fluid a long time before they are transferred to alcohol. It is readily perceived that the contractile animals, when they have been narcotized by one of the usual methods, may be temporarily preserved in formalin in case alcohol is lacking. Colors certainly are preserved for a longer time in formalin than in alcohol, but in time those which are fugitive in one disappear in the other also. The preservative medium has not yet been discovered which will permanently preserve the colors which are due to a pigment in the skin or substance of an animal.

Chromic acid.—Next to alcohol an aqueous solution of chromic acid is the most useful reagent, and it serves especially for killing and hardening gelatinous and soft animals. Objects, however, should not remain in the fluid longer than is necessary, because they become too deeply tinged and are rendered fragile.

After treatment with the acid it is necessary to wash the animals with fresh water to avoid the formation of a precipitate when they are placed in alcohol. If they are not well washed, they will acquire in time a greenish hue. Chromic acid is used mixed with osmic, acetic, or picric acid, with corrosive sublimate ($HgCl_2$), and rarely with alcohol. The solutions are made in ordinary fresh water when possible, though occasionally salt water may be used. They will not keep long. That which has served once may be used again if it will not be too dilute when added to the water containing the animal and if too much time has not elapsed. When the solution has turned green after standing it is not fit to use.

Acetic acid.—This is a reagent which has the property of permeating tissues instantly and hardening them, and it is a very efficacious means of rapidly killing contractile animals, but it has the disadvantage of softening them again if they remain in it too long a time. Objects remain relatively transparent. In certain cases it is necessary to use a concentrated solution of the acid. It is often mixed with chromic acid for killing and hardening noncontractile transparent animals.

Osmic acid.—In general, osmic acid is not used as much now as formerly, because its use has several inconveniences. Efforts have been made at the station to substitute other reagents for it, and in many cases they have been successful. It hardens gelatinous forms well and preserves the transparency sufficiently, but its action is too great eventually. The preparations become dark-colored and are rendered fragile; consequently they should remain only until they have acquired a light brown tint.[1] Before they are transferred to alcohol

[1] Dr. Paul Mayer's method for bleaching objects which have been too much blackened is not practicable for soft animals, since it softens them too much. (Mitth. Zool. Stat. Neapel, II, 1880, p. 8.)

they should be washed for some minutes in fresh or distilled water, as should be done with all animals which have been treated with any mixture containing osmium.

Kleinenberg's liquid[1] was one of the first adopted at the Zoological Station for the preservation of marine forms. Since it presents the disadvantage of staining the alcohol, even after repeated washings, and of not hardening the animals sufficiently, its use has been given up little by little, until now it is confined to the preparation of histological subjects, with the single exception of *Balanoglossus*, which is killed with this solution for exhibition as well as for study.

Lactic acid, in a solution of one in a thousand in sea water, serves well in treating larvæ and small gelatinous organisms.

Hydrochloric, *pyroligneous*, and *sulphuric acids* are used rarely.

Corrosive sublimate, recommended first by A. Lang, is much used as a fixing agent, because it has the property of permeating tissues rapidly and hardening greatly. It is used in concentrated solution in fresh or sea water, either cold or hot. In manipulations with sublimate, metallic implements must not be used, because they decompose the solution and stain the preparations. The solution is made, when possible, with hot water for economy of time, and in vessels of glass or porcelain. Care must be exercised to avoid boiling the sublimate in open vessels, and not to inhale the vapors. The hands must not be immersed in the solution if they have on them open cuts or sores.

All animals which have been prepared with this reagent can be used for histological researches. Corrosive sublimate is also used mixed with acetic or chromic acid or with sulphate of copper. Animals which have been treated with corrosive sublimate must be washed carefully and thoroughly in fresh water before they are placed in alcohol. Add a solution of iodine drop by drop until the alcohol remains permanently colored thereby; this insures the entire removal of crystals of corrosive sublimate from the substance of the animal. If this precaution is not taken, the mercury will be reduced from the corrosive sublimate and will stain the animal black, forming a black precipitate on the sides and bottom of the vessel. The amount of iodine to be used depends upon the size and character of animal to be treated.

Bichromate of potassium.—This is used as a 5 per cent solution for slowly hardening gelatinous animals without rendering them too fragile, when it is not possible to work with chromic acid. On account of the troublesome precipitate which forms when objects treated with bichromate are transferred to alcohol, the use of this reagent is not recommended. For bleaching the preparations before they are put into alcohol, use a few drops of concentrated sulphuric acid.

Sulphate of copper.—This is used only in solutions from 5 per cent to 10 per cent strength, which are made with hot fresh water, and used

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[1] Kleinenberg's liquid is made by mixing 100 c. c. of a saturated aqueous solution of picric acid with 2 c. c. of concentrated sulphuric acid. Filter and add three volumes of distilled water.

alone or mixed with corrosive sublimate for killing larvæ and delicate animals. The objects which have been treated with this reagent must be washed repeatedly with water or else they will not remain perfectly clear, owing to the formation of crystals within the tissues, which render them opaque. If they afterwards prove to have been washed too little, the objects should be treated several times with an acid.

Chloral hydrate.—This is used in very weak solution, from 0.1 to 0.2 of 1 per cent made fresh in sea water, for narcotizing several forms before fixing them. This method has the advantage that, if the animal after a certain time does not remain in the condition desired for preservation, it can be replaced in sea water, where it will regain power of motion and continue to live. It is used for killing animals which live in the crevices of a rock, in incrustations of calcareous algæ, and among colonies of serpulas and of madrepores. Such must be allowed to remain in the solution from six to twelve hours. It is not necessary to use a fine quality of the drug.

Cocaine.—A solution of cocaine is made by dissolving 2 grams of the powder in 100 cubic centimeters of 50 per cent alcohol. This is a most excellent narcotizing medium, but its high cost prevents its extensive use. It is the best reagent thus far discovered for the treatment of gastropods. A few drops are carefully distributed over the surface of the water containing the animals, and the operation is repeated until the animals cease to respond to any stimulus.

Other reagents that are used occasionally are *chloroform*, *ether*, and *tincture of iodine*.

Mixtures frequently used.

Alcohol of 70 per cent and chromic acid of 1 per cent in equal parts.

Alcohol of 50 per cent	cubic centimeters	100
Hydrochloric acid (concentrated)	do	5
Alcohol of 35 per cent or of 70 per cent	do	100
Alcoholic tincture of iodine	do	2.5
Alcoholized sea water:		
Sea water	do	100
Absolute alcohol	do	5
Chrom-acetic mixture No. 1:		
Chromic acid of 1 per cent	do	100
Concentrated acetic acid	do	5
Chrom-acetic mixture No. 2:		
Chromic acid of 1 per cent	do	10
Concentrated acetic acid	do	100
Chrom-osmic mixture:		
Chromic acid of 1 per cent	do	100
Osmic acid of 1 per cent	do	2
Chrom-picric mixture:		
Chromic acid of 1 per cent	do	50
Kleinenberg's solution	do	50
Sulphate of copper, solution of 10 per cent strength	do	100
Corrosive sublimate, saturated solution	do	10

Potassium bichromate, 5 per cent solution	cubic centimeters	100
Osmic acid, 1 per cent solution	do	2
Corrosive sublimate, saturated solution	do	100
Acetic acid, concentrated	do	50
Corrosive sublimate, saturated solution	do	100
Chromic acid of 1 per cent	do	50
Kleinenberg's solution:		
Picric acid, saturated solution	do	100
Concentrated sulphuric acid	do	2
Filter and add three times the volume of distilled water.		
Flemming's solution:		
Chromic acid of 1 per cent	do	25
Osmic acid of 1 per cent	do	10
Acetic acid (glacial)	do	5
Distilled water	do	60
Perenyi's solution:		
Nitric acid of 10 per cent	do	40
Chromic acid of ½ per cent	do	30
Alcohol of 90 per cent	do	30
Müller's solution:		
Potassium bichromate	grams	2
Sodium sulphate	do	1
Distilled water	cubic centimeters	100
Formalin solution (standard):		
Commercial formalin 40 per cent	do	10
Water	do	90

METHODS OF PREPARATION AND PRESERVATION.

PROTOZOA.

Protozoa are so small for the most part as to be invisible to the unaided eye, and their preparation therefore comes within the field of the microscopist, for which reason only the larger species will be mentioned here. Certain Gregarinas which occur as parasites in the intestinal nucleus of *Salpa maxima-africana* are best preserved with Kleinenberg's solution, where they may remain for about an hour before they are transferred to weak alcohol.

RADIOLARIA.

Thalassicolla is well fixed in chromic acid of ½ of 1 per cent, where it may remain about an hour and then be transferred gradually to alcohol of 70 per cent.

Aulacanthidæ and Acanthometræ are placed directly in 50 per cent alcohol, and after a few hours are transferred to that of 70 per cent. Good preparations have also been made by dropping a few drops of 1 per cent osmic acid into the sea water containing the animals and then transferring them to alcohol after washing them in fresh water. Excellent microscopic preparations of some of these species of minute pelagic organisms have been made by a treatment with a saturated solution of corrosive sublimate.

Sphærozoidæ.[1]—The different species of the genera *Sphærozoum* and *Collozoum*, which have spherical or cylindrical form, are fixed in iodinized alcohol of 35 per cent, where they should remain from fifteen minutes to about an hour. The vessel containing them should be shaken from time to time, because the animals flatten out if they are allowed to remain too long on the bottom. If it is desired to prepare a large number at one time, it is necessary to put the fixing liquid into a crystallizing dish of ample size, for convenience in manipulation. After a sufficient time they are transferred to alcohol of 35 per cent, where they can remain a few hours. The change is effected by transporting the colonies with a spatula to another crystallizing dish of the same size without allowing the animals to be without liquid. In the same manner they are transferred to alcohol of 50 per cent, and after twelve hours to that of 70 per cent, and the last should be renewed after twenty-four hours. In this manner colorless preparations are obtained which can also serve for histological studies. Osmic acid is not recommended, because it darkens the preparations too much.

In colonies of *Sphærozoum* with isosporic structure the shape is not fixed with iodinized alcohol, and it is necessary to use saturated sublimate. The genera *Myxosphæra*, *Acrosphæra*, and *Collosphæra* are killed in chromic acid of 1 per cent, to which a few drops of osmic acid have been added, using the same form of receptacle and the same precautions mentioned under *Collozoum*. After from half an hour to an hour the acid solution should be poured off and fresh water substituted for washing, but great care must be exercised not to break the colonies. Then the objects are gradually transferred to alcohol.

Acinetidæ.—Trichophrya salparum has yielded beautiful microscopical preparations when treated with concentrated sublimate in sea water. With *Acineta fœtida*, which usually lives among hydroids, better results can be obtained with osmic acid.

Vorticellidæ.—The colonies of *Zoöthamnium* are best killed with boiling saturated sublimate.

PORIFERA.

For sponges which are to be used for exhibition, it is enough to immerse them directly in 70 per cent alcohol, renewing it when it becomes discolored. To avoid the contraction of Halisarcidæ, they should be fixed in chromic acid of 1 per cent for about half an hour, or in saturated sublimate for fifteen minutes. Those sponges which are to serve for study, if they are not too large—that is, if they are not more than 10 cm. (4 inches) in diameter—are immersed in 90 per cent alcohol or in absolute alcohol, which should be renewed after three or four hours, and again after twenty-four to forty-eight hours. If the

[1]These methods are described in full by K. Brandt on pp. 7–11 of his monograph: Die Koloniebildenden Radiolarien (Sphærozoïen) des Golfes von Neapel, in Fauna Flora Golf Neapel, XIII, Monograph, 1885.

specimens are too large, small pieces may be cut off and treated in this manner.

If they are to be dried, they should be washed first in fresh water for a few hours, then they should lie for about a day in ordinary alcohol, and then be placed in the air or in the sun. If treated in this way, they will not have an offensive odor. If it is desired to retain the rosy color of certain sponges (*Suberites*, *Axinella*) for several days, it is enough to place them in 40 per cent alcohol and not change it.

ANTHOZOA.

The first thing to be done when an Anthozoan has been caught is to place it in a receptacle with fresh sea water. It always happens that these animals, when disturbed by the fishing apparatus or transportation, contract or withdraw into themselves completely. To cause them to expand, it is enough to let them remain in a jar with pure sea water, although it may be necessary to keep them for a longer or shorter time in running water. Many times it has been noticed that the water soon becomes bad if it is not changed.

The following methods, especially that with the chrom-acetic mixture No. 2, are used for preserving animals for museums and to some extent for the study of gross anatomy.

Since all the Alcyonarians contain minute calcareous spicules which furnish the specific characters, they should remain in the acid mixture as short a time as possible so that the acid may not attack the spicules.

In those cases in which chrom-acetic mixture No. 2 has not given good results, a mixture of sublimate and acetic acid may be employed, but always for the killing alone. The animals should be transferred quickly to weak alcohol.

A method used by G. von Koch is quickly to immerse the distended animals in absolute alcohol or that of 90 per cent, making an injection of the same afterwards into the interior of the animal.

When the colonies of *Cornularia*, *Clavularia*, *Rhizoxenia*, and *Sympodium* have become expanded, siphon off the water in the receptacle until only enough remains to cover them. This operation should be performed with great care to avoid any shock which could cause the retraction of the tentacles. Then pour rapidly into the jar a volume of chrom-acetic No. 2 double that of the water in which the animals remain, and immediately afterwards transfer them to alcohol of from 35 to 50 per cent, giving the preparation a few gentle shakes to free the tentacles and dispose them in natural manner. Another good method of killing is with hot saturated sublimate, using the same proportions as of the chrom-acetic mixture, and washing the animals when scarcely dead in fresh water before the transfer to weak alcohol.

The large *Alcyonium* is treated in the following manner: After the rapid bath in chrom-acetic No. 2 it is suspended, scarcely dead, in a jar containing weak alcohol in such a way that its tentacles do not touch the walls of the jar, and if the polyps remain well distended, the change to the different grades of alcohol then goes forward very gradually. In the weak alcohol minute bubbles of air frequently form and attach themselves to the tentacles, giving them a tendency to float and thus causing distortion. Striking the sides of the receptacle with light blows will rid the tentacles of the bubbles.

Pennatula phosphorea and *Kophobelemnon*, when they have become well distended, are taken by the naked base and very swiftly immersed in a tall, cylindrical jar containing the chrom-acetic mixture No. 2, and after a few seconds are placed in a crystallizing dish containing 50 per cent alcohol, where they are allowed to rest on their backs. Then with a small syringe with a very fine point inject alcohol into them through a minute hole made in the extremity of the base. In this manner the alcohol penetrates to all parts of the interior and distends the polyps. Tie a thread around the end of the base above the hole which was made so that the escape of the alcohol may be prevented. After some hours the animals should be transferred to 70 per cent alcohol, and in the final receptacle *Kophobelemnon* should be suspended upside down by means of a glass float with a hook in it.

Pennatula rubra, *Pteroides spinulosus*, *Veretillum*, and *Funiculina* are killed like the Pennatulids just mentioned, but no injection is made after the transfer to weak alcohol. Soft forms like *Veretillum* should be suspended in the final receptacle. Small forms of the Pennatulids may be killed without removing them from the vessel in which they have become distended, and they are then treated like the Cornularians.

Gorgonia, *Gorgonella*, *Primnoa*, *Muricea*, *Isis*, etc., should be killed with chrom-acetic mixture No. 2 in the same dish in which they have become distended on account of the great sensitiveness of their polyps. It is always advisable to have as little water as possible in the dish at the time of killing these animals, and to pour over them a volume of the mixture twice as great as that of the water in which they are. Several times it has been noted at the station that the Gorgonidæ which have expanded in sea water which has begun to turn bad are those which have given the better preparations. The small colonies, or pieces of colonies, remain with their polyps distended if they are killed with boiling saturated sublimate. *Isis* may be well preserved by using a mixture of sublimate and acetic acid.

Corallium rubrum, after it has been allowed to expand in running sea water, should be killed with boiling saturated sublimate solution (half as much as the water containing the coral), and quickly transferred to weak alcohol. By this method the color is almost perfectly preserved, while by the use of the chrom-acetic mixture it is very much injured. The alcohol which has been used for this coral can not well be used afterwards for the preparation of any delicate organism. A colony of *Antipathes* which was placed in such alcohol was dyed red within twenty-four hours.

ZOANTHARIA.

All the species of *Antipathes* are fixed with saturated sublimate, and, on account of the slight contractility of the polyps, their preparation always succeeds. The saturated sublimate, which is used cold, should be of the same volume as the water containing the animals.

ACTINIARIA.

The preparation of this group is very difficult, the great contractility and resistance of the muscular system of the majority of the species frequently constituting insurmountable obstacles to success. Many times when it is thought that the animal has been deprived of any sensitiveness, immersion in a reagent of rapid action is sufficient to show sudden and surprising contraction of the tentacles and of the whole body. When several specimens of certain forms are treated with the same method and under the same conditions, some die distended and the rest contracted. Good results depend, in some cases, on circumstances which, up to the present time, are wholly unknown. After all, however, there are many species with which perfect results can be attained, if great care be exercised in the manipulations.

Anemonia sulcata (*Anthea cereus*) is the easiest to prepare. When well distended in running water, the animals are killed with the chrom-picric solution, used in volume equal to that of the water in which they are. This should be rapidly poured into the jar containing the Actinian, after as much of the water therein has been poured off as may be and leave the animal immersed. A solution which is now much used instead of the chrom-picric mixture just mentioned is made of—

Chromic acid, of 1 per cent	1 part
Saturated solution picric acid	1 part
Formalin, of 4 per cent	1 part

When the animals die, they will fall from the sides of the glass, and they should then be transferred to another jar containing chromic acid of one-half per cent, where they should be suspended upside down by means of a glass float, the hook of which has been passed through the lower rim of the body. The animals should be gently shaken to give the tentacles a natural position. After half an hour they are placed in weak alcohol, and then gradually transferred to that of 70 per cent. It is a good plan to suspend the animals upside down by means of a float in the final receptacle, though it is hardly worth while to do this for the smaller specimens.

The following Actinians may be killed with boiling saturated sublimate: *Eloactis*, *Sagartia dohrni*, *Paranthus*, *Corynactis*, and small specimens of *Aiptasia.* Before they are transferred to alcohol, the animals should be allowed to harden for some minutes in chromic acid of one-half per cent.

When *Heliactis bellis*, *Bunodes gemmaceus*, and *B. rigidus* are well distended, two-thirds of the sea water in the jar containing them should be removed and its place filled by a chloral hydrate solution 0.2 of 1 per cent. After a few minutes this liquid should be poured off until there is barely enough in the jar to cover the animals, which should then be killed with cold saturated sublimate.

Adamsia rondeleti is narcotized with tobacco smoke in the following manner: Remove the hermit crabs from the shells on which the actinias are growing and kill them in fresh water. Suspend the shells by threads in beakers of sea water in which the actinias will have ample room for expansion. The thread may be wound around the shell or passed through a hole in it and then tied over a stick of wood which rests on the edge of the beaker. Place one or more of the beakers in a shallow tray (preferably with flat bottom and perpendicular sides) containing a little water and cover with a bell glass. Fill the bell glass by means of the bellows and pipe described on page 9, being careful at the same time to insert a U-shaped piece of glass tubing under the edge of the bell glass to permit the escape of the confined air as the smoke is forced in. Avoid jarring the glasses containing the actinias.

To regulate properly the duration of the whole operation it is necessary that the first fumigation should be made about 2 o'clock in the afternoon. Little by little the smoke clears up and the water begins to absorb the narcotizing substances contained therein and the animals for the most part distend the corona of tentacles. About 5 o'clock a second fumigation like the first should be made, and the objects are allowed then to remain overnight. The following morning carefully remove the bell jar and touch the tentacles with a needle to learn in what condition of sensibility they are. If they do not contract under this stimulus, place a small open beaker containing a few cubic centimeters of chloroform beside the jar containing the actinia and replace the bell jar, allowing the fumes of the chloroform to work for two or three hours. Lastly the animals are killed in the chrom-acetic mixture No. 2, hardened with chromic acid of one-half per cent and placed in weak alcohol and so on, where they are to remain suspended. If the tentacles give signs of sensitiveness, make a third fumigation and after a few hours test again. This is the only method which has proved successful in obtaining specimens with the column well distended and with the disk and tentacles in full expansion. Cold weather retards this and other narcotizing processes in a very marked degree.

Adamsia palliata can be prepared in the same manner without suspension. Good results have also been obtained by narcotizing the animal slowly with alcoholized sea water and then killing with the chrom-acetic mixture No. 2, or with hot saturated sublimate.

Cladactis, *Cereactis*, and the little *Bunodeopsis strumosa* are killed with the chrom-acetic mixture No. 2, and immediately afterwards hardened in chromic acid of 1 per cent. The first two should be suspended in the hardening and the preserving fluids by means of a glass float, the hook of which has been passed through the margin of the base. Before beginning operations, see that the specimens of *Cladactis* and *Cereactis* are perfectly sound and especially that they are not torn or cut, otherwise when they are placed in alcohol the liquid contents of the body will exude through the rents. Large specimens of *Cerianthus* are fixed with acetic acid and immediately afterwards are suspended in weak alcohol by means of a thread fastened around the column near the base. A few gentle shakes may be needed to adjust the tentacles. It is not necessary to suspend the small specimens.

Actinia equina and *A. cari* are treated with boiling mixture of sublimate and acetic acid, followed by chromic acid of one-half of 1 per cent for hardening. Frequently success has been attained with the first of these species by lifting it gently with a spatula from the beaker in which it is expanded and immersing it in a saturated solution of sublimate.

Edwardsia is slowly narcotized by dropping from time to time a few drops of 70 per cent alcohol into the sea water in which it is. It is then killed with hot saturated sublimate. Success depends upon the complete loss of sensitiveness, which may be tested by touching the tentacles with a needle point.

Certain species of *Polythoa* are very difficult to prepare. Even with reagents of rapid action they will have the body well distended and often only a portion of the tentacles outside the disk. One species which lives in sponges and among calcareous algæ (probably a variety of *P. axinellæ*) is prepared very successfully with boiling saturated sublimate.

Larvæ of the Actinians are killed with saturated sublimate or with chrom-acetic No. 2.

MADREPORARIA.

Astroides calycularis is allowed to remain overnight in a beaker filled with clear sea water. The following morning usually shows the polyps in full distension. Then, after turning off a portion of the water (enough to leave the animals barely covered), kill them with a solution of boiling sublimate and acetic acid in volume equal to that of the sea water, and immediately afterwards transfer the colony to 35 per cent alcohol, making an injection of the alcohol into each polyp to keep it well distended. At each change of alcohol up to 70 per cent make a similar injection, and be sure to test the final solution with tincture of iodine to see that the sublimate has been eliminated.

Caryophyllia, *Dendrophyllia*, and *Cladocora* are fixed with boiling saturated sublimate, but it is very difficult to prepare them with the polyps in perfect expansion on account of their great contractility and also by reason of the extreme delicacy of their walls.

HYDROMEDUSÆ.

The Hydromedusæ in general are very delicate forms, which are easily injured and which quickly decompose, hence it is necessary to proceed with their preparation as soon as possible after they have been taken from the sea. Certain Campanularidæ in particular, such as *Aglaophenia*, *Plumularia*, *Sertularia*, and the like, which live in deep water, almost always arrive at the laboratory in a damaged condition or dead. They are more easily injured than other forms by the dredge, the bottom net, or other fishing apparatus. The best plan to follow with such specimens is to put them directly into alcohol, to preserve the perisarc at least. To treat the animals perfectly, they must be attended to on shipboard as soon as caught.

Other forms which live at less depth, and which can be fished by using every precaution against injuring them, must be handled with great rapidity, otherwise, after a short time, the polyps become retracted, and it is very difficult to kill them in an expanded state. In general, these forms are more contractile than the Tubularidæ.

All the Hydroidea—that is to say, the permanently polypoid forms, with very rare exceptions—are killed with hot saturated sublimate. If the polyps are not in complete expansion when received, the colonies should be allowed to expand in beakers of fresh sea water. As soon as the fixing fluid has been poured over the animals the whole should be turned into a crystallizing dish, containing fresh water, to cool; then the animals should be removed to another dish of fresh water for washing, and after five minutes to weak alcohol (50 per cent). If it is desired to avoid the heating of the liquid, cold sublimate can be used, but only for the Tubularidæ.

Large colonies of *Tubularia* and *Pennaria* are killed with the mixture of sublimate and chromic acid in volume equal to that of the water in which they are, and after a few minutes they are washed and removed to alcohol. *Antennularia* may be killed in cold sublimate, washed in fresh water, and placed in 50 per cent alcohol, and so on.

MEDUSA FORMS OF THE TUBULARIDÆ.

The small forms, *Eleutheria* (*Clavatella*), *Cladonema*, *Podocoryne*, and the like, are killed with the mixture of sublimate and acetic acid, used in large proportion. *Eleutheria* may be killed with Kleinenberg's solution.

Lizzia kœllikeri and *Oceania pileata*, as soon as the tentacles have become well distended, are killed with concentrated acetic acid and immediately poured into a tube containing the mixture of alcohol and chromic acid. By gently agitating the tube the animal regains its normal form. After remaining in the mixture about fifteen minutes it is placed in 35 per cent alcohol, and then gradually transferred to that of 70 per cent. Another and perhaps better way of handling these forms is to allow them to expand in a specimen tube less than half full of water, and when they are well distended to fill the tube with acetic acid. Transfer them at once by pouring into the tube containing the mixture of alcohol and chromic acid. A few minutes later pour out a small portion of the liquid in the tube and add chromic acid, because considerable water will have gone over with the animals. After fifteen minutes wash in fresh water and transfer to 35 per cent alcohol. Still another method is to use the chrom-osmic acid mixture as a hardening medium, but the animals do not remain as transparent and the tentacles are somewhat contracted.

During the hardening process, especially when many of the medusæ are treated at the same time, the tube should be held in a horizontal position in such a way that the bells are down on the side of the tube and the animals not in contact. For the final preservation of certain forms (like *Lizzia*) place them in alcohol in a small tube, separating the individuals by wads of cotton, and put this into the exhibition jar.

Oceania conica and *Tiara pileata* are narcotized in alcoholized sea water (3 per cent) and then treated like the preceding.

MEDUSA FORMS OF THE CAMPANULARIDÆ.

Eucope, *Gastroblasta*, and *Obelia* are fixed in the mixture of sulphate of copper and sublimate and after a few minutes are washed in fresh water until every trace of precipitate has vanished, and then placed in weak alcohol, and so on.

Mitrocoma and *Æquorea* are killed with acetic acid and immediately transferred to the chrom-osmic mixture, where they may lie from fifteen to thirty minutes, according to their size. Small specimens of *Æquorea* can be placed at first in the chrom-osmic mixture.

Tima flavilabris is best preserved by killing in formalin of 4 per cent, where it may remain from five to twenty days, if desired, before the transfer to alcohol begins. This transfer must be made very gradually. The older method of treatment is to kill the animal with chromic acid of 5 per cent in volume equaling that of the water in which it is, and after five minutes to transfer it to the chrom-osmic mixture. After half an hour in the latter mixture wash in fresh water and transfer to alcohol. This method stains the animal brown, while that with formalin leaves it colorless.

Olindias mülleri.—The old method is to kill with acetic acid and immediately transfer to chromic acid of 1 per cent, where the marginal tentacles are to be stretched out by means of a pair of forceps, and where the animals may remain about a quarter of an hour before they are removed to the weak alcohol. The new and more satisfactory method is to place them bottom side up in a shallow tray partly filled with sea water and suddenly pour over them a volume of 6 per cent formalin equal to that of the water in the tray. In the 3 per cent solution of formalin thus made they are to remain at least a week before they are removed to 35 per cent alcohol, and gradually thereafter to 70 per cent alcohol.

Trachymedusæ.—*Rhopalonema*, *Cunina*, *Ægineta*, *Æginopsis*, *Liriope*, and *Carmarina* are fixed in the chrom-osmic liquid for five to twenty minutes, according to their size, washed in fresh water, and gradually transferred to alcohol. *Cunina* is better when killed with concentrated acetic acid before being hardened with the chrom-osmic mixture. A simpler method for *Carmarina* is to use formalin of 4 per cent and chromic acid in equal parts for killing and hardening. Allow the specimens to remain in this mixture from one to two hours; then wash in fresh water and transfer to alcohol.

To prevent the flattening of the bell of *Carmarina*, *Tima*, and other large forms place a watch glass in the bottom of the jar and rest the bell of the hydromedusa in its concave side.

ACALEPHÆ.

Charybdœa should be killed with the chrom-acetic mixture No. 2 and immediately afterwards treated with chromic acid of one-half of 1 per cent. After a half hour transfer to alcohol, taking care for the proper suspension of the tentacles.

Nausithoe, the ephyra of *Pelagia*, and *Rhizostoma* are killed by pouring into the sea water containing them 3 per cent of a 1 per cent solution of osmic acid. When they have just begun to take on a brown tint they should be washed in fresh water and placed in 35 per cent alcohol. Formalin of 4 per cent may be used with excellent results with these animals, because it does not give the brown tint which is imparted by osmic acid. To avoid the flattening of the umbrella of *Rhizostoma*, the animal is killed in an exhibition jar with a somewhat narrow neck. After the transfer to weak alcohol the mouth of the jar should be covered with a piece of bladder and should stand upside down, with the convex part of the bell resting in the neck. The medusa should remain in this position until the alcohol has been changed to 70 per cent and the whole body has become permeated with the fluid. When formalin is used for killing and hardening, this inverted position should be maintained from the first.

Pelagia noctiluca should remain in the chrom-osmic liquid about an hour, and then be washed and placed in weak alcohol. In the alcohol the animal should be suspended by threads tied carefully to the extremity of each tentacle without tearing it. See that the bell does not touch the bottom of the jar and let the animal remain thus only until completely hardened.

Cotylorhiza tuberculata (*Cassiopeia*).—Formalin of from 2 to 3 per cent may be used to good advantage for killing and hardening this species. Another method is to treat with osmic acid, as was done with *Rhizostoma*, but when the brown tint begins to appear, a 5 per cent solution of bichromate of potassium should be substituted for the osmic acid and should be renewed after a few days. The animal ought to remain in this reagent for about two weeks, but it can not remain much longer than that without suffering injury. Then remove the object to 35 per cent alcohol. Numerous crystals of a salt are formed on the outside of the animal and a heavy precipitate falls to the bottom of the receptacle, making it necessary to change the alcohol frequently and to add a few drops of concentrated sulphuric acid thereto.

The larval forms of the Acalephs (*Scyphistoma*, *Strobila*) are killed with hot saturated sublimate. *Strobila* is also well fixed with a mixture consisting of 9 parts of concentrated acetic acid and 1 part of osmic acid of 1 per cent. From this it is quickly transferred to fresh water for washing and put into alcohol.

SIPHONOPHORA.

As with the Hydromedusæ, the preparation of the Siphonophora should be accomplished as soon as possible after capture, and only those specimens should be treated which are in good living condition. Particularly with the Physophoridæ is it true that the whole colony will go to pieces if it remains for a few hours in the same receptacle in which the water has had a sudden change of temperature, though frequently the breaking up does not take place until the colony comes in contact with the fixing fluid. Much care must also be exercised not to shake roughly the vessel which contains the animals before they have been killed. It has often been observed that a trace of an acid or other reagent in the water is enough to destroy the colony. The receiving vessel must be perfectly clean.

Athorybia rosacea, the single representative of the family of Athorybiadæ, which is found in the Bay of Naples, is very rare, and but one specimen has been prepared at the station. That was killed with the mixture of sulphate of copper and sublimate. The colony contracted somewhat, but remained entire. It was washed with fresh water and then placed in alcohol.

The very delicate species (*Physophoridæ*, *Agalmidæ*) must be transferred from the jar in which they were captured to the crystallizing dish in which they are to be killed by immersing both vessels in a tank of water and cautiously pouring the animals over. Leave water enough in the crystallizing dish to give the colony free movement, and wait for the polyps and the nettle-filaments to become well distended and naturally arranged before going on with the treatment.

Physophora, *Agalma*, *Halistemma*, and *Forskalia* are killed with the mixture of sulphate of copper and sublimate in volume equal to or double that of the water in the crystallizing dish containing them. The mixture must be poured rapidly into the dish and not directly onto the animal. After a few minutes, as soon as dead, the colony should be transferred by means of a large horn spatula to the hardening solution, which is not the same for all the species.

(*a*) *Physophora*, *Agalma*, and *Halistemma* are put directly into 35 per cent alcohol, and after a few hours transferred to that of 70 per cent. As soon as *Physophora* has been put into the 35 per cent alcohol, its nettle-filaments should be stretched out as far as possible with a pair of light forceps before they become rigid. To change the liquid in the swimming bell it is necessary to make an injection with a pipette. Bubbles of air always form in the bells, which, through their tendency to float, tend to change the natural shape of the bells, or, raising the whole colony, flatten it at the surface of the liquid. To get rid of these bubbles it is necessary to compress the bells gently.

(*b*) The genus *Forskalia* is transferred from the mixture of copper sulphate and sublimate to Flemming's solution.[1] The animals remain in this form two to six hours, according to their size, and are then washed in fresh water and transferred to weak alcohol, and so on gradually. The hardening of large colonies succeeds better in the mixture of bichromate of potassium and osmic acid, where they can lie even twenty-four hours without hardening too much. To free the animal from the crystals which form in the tissues and render them opaque, a few drops of concentrated sulphuric acid should be added to the first alcohol into which the colony is put. After that, pure alcohol may be used.

For the permanent preservation of the Physophoridæ, after they have remained for a few days in 70 per cent alcohol in crystallizing dishes for hardening, they are to be put into tubes, arranging them so that the anterior end of the colony is toward the mouth of the tube, by immersing the tube in the liquid and gently working the colony into it. Small specimens of *Agalma* and *Halistemma* can be taken by the posterior end with small forceps and gently forced into a tube filled with 70 per cent alcohol so that the bells point toward the opening. The tube should be small enough to keep the colony in proper position within it. It should be plugged with cotton and placed within a larger tube filled with 70 per cent alcohol and closed with a cork. This double-tube system prevents movement of the liquid about the colony itself, even when the outer tube is not entirely filled with alcohol. It is likewise very useful for shipment of specimens, and especially so for purposes of demonstrations. It is recommended for all very delicate animals and those with appendages which can be injured easily.

Apolemia uvaria is killed as are the preceding species and hardened with 1 per cent chromic acid, which is substituted (in the same dish) for the sulphate of copper and sublimate mixture which has been drawn off through a siphon. After twenty minutes in the acid, wash in fresh water and transfer to alcohol, the change of fluids being effected by means of siphons.

Rhizophysa should be allowed to expand in a beaker with the least practicable amount of water and should then be killed with hot saturated sublimate. Wash at once and put into weak alcohol, rearranging as far as possible the nettle-filaments and tentacles which have become tangled during the handling.

Physalia caravella should be permitted to expand its appendages and polyps in a tall cylinder filled with clear sea water, taking care not to touch the pneumatophores on account of their severe stinging action.

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[1] Chromic acid of 1 per cent, 25 c. c.; osmic acid of 1 per cent, 10 c. c.; glacial acetic acid, 5 c. c., and distilled water, 60 c. c.

The preparation succeeds much better in a very high cylinder, on account of the great extensibility of the nettle-filaments. When the colony is well distended pour over it a volume of the sublimate and acetic acid mixture equal to one-fourth that of the sea water containing it. As soon as dead, the colony should be transferred in the same manner as at first to a similar cylinder containing chromic acid of one-half of 1 per cent and after twenty minutes to 50 per cent alcohol, and finally to that of 70 per cent.

Hippopodius, *Galeolaria*, and *Abyla*.—Kill with the mixture of sulphate of copper and sublimate and put directly into weak alcohol. The bell of *Abyla* is also well prepared with the chrom-osmic liquid.

Praya is fixed like *Hippopodius*, but is hardened in the mixture of potassium bichromate and osmic acid, where it may remain one or two days.

Diphyes.—Use hot sublimate for killing, with the chain of the individuals distended.

Velella is killed with the chrom-picric mixture, or with that of sublimate and chromic acid, and after a few minutes is removed to weak alcohol.

Porpita is slowly killed by dropping with a pipette a few drops of Kleinenberg's solution into the beaker where it has become distended. When the beautiful blue color of the colony has begun to turn red as an effect of the acid, it should be removed to the Kleinenberg solution, where it may remain fifteen minutes before it is put into weak alcohol.

CTENOPHORA.

Beroe ovata, *Hormiphora*, *Callianira*, *Lampetia*, *Euchlora*, and young specimens of *Cestus*, *Eucharis*, and *Bolina* are killed in the chrom-osmic mixture, in which they remain from fifteen to sixty minutes, according to size, and are then transferred gradually to 70 per cent alcohol.

While *Beroe ovata* is hardening in the alcohol, insert a short glass tube of the proper size into its gastric cavity to keep it distended in natural shape. Fix the tube so that it acts like a float to keep the animal suspended in the liquid. This operation must be effected with great care to avoid injuring the longitudinal series of vibratile plates. After one or two days, when the animal is in the 70 per cent alcohol, the tube may be removed and the hardened animal will preserve its form.

Beroe forskalii, to be preserved in a state of expansion, must be immersed in the sulphate of copper and sublimate mixture, and as soon as dead must be placed in the chrom-osmic mixture to harden for an hour. Since this species is naturally flat, it is not necessary to introduce a tube into it.

Callianira may be treated like the last species, but another good method is to kill it in a solution composed of—

Concentrated pyroligneous acid	1 part.
Saturated sublimate	2 parts.
Chromic acid of one-half per cent	1 part.

Cestus veneris.—Have the animal in a little water in the exhibition jar and rapidly pour over it enough of chrom-acetic mixture No. 1 to fill the jar three-quarters full, arranging the animal in a coil with the broad edge on the bottom by means of a slender glass rod. After ten minutes substitute chromic-acid solution for the chrom-acetic, and after fifteen minutes therein wash thoroughly in fresh water by decantation and place the animal in 35 per cent alcohol. The gradual transfer to 70 per cent alcohol must take several days, and the jar must not stand in direct sunlight or even strong diffused light. The specimens to be treated should be in perfect condition; otherwise they will go to pieces in the fixing fluid. *Cestus veneris* can be well prepared in the chrom-osmic mixture also, but many specimens are injured and colored too much, whereas by the method just described they remain white and nearly transparent.

Vexillum may be treated like *Cestus veneris.*

ECHINODERMA.

Crinoidea.—*Antedon rosacea* (*Comatula*) is put directly into 70 per cent alcohol, but *A. phalangium*, on account of its tendency to break in pieces of itself, must be killed in that of 90 per cent. Shake the vessel violently to hasten death and prevent the animals from breaking off their arms. When in doubt about the species use 90 per cent alcohol.

The larval forms of the Pentacrinoids are narcotized with chloral hydrate of 0.1 of 1 per cent—a process requiring two to four hours. If they are then hardened in alcohol, they will remain with the arms perfectly distended. The more advanced stages are best killed with saturated sublimate, where, however, they should remain only a few moments to avoid injury to the membranes.

Asteroidea.—To prepare the Stellarids with the ambulacral feet in a state of distention, they are allowed to die in alcohol of 20 to 30 per cent, being placed in the vessel ambulacra uppermost.

Luidia.—Lay the animal on its back in a shallow tray in barely enough water to cover it. Then, when the ambulacral tentacles, which are very long, are well distended, pour over it the chrom-acetic mixture No. 2 and immediately transfer to 50 per cent alcohol and after two hours remove to 70 per cent alcohol. Small individuals may be killed with 55 per cent acetic acid, but greater care must be used to transfer them to alcohol as soon as dead.

Brisinga easily breaks off its arms, to avoid which it should be quickly immersed in absolute alcohol.

Bipinnaria makes excellent preparations when killed with the chrom-acetic mixture No. 1, and even better with the chrom-osmic mixture, in which it should remain only a few minutes. Other larval forms are treated with saturated sublimate solution.

Some Ophiuroids are allowed to die in fresh water because they thus remain distended and entire. *Ophiothryx echinata* is an example. Certain small forms (*Amphiura*, *Ophiactis*) can be fixed directly in weak alcohol, shaking the vessel violently to hasten death. *Ophiomyxa pentagona*, which has a soft body, is hardened in chromic acid of one-half per cent. *Ophiopsila annulosa* breaks in pieces of itself in fresh water, and is therefore killed in absolute alcohol.

Echinoidea.—To prepare these with the ambulacral feet well distended they are placed in just sea water enough to cover them and an equal volume of chrom-acetic mixture No. 2 is poured into the jar. They must be transferred at once to alcohol, so as not to give time to the acid to corrode the calcium carbonate of the animal. If desirable to preserve the soft parts of the animal for anatomical purposes, or even for form only, two small holes must be made in the shell opposite each other to discharge all the fluid contained therein. After immersion in alcohol one must see that the liquid fills the internal cavity, and, on changing the animal to stronger alcohol, that the liquid contained within the shell is changed also.

If dry specimens of echini are wished, discharge the water within the shells and let the animals lie in ordinary 70 per cent alcohol for one or two days before placing them in the wind and sun to dry. Starfish also make better dried specimens if they are killed in 70 per cent alcohol and allowed to remain there two or three days before they are dried.

Holothurioidea.—Holothurians require more care than other echinoderms, because they have soft and very contractile bodies and all are furnished with tentacles which contract or retire within the body on contact with a reagent. Some species, furthermore, soon after they are immersed in the fixing fluid expel their viscera and become valueless as specimens—a thing which may happen in the sea water also, if that is changed too suddenly. All these inconveniences are avoided by treating the animals by the methods here described.

First of all, as with other animals which must become expanded, they are placed in clear sea water. Those species which are killed in acids should be allowed to remain in them only just long enough to cause death, so that the calcareous cutaneous spicules be not injured. Large specimens of *Holothuria* and *Stichopus* as soon as the tentacles are fully distended should be seized with two fingers, or with a pair of forceps, a little below the tentacles, lifted from the sea water, and be immersed as to the anterior portion only in a rather deep vessel containing concentrated acetic acid. At the same time another person should inject some 90 per cent alcohol into the animal through the anal aperture with a syringe, taking care not to exert too great pressure, lest the body be distended too much. Before the Holothurian is quite dead it is to be immersed in 70 per cent alcohol, closing the anal orifice with a small cork to prevent the escape of the liquid and the consequent flattening of the body. The injection should be repeated at each successive renewal of the alcohol.

With certain species, as, for example, *Holothuria poli*, the operations must be performed with much caution, because the skin is easily injured.

H. impatiens, which has a long, soft body, is to be seized by the neck, so that the tentacles can not contract, and by the posterior extremity, so that the body may not shorten, and in this manner the whole animal is immersed in concentrated acetic acid. When dead it is transferred at once to alcohol, without making an injection.

Thyone, *Thyonidium*, and *Phyllophorus* are strangled without using much force, wholly immersed in acetic acid, and then removed to alcohol as soon as dead. If the individuals are very small, the pressure on the neck should be made with forceps instead of the fingers.

Cucumaria plancii is treated like the large Holothurians, except that the injection of alcohol is made through the mouth, taking care to keep the tentacles distended, and it is not necessary to close the opening with a cork. The other species of *Cucumaria* are killed in the same manner. It is not necessary to inject the small specimens.

The large *Synapta*, in the preparation of which much difficulty has been experienced on account of its tendency to break to pieces, is killed by immersion in a tube containing sea water and ether in equal parts. In this mixture the animals usually die completely distended. When dead and well distended, they are washed in fresh water and put into weak alcohol. The transfer to 70 per cent alcohol should be very gradual, to avoid contraction. Chloroform may be used instead of ether. The hardening may also be done by putting 2 or 3 c. c. of 1 per cent chromic acid into the water in which they have been washed. After a few seconds remove to weak alcohol.

The rare *Molpadia musculus* and the little *Chirodota venusta* have been also prepared by this method. *Auricularia* is best killed in the mixture of sulphate of copper and sublimate or in sublimate alone.

ENTEROPNEUSTA.

Balanoglossus is killed with the Kleinenberg solution or in chromic acid of one-half of 1 per cent, but the former is much better. When narcotized in alcoholized sea water the animals remain well distended and straight. *Tornaria* is killed with the sulphate of copper and sublimate mixture. It is well preserved also with saturated sublimate or with the chrom-osmic mixture.

VERMES.

The Cestodes are fixed with cold saturated sublimate, the Trematodes with the same solution hot. If it is desired to have flat preparations to mount for the microscope, the animals should be placed between two plates of glass, which are brought together by gradual pressure, and then placed in a crystallizing dish under moderate weights. When the animals are flattened enough and there is as little water as is practicable in the dish, pour over them boiling saturated sublimate and leave them therein until they show no signs of contraction. Then, the plates of glass being removed, the worms are allowed to harden thoroughly in cold saturated sublimate, since the boiling sublimate fixes only the margins of the objects, not being able to penetrate well between the two plates. In this manner well-distended, flat preparations have been made of *Tristomum*, *Acanthocotyle*, *Distomum*, *Calicotyle*, and of many other Distomata and Polystomata.

Rhabdocœlia and Dendrocœlia.—When they are not quite thoroughly distended in a little water they are killed with boiling saturated sublimate and at once poured into a larger receptacle containing fresh water, where liquid and animals are allowed to cool. From this mixture they are transferred to fresh water, and after a few minutes to alcohol. For certain Polyclades (*Eurylepta*, *Pseudoceros*) it is necessary that the sublimate be warmed a little again, otherwise the bodies break up.

Müller's larvæ may be killed with saturated sublimate, either cold or hot.

Nemertinæ.—Great difficulty has been encountered in dealing with the nemertine worms, because before they are competely distended they contract again, twisting the body badly and breaking to pieces. For some time the effort was made to narcotize the different species by dropping alcohol little by little into the sea water containing the animals, so that as the two mixed the animal would gradually lose sensitiveness and would die. Although this operation was performed with the greatest care, and the worms showed no signs whatever of life, when transferred to the fixing liquid they contracted and became distorted. If the method just described be used with large specimens of *Cerebratulus marginatus*, one can not tell whether the animals are entirely dead or not. Good success, however, has been attained by rapidly plunging them head first into a mixture consisting of Müller's solution[1] 7 parts and concentrated hydrochloric acid 1 part. After a few minutes wash the animals and harden them in alcohol in a wax-bottomed tray.

After repeated experiments the Nemertines were at last successfully narcotized in a solution of chloral hydrate in sea water of 0.1 of 1 per cent strength, where they were allowed to remain from six to twelve hours and then hardened in alcohol in the long zinc box with wax in the bottom. When these animals have been narcotized for not too long a time in the chloral hydrate they will fully regain vitality and power of movement after a little if placed again in sea water.

By this method good preparations can be made of the genera *Carinella*, *Cerebratulus*, *Drepanophorus*, *Nemertes*, *Polia*, etc., in a state of perfect distention and with the proboscis protruded. The more resistant forms (*Langia*, *Amphiporus*, and also *Drepanophorus*), after they have been narcotized in a 0.1 of 1 per cent solution, may well be placed for some hours in a 0.2 of 1 per cent solution before they are killed.

The larval form, *Pilidium*, is killed either with the sulphate of copper and sublimate mixture or with saturated sublimate alone.

[1] Potassium bichromate, 2 grams; sodium sulphate, 1 gram; distilled water, 100 grams.

The Nematodes, free and parasitic, are killed with saturated sublimate or with Kleinenberg's liquid.

Chætognatha.—These are very well treated in the mixture of sulphate of copper and sublimate and in the chrom-osmic mixture.

Gephyrea—*Sipunculus* is killed with chromic acid of one-half of 1 per cent or even weaker, in which the tentacles usually, but not always, expand before death. The animal, after being narcotized with chloral hydrate of 0.1 of 1 per cent in sea water, dies with tentacles distended. Both methods are good, but sometimes a portion of the animal remains contracted, and sometimes during the process the skin in front breaks and allows all the perivisceral liquid to escape, with resulting distortion of the body.

Phascolosoma may be placed in alcoholized sea water and allowed to remain there until dead (three to six hours). *Phoronis* is allowed to remain half an hour in alcoholized sea water and then is killed with boiling saturated sublimate. With the large specimens of *Bonellia* it is best to wait until the proboscis has become well distended and then seize the body of the animal with one hand and the extremity of the proboscis with a pair of forceps so that it can be kept distended. Then quickly immerse the whole in Kleinenberg's liquid in the wax-bottomed tray, and, always keeping the animal stretched out to prevent contraction, wait until it dies. After lying for an hour in this solution the transfer to alcohol may begin. Small Bonellias are narcotized in alcoholized sea water and fixed in weak alcohol. The very small specimens of these Gephyreans are very well killed with hot sublimate. The pelagic larvæ of *Echiurus* are well fixed by allowing them to lie for some minutes in the mixture of sulphate of copper and sublimate.

Hirudinei, *Pontobdella*, and *Branchellion* are killed in chromic acid of one-half of 1 per cent. If in doubt about worms of this family, hot saturated sublimate may be recommended for use. In any case long specimens must be straightened and hardened in the wax-bottomed tray.

Chætopoda.—Many of these, if placed in a fixing fluid which is too energetic in action, contract greatly and twist out of shape, and many of them break to pieces, so that an idea of the natural form is lost. This trouble has been obviated by very gradually pouring over the surface of the sea water in the crystallizing dish a stratum of a mixture of glycerin, 1 part, 70 per cent alcohol, 2 parts, and sea water, 2 parts. This stratum will slowly diffuse throughout the water, and after some hours the animals will be narcotized and will remain fully distended, if transferred to alcohol.

Experience at the station has shown that alcohol alone suffices for the treatment of these worms. Instead of the mixture just described, one may add to the sea water 5 per cent of absolute alcohol and let the animals remain therein until they have lost motion, an operatic which varies from two to twelve hours for the different species. It a good plan not to allow these worms to become entirely dead in th sea water. The hardening is done in the long wax-bottomed trays with 70 per cent alcohol, straightening out the animals and holding them in place when necessary by means of wooden pins. After a few hours in the tray, they should be put into tubes and allowed to rest in a horizontal position for a day or so. Since 70 per cent alcohol does not penetrate the tissues of these animals well enough to prevent maceration, 90 per cent alcohol must be used for permanent preservation. Large specimens should be suspended in the tube by means of a thread attached to a float.

The method just described has given good results with annelids belonging to the following families: Polygordiidæ, Opheliadæ, Capitellidæ, Telethusidæ, Maldanidæ, Ariciidæ, Cirratulidæ, Spionidæ, Terebellidæ, with the exception of the genera *Polymnia* and *Lanice*, which are killed with the mixture of sublimate and chromic acid; among the Aphroditidæ certain Polynoinæ, and all the Sigalioninæ; the Amphinomidæ, which can also be well treated with saturated sublimate; among the Eunicidæ, the Staurocephalinæ, Lysaretinae, and Lumbriconereinæ; all the Nereidæ, Glyceridæ, Syllidæ, Hesionidæ, and Phyllodocidæ.

In the family of the Chlorhæmidæ the genera *Stylarioides* and *Trophonia* are narcotized with alcoholized sea water, hardened in chromic acid of 1 per cent, and transferred to alcohol. *Siphonostomum diplochaitos* of the same family is killed in a solution of chloral hydrate of 5 per cent, and after hardening for fifteen minutes in 1 per cent chromic acid is transferred to alcohol. Another good method is to use the sulphate of copper and sublimate mixture for killing, allowing the animals to remain five minutes in the solution. Animals of this species, when treated with the ordinary reagents, break to pieces with the greatest ease.

Hermionidæ are immersed directly in 70 per cent alcohol (old solution will do), taking care that the animals do not die in a curved position.

Chætopteridæ, Sternaspidæ, the large *Spirographis* and the large Serpulinas of the genus *Protula* are killed in 1 per cent chromic acid, where they are allowed to rest at least half an hour. Then after thorough washing in fresh water, they are put into alcohol of 70 per cent, and afterwards into that of 90 per cent. *Spirographis* can not be well treated in its tube or be returned to it after treatment. *Myxicola infundibulum* is killed in saturated sublimate, and, after ten or fifteen minutes, thoroughly washed and put into 50 per cent alcohol for a few hours before it is put permanently into that of 70 per cent.

The following annelids are killed with cold saturated sublimate, in which they should not be allowed to remain more than fifteen minutes; all the Amphictenidæ (which may be placed in alcoholized sea water until well out of their tubes), the Hermellidæ, the Serpulidæ (some of which should remain for some hours in a 0.1 of 1 per cent solution of chloral, so that they may come wholly or partly out of their tubes), of the

Aphroditidæ certain Polynoinæ, *Polyodontes maxillosus*, of the Eunicidæ all the group of the Eunicinæ. Some of these, like *Dioptara*, are best fixed by narcotizing them in alcoholized sea water.

Alciopidæ are very well prepared by letting them die in the sulphate of copper and sublimate mixture. They should remain in the solution not to exceed five minutes, and then be washed thoroughly in fresh water before they are placed in alcohol.

Tomopteridæ are preserved in the way just described, or with cold saturated sublimate. Remove the last traces of sublimate with iodine.

CRUSTACEA.

The marine Cladocera (*Podon*, *Evadne*) are killed with saturated sublimate, or with a few drops of osmic acid of 1 per cent in the sea water containing them, removing them when they begin to turn brown. Wash and put into 70 per cent alcohol.

Ostracoda are put at once into 70 per cent alcohol.

Copepoda.—The free forms are killed in a saturated solution of sublimate in sea water, where they are allowed to stay from five to ten minutes. The parasitic forms may be killed in the same way or be put at once into weak alcohol.

Cirripedia.—To prepare *Lepas*, *Conchoderma*, etc., with the cirrhi distended, let them die in alcohol of 35 per cent. If the cirrhi of certain species contract they can easily be drawn out again by means of forceps.

Balanus and similar forms are immersed directly in alcohol of 70 per cent, taking care to change the liquid soon.

Rhizocephala (*Sacculina*, *Peltogaster*, etc.) are placed for fifteen minutes in a mixture of 90 per cent alcohol and sublimate in equal parts, and then transferred to 70 per cent alcohol.

Amphipoda.—All the Læmodipodes, Crevettines and Iperines were formerly prepared by putting them at once into alcohol of 70 per cent, but now they are put into Perenyi's solution for fifteen minutes before they are immersed in the alcohol. The transparent forms of the last division (*Phronima*, etc.) are killed in sublimate.

Isopoda.—These are put at once into 70 per cent alcohol, with the exception of the *Bopyrides* and *Entoniscides*, which are first placed in a mixture of 90 per cent alcohol and saturated sublimate in equal parts (like the Rhizocephala) or in saturated sublimate alone.

Cumacea and *Stomatopoda* go directly into alcohol, though the transparent larval forms of the latter are first put into saturated sublimate for a few minutes.

Schizopoda go at once into alcohol or they may be treated first with saturated sublimate.

To avoid the breaking of the appendages of the *Decapoda*, these forms are allowed to die in fresh water before they are put into alcohol. They remain in fresh water only as long as is necessary, otherwise the membranous appendages are injured.

With the Paguridæ the alcohol must be changed often, and they are to be preserved permanently in 90 per cent alcohol, because the shell is permeable to only a small degree.

The larvæ of the Decapods (*Zoëa*, *Phyllosoma*, etc.) are killed in sublimate or with a few drops of osmic acid of 1 per cent.

PANTOPODA.

The Pantopoda are killed in chromic acid of one-half per cent so that they will remain with the legs distended. As they are almost always covered with foreign bodies, it is necessary to let them live for several days in beakers of fresh sea water, so that they may clear themselves of these extraneous growths.

MOLLUSCA.

Lamellibranchs may be prepared with the valves open by narcotizing them in alcoholized sea water, where they may remain from six to twelve hours or even more, according to the species. The siphonate forms should not be transferred to alcohol before they are thoroughly stupefied, otherwise the siphons will contract. After the animals have been narcotized, it is an excellent plan to place them in chromic acid of 1 per cent for about a half hour. They are very likely to open their shells wider after they have been placed in the chromic acid. When chromic acid is not used, it is well to place a bit of wood between the valves to keep them apart when first put into alcohol. Cocaine may be used instead of alcoholized sea water for narcotizing the animals. The animals are preserved in a more distended condition, but its use is not as necessary for lamellibranchs as for gastropods, and the method will be described when the latter are discussed.

Lima, which has a large number of tentacular filaments around the edge of the mantle, which break off if alcoholized sea water be used, is killed with chromic acid of one-fourth of 1 per cent. Large specimens, however, yield better results if treated with the copper sulphate solution first.

Scaphopoda.—*Dentalium* is narcotized with chloral hydrate of 0.2 of 1 per cent, in which it remains from ten to twelve hours or more, and is then put into 70 per cent alcohol.

Gastropoda.—The use of cocaine for narcotizing all species of gastropods is strongly recommended. The solution consists of 2 grams of cocaine powder dissolved in 100 c. c. of 50 per cent alcohol. Place the animals in the least practicable amount of water. Drop in a few drops of the cocaine solution, and after two hours add a few more, and continue the operation until the animals are thoroughly insensible. The action is much slower in winter than in summer. To avoid the contraction into the shell, which is apt to take place with prosobranchs having a spiral shell, even when the narcotizing has seemed to be complete, draw the operculum as far out as possible with a pair of pincers and bind it to the shell.

As cocaine is not always available, the old methods for treating gastropods will be detailed. It is to be understood that when cocaine is used for narcotizing the subsequent treatment is that indicated below:

The Placophora and the families of the Patellidæ, the Fissurellidæ, and the Haliotidæ may be prepared in a distended condition by narcotizing them with alcoholized sea water.

Natica josephinia may be fixed in complete distention by dropping 70 per cent alcohol little by little into the sea water until the animals no longer respond to any stimulus, an operation which often lasts two or three days. Then they are killed by rapidly pouring concentrated acetic acid over them, and they are transferred at once to weak alcohol. If one desires to get perfect specimens he must treat several at once, because out of every lot some are sure to remain more or less contracted.

Natica millepunctata and *N. hebrea*, when treated in the manner just described, remain entirely contracted. Good results may be obtained, however, by letting them remain for some days in a mixture of sea water and fresh water in equal parts, and afterwards killing them with acetic acid. This may be used for preparing several species of *Nassa*, *Columbella*, *Conus*, and *Trochus*.

Heteropoda.—The Atlantidæ may be narcotized in alcoholized sea water, where they are allowed to remain for from six to twelve hours, and are then placed directly in alcohol. Cocaine, however, is much better for narcotizing.

The Pterotrachaidæ are killed by immersing them in chrom-acetic mixture No. 1 for from ten to thirty minutes according to their size. Wash thoroughly in fresh water and transfer gradually to the different grades of alcohol. These animals are well prepared also with the chrom-osmic mixture, and the little specimens of *Carinaria* are best treated with the mixture of sulphate of copper and sublimate. Large specimens should be suspended in the permanent receptacle by a thread tied around the end of the proboscis.

Opisthobranchiata.—The Bullas are slowly narcotized in the mixture of sea water and fresh water in equal parts or in alcoholized sea water and allowed to remain therein until thoroughly insensible. They are killed with concentrated acetic acid and transferred at once to alcohol.

Gastropteron meckeli is killed in Kleinenberg's solution, thereby retaining its natural red color very well. It loses its color in the ordinary liquids.

Doridium and Scaphander.—Narcotize in alcoholized sea water, kill in concentrated acetic acid, and quickly transfer to alcohol. If not hard enough, or if softened at all in the acetic acid, they may be placed in chromic-acid solution of 1 per cent for ten or fifteen minutes before they are put into alcohol.

Philine.—When the animal is well distended in a little sea water, suddenly pour over it concentrated acetic or pyroligneous acid and quickly transfer to alcohol.

Pleurophyllidia is narcotized with alcoholized sea water and then killed with concentrated acetic acid.

Aplysia limacina and *A. punctata* are fixed in 1 per cent chromic acid, where they are allowed to remain from fifteen to sixty minutes, according to their size. *A. depilans* is narcotized in chloral hydrate solution of 1 per cent (which may take twelve hours), killed with concentrated acetic acid, transferred at once to chromic acid of 1 per cent, and after half an hour put into 50 per cent alcohol, and so on.

Pleurobranchia meckeli is best treated with cocaine and then put into chromic acid of 1 per cent, where the animals may remain about an hour before they are washed and put into alcohol.

Pleurobranchus meckeli and *P. testudinarius* may be killed in chromic acid of 5 per cent. When scarcely dead the animals are transferred to that of 1 per cent, where they may remain from fifteen to sixty minutes, according to their size. The small specimens can be well prepared with chloral hydrate, also, afterwards fixing them with chromic acid of 1 per cent.

Umbrella is slowly killed in alcoholized sea water, after which it is put into weak alcohol.

The Elysiidæ and the Æolidiidæ are permitted to expand in the least practicable amount of sea water. They are then killed by rapidly pouring over them a volume of concentrated acetic acid double or equal to that of the sea water, and when scarcely dead they are transferred to weak alcohol.

Phyllirrhoe bucephalum is fixed in the chrom-osmic mixture for a few minutes or in the chrom-acetic mixture No. 2.

Doris, *Chromodoris*, *etc.*—The larger specimens of these animals may be narcotized by adding 70 per cent alcohol, a little at a time, to the water containing them, until touching the branchial appendages on the back produces no contraction. They should then be killed with concentrated acetic acid or boiling saturated sublimate. If cocaine is used for narcotizing the animals, they should be killed in concentrated acetic acid, placed in chromic acid of 1 per cent for ten minutes and then transferred to 50 per cent alcohol, and so on. The small specimens need not be narcotized.

Triopa, *Idalia*, and *Polycera* are treated like the Elysiidæ.

The large specimens of *Tritonia* are immersed until dead in fresh water, to which a few drops of acetic acid have been added, when they are hardened in chromic acid of one-half of 1 per cent. By this method they remain well distended and the shape suffers no alteration. Small Tritonias are treated with cocaine and then hardened and placed in alcohol.

Marionia is narcotized in alcoholized sea water and killed in acetic acid.

To prepare *Tethys* with the dorsal appendages in position, the animal is allowed to expand in a large, low crystallizing dish in the least amount of water possible necessary to cover it. It is killed by pouring over it a quantity of concentrated acetic acid at least as great as the water in the dish. Then the liquid is removed by means of a siphon and chromic acid of 1 per cent substituted therefor. Then carefully try to give the animal a lifelike appearance by flattening the foot on the bottom of the receptacle and arranging the cephalic lobe so that it rests easily rolled up in conical shape. In this manner it should harden, and after half an hour the chromic acid should be siphoned off and weak alcohol introduced. The animal must be suspended in the final receptacle.

Pteropoda.—The Hyaleidæ are placed in a little water and allowed to expand the two wings, when saturated sublimate solution is poured over them. After a few minutes they are washed and placed in weak alcohol, and so on. *Criseis acicula* is well prepared by killing it with alcoholized sea water.

Cymbuliidæ are very well killed in Perenyi's solution, where they may remain fifteen minutes before they are transferred to 50 per cent alcohol. If they are prepared with the chrom-osmic mixture, their form is perfectly preserved, but the transparency is partly lost.

The *Gymnosomata* are placed in chloral hydrate solution of 0.1 of 1 per cent for from six to twelve hours and then are quickly killed with acetic acid or sublimate. Good preparations of *Cliopsis* have been made by letting the animals die in chromic acid of one-fourth of 1 per cent.

Cephalopoda.—The preparations are much better, of course, when the animals are immersed in the preserving fluid while still alive. If they have been dead for some time when received, they can be made to regain their shape in part by allowing them to lie in sea water for about an hour. Then they had better be hardened in 1 per cent chromic acid for fifteen to sixty minutes, according to their size.

Small octopods are narcotized in chloral hydrate of 0.2 of 1 per cent, and then immersed in alcohol, where they sometimes contract, twisting the arms about the body, but after the animals are dead it is easy to stretch out the arms and dispose them in a natural position. The larger animals (of a length of 15 cm. (6 inches) or more) are killed in 1 per cent chromic acid, where they are usually kept a half hour, though very large ones may remain even so much as two hours. After washing them in fresh water, transfer to 70 per cent alcohol, taking care to change the latter several times.

Ocythœ catenulata (*Philonexisa*).—Females of medium size are immersed directly in 70 per cent alcohol and after they are dead their arms are straightened out. *Scœurgus tetracirrhus* (*Octopus*) is killed in the mixture of alcohol and chromic acid and after twenty minutes is transferred to alcohol.

The Decapods may be put at once into alcohol of 70 per cent, taking care, before they are quite dead, to pull out the two tentacular arms, which usually have contracted. The small species should be narcotized in chloral hydrate of 0.2 of 1 per cent or in alcoholized sea water before they are put into the alcohol. To facilitate the penetration of the alcohol into the visceral region of the largest specimens an incision should be made in the ventral part of the body.

The transparent pelagic forms (*Loligopsis*, *Verania*) are put first into Kleinenberg's solution and after an hour are transferred to weak alcohol, from which they are gradually changed to that of 70 per cent. The forms which are contained in a common gelatinous substance are fixed with chromic acid of one-half of 1 per cent and then transferred to 50 per cent alcohol, where they remain permanently.

BRYOZOA.

Bryozoa are best preserved when they are treated on board ship immediately after they have been caught.

Pedicellina and *Loxosoma* are left for an hour in chloral hydrate of 0.1 of 1 per cent and then killed with saturated sublimate, cold or hot. Wash immediately afterwards and place in alcohol. Certain species of *Bugula* (*purpurotincta*, *turbinata*), after the animals have become well distended in a little sea water, are killed quickly with hot sublimate. By pouring some 70 per cent alcohol slowly over the surface of the water in which they are, *Flustra*, *Cellepora*, *Crisia*, *Bugula*, and *Zoobotrium* have been prepared in a state of complete distention. The other species can be killed with the animals more or less out of their cells by using a weak solution of chloral hydrate or alcoholized sea water, but generally good results depend upon the skill of the preparator.

BRACHIOPODA.

Brachiopods are narcotized by letting them lie in alcoholized sea water for some hours before they are put into alcohol. Put a bit of cork between the valves to keep them open. Small forms may be put at once into 70 per cent alcohol.

TUNICATA.

The Appendiculariæ are killed by letting them rest for five minutes in the chrom-osmic mixture.

Ascidiæ simplices.—To treat *Clavellina* and *Perophora* so that the orifices shall remain open, first allow them to expand in running sea water and then immerse them in chloral hydrate of 0.1 of 1 per cent, letting them remain from six to twelve hours; then kill them with chrom-acetic No. 2 and immediately afterwards transfer to chromic acid of 1 per cent, some of which should be injected into the interior of each individual. After a half hour transfer the animals to 35 per cent alcohol, repeating the injection with that fluid, and finally to alcohol of 70 per cent. *Clavellina rissoana* is usually killed in acetic acid; it is not necessary to inject each individual.

Ascidia (*Phallusia*), after from three to six hours in chloral hydrate of 0.1 of 1 per cent, is hardened for half an hour in chromic acid of 1 per cent, washed, and transferred to alcohol.

Ciona intestinalis is killed slowly by putting into the water in which the animals have expanded a few drops of the chrom-acetic mixture No. 2. When the animal has died, which happens in about a half hour, it is to be taken by the anterior orifice, to avoid the discharge of the water within, and put into chromic acid of 1 per cent, making an injection of the same into the body cavity. The transfer to the alcohol series should be made in the same way.

Certain ascidians (*Ascidia* and *Rhopalea*) are killed in the following manner, so as to keep the orifices open: They should be placed in beakers with from 4 to 5 cm. (about 2 inches) of sea water above them. Then slowly drop in 1 per cent chromic acid in such a manner as to form a stratum on the top of the water. Little by little the chromic acid will diffuse through the water, usually killing the animals in from twelve to twenty-four hours. If the animals are not dead by that time, add a little more chromic acid. Harden in chromic acid of 1 per cent, wash in fresh water, and put into alcohol. The animals should not rest against the sides of the beaker during narcotization. If the animal has not a good base upon which to stand, some clean sand may be placed in the bottom of the glass, in which it can be arranged in the desired position.

Molgula, *Polycarpa*, *Rhopalea*, and *Chevreulius* (*Rhodosoma*) must remain for twelve hours in chloral hydrate of 0.1 of 1 per cent. Then kill them in chrom-acetic No. 2 and transfer at once to 1 per cent chromic acid for a little time to harden.

Cynthia and *Styela* are narcotized in 0.2 of 1 per cent chloral hydrate for twenty-four hours and then treated like the last-mentioned genera. *Cynthia papillosa*, however, sometimes contracts greatly when immersed in chloral hydrate of 0.2 of 1 per cent. When it does, put it back into running sea water to expand again, and then try treating it with 0.1 of 1 per cent chloral hydrate.

Ascidiæ compositæ.—The gelatinous forms—for example, the Botryllidæ, *Polycyclus*, *Circinalium*, and *Fragarium*—are allowed to lie in chloral hydrate of 0.1 of 1 per cent for a few days and then are killed by pouring hot saturated sublimate over them. Immediately afterwards they are transferred to chromic acid of one-half of 1 per cent, where they are left for a half hour before they are washed and transferred to alcohol.

Distaplia, after it has been narcotized with 0.1 of 1 per cent chloral, is killed with chrom-acetic No. 2, washed, and put directly into weak alcohol.

Diazona violacea should remain twelve hours in chloral hydrate of 0.2 of 1 per cent, and then the killing and the hardening should be done as with the Botryllidæ, except that the individual animal should be injected with the liquid. Small colonies may be killed in acetic acid and hardened in one-half per cent chromic acid.

Leptoclinum and other forms of a certain consistency are transferred from the chloral directly to the alcohol.

Pyrosoma is suspended by a thread in the mixture of alcohol and hydrochloric acid in a cylindrical jar, and, after a quarter of an hour, is transferred to 60 per cent alcohol and gradually to that which is stronger. Good preparations have been made by putting the colony directly into 50 per cent alcohol. Care must be exercised to get rid of the minute air bubbles which are apt to form on the surface of the colony, though they usually disappear of themselves.

The Salpidæ include animals of very various consistency, from slimy to cartilaginous. Certain species, furthermore, although they have consistency when young, become soft in the adult stages and difficult to preserve. Sometimes the Salpas when immersed in the fixing fluid contract greatly, closing the orifices and dying in this condition. This may be remedied by introducing a closed glass tube into one of the openings, which, by allowing the entrance of the liquid, causes the animal to resume its natural shape.

The species with a hard body (*Salpa bicaudata* when solitary and young; *S. tilesi*, both chain and solitary forms; *S. zonaria*, both chain and solitary forms), are immersed in a mixture of fresh water (100 c. c.) and concentrated acetic acid (10 c. c.), where they remain for fifteen minutes. Then they are washed in fresh water for ten minutes, and then transferred gradually to alcohol, where it is necessary to float the larger forms by means of pieces of cork attached to them with threads so that the gelatinous sac shall not flatten down upon the intestinal nucleus within. When treated in this manner, the animals remain very transparent, crystals of marine salts forming in the tissues much less than with the other liquids.

The forms of medium consistency (young chains and solitary individuals of *Salpa maxima* and *S. pinnata*, young chains of *S. bicaudata*, both the adult forms of *S. fusiformis* and *S. democratica-mucronata*) are placed in the chrom-acetic mixture No. 1 for ten minutes and then put directly into weak alcohol.

The very soft forms (large chains of *Salpa bicaudata* and *S. punctata*, both forms of *S. maxima*, *S. pinnata*, and *S. virgola*) are immersed in the chrom-osmic mixture for from fifteen to sixty minutes, according to their size. Then they are washed in fresh water and transferred to weak alcohol.

Very large specimens of *Salpa maxima* flatten out of their own weight when put into weak alcohol. This may be obviated by blowing a few bubbles of air into the cavity of the animal or by putting therein a tube of thin glass closed at both ends to act as a float. The tube or the bubbles of air should be removed before the animal is entirely hardened.

Professor Todaro, to preserve Salpas for histological purposes, immerses them at first in Kleinenberg's solution, and after an hour transfers them to alcohol. When preserved in this manner, however, all but the hard species lose their form entirely.

One can easily inject the circulatory system of living Salpas with Prussian blue by placing the point of a fine syringe in the slender canal of the heart and operating it with a very gentle pressure. After this the animals can be treated by the methods already detailed, and the color will remain very well after they have been put into alcohol.

The Doliolids give good preparations when killed with the mixture of sulphate of copper and sublimate, saturated sublimate alone, or with the chrom-osmic mixture. After a few minutes wash the animals thoroughly with fresh water and transfer them gradually to 70 per cent alcohol.

FISH.

In general, fish present no difficulties in their preparation. If possible, they should be alive when put into the fixing fluid, because thus only do they preserve the shape of the body well and keep the fins completely distended. Those which have been dead for some time and have been left to dry, having already lost much water, have the fins contracted and dried, and when placed in alcohol they contract still more. To preserve dead fish for anatomical purposes, inject them first through the anus with 90 per cent alcohol and then put them into that of 70 per cent.

To prepare *Amphioxus* with the mouth cirrhi distended, the animals are allowed to die in sea water alcoholized to 10 per cent, and after death, which usually occurs in a few minutes, they are transferred to alcohol of 50 per cent, and gradually to that of 70 per cent. Müller's solution[1] can also be used for killing, if suitable for the purpose for which the animals are intended; but they remain colored, and often swellings are formed in the sides of the body. Chromic acid of 1 per cent is sometimes used for the killing.

Cyclostomans, Selachians, and Ganoids.—Small specimens are put at once into 70 per cent alcohol. With large specimens it is difficult for the alcohol to penetrate the viscera, and it is necessary to make an incision in the belly, or else to inject 90 per cent alcohol through the anus repeatedly and at every change of fluid.

Certain species of soft consistency, like *Torpedo*, are better fixed if they are allowed to lie in 1 per cent chromic acid for a half hour before they are put into alcohol.

Embryos of Selachians (from 1 to 10 c. m. in length) are fixed in saturated sublimate, where they may remain from five to fifteen minutes. Be careful to wash well and to make use of the usual test with iodine. When prepared thus they are also good for histological studies. Fair success has attended the treatment of the embryos of *Torpedo*, with the entire yolk sac attached, by placing them for fifteen minutes in a mixture consisting of 1 per cent chromic acid and saturated sublimate

[1] Potassium bichromate, 2 grams; sodium sulphate, 1 gram; distilled water, 100 grams.

in equal parts, then washing them in fresh water and putting them into alcohol.

If it is desired to preserve moderately large Selachians for the future preparation of the skeleton as well as the skin, it suffices to open the belly, remove the intestines, and immerse the animal in a 10 per cent solution of common salt.

The Teleosts are treated like the Selachians, but the alcohol penetrates the tissues with still greater difficulty, and it is necessary, particularly with the larger forms, to make repeated injections of the liquid. The Teleosts with silvery skin (*Trachypterus*) are put into saturated sublimate for a few minutes before they are placed in alcohol. The transparent larval forms may be put directly into weak alcohol, or may be fixed first with saturated sublimate.

The transparent fertilized eggs can be preserved for purposes of demonstration by allowing them to remain for some minutes in the mixture of alcohol and hydrochloric acid and then transferring them to pure alcohol.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR PREPARING STUDY SPECIMENS OF SMALL MAMMALS.

BY

GERRIT S. MILLER, Jr.,
Assistant Curator, Division of Mammals.

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DIRECTIONS FOR PREPARING STUDY SPECIMENS OF SMALL MAMMALS.

By Gerrit S. Miller, Jr.,
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For preparing study specimens of mammals ranging in size from that of the smallest mice and shrews to that of a woodchuck, hare, or large skunk, the following instruments and materials are necessary:

Scalpel or pocket knife with small blade.
Fine pointed forceps.
Scissors.
File.
Metric rule.
Dividers.
Cotton, tow, and excelsior for stuffing.
Galvanized iron wire of several sizes, from about No. 15 to No. 23, for feet and tails.
Combined cutter and plier for manipulating wire.
Dry white arsenic, or a mixture of one-half arsenic and one-half powdered alum.
Corn meal, fine sawdust, sand, or clean, dry earth, to be used as an absorbent.
Strong paper for labels.
Medium soft pencil, or waterproof ink.
Needles and thread.
Pins.
Alcohol, formalin, or strong cane rum.
A pair of long forceps or 'stuffers,' and a fat scraper will often prove convenient for use on larger skins.

Specimens of small mammals are to be preserved (*a*) as skins, (*b*) as skeletons, and (*c*) entire in alcohol or formalin.

SKINS.

Mammals should be skinned as soon as possible after death. They spoil much more quickly than birds.

In hot climates the viscera should be removed from small mammals immediately, and the abdominal cavity filled with cotton, tow, or leaves.[1]

[1] Mr. E. W. Nelson has furnished the special recommendations for work in tropical climates.

This precaution is especially important with rats, mice, shrews, and rabbits, or with any specimens that must be kept over night before skinning.[1]

1. Prepare two labels, one for the skin, the other for the skull. On the skin label record: (*a*) Number, (*b*) sex,[2] (*c*) locality, (*d*) date, (*e*) name of collector, (*f*) total length (tip of nose to tip of tail bones, animal stretched straight), (*g*) tail (turn tail at right angles with back, and measure with dividers from angle to tip), (*h*) hind foot from heel to most distant claw tip.

ALL MEASUREMENTS TO BE MADE EXCLUSIVE OF HAIR. They should be recorded in millimeters.

On the skull label record: (*a*) Same number as that on skin; (*b*) collector's name or initials. Both labels should be made of strong paper, and the writing on the skull label should be in pencil (heavily marked) or waterproof ink.

2. Lay the animal on its back. Make an incision in median line of belly, running from shortly behind breastbone to base of tail. Work the skin loose at one side until a hind leg is exposed. Push the leg from the outside and pull it from the inside, at the same time stripping back skin until loosened as far as heel. Then, if the animal is smaller than a red squirrel, cut off the leg (with scissors), flesh, bone, and all, a little *above* heel, taking care not to injure the skin. In larger animals the flesh should be cut through to the bone at heel and stripped upward to knee, where the bone is to be disjointed. The same course may be followed with smaller specimens, but it takes more time, without materially improving the result, except when the specimens are intended for mounting. *In animals the size of a skunk, or larger, the process of skinning should be continued to the toes*, and the flesh removed from the foot, the bones of which are to be left in place. Repeat the process with the other leg.

3. After the hind legs are finished, skin around base of tail and across rump. Then seize the tail bone lightly with forceps or a split stick held close against the skin with the left hand, and with the right hand draw the bone out of the skin. The fingernails of the left hand will often prove more convenient than forceps for stripping the tail. This process may be troublesome at first, but it presents no real difficulty except in the case of some large long-tailed animals.

4. Hold the body by the hind quarters grasped in the right hand, and with the fingers of the left hand drawing with an equal pressure on all sides simultaneously, slip the skin back until the front legs appear. With larger specimens it may be more convenient to hold the skin in the left hand and let the body dangle over the edge of the table, while with the right hand the skin is loosened around the circle

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[1] It is probable that specimens may be temporarily preserved by keeping them exposed to the fumes of strong formalin in some tight receptacle. This method should be tested.

[2] ♂ = male, ♀ = female.

of contact. By cutting carefully close to the skin, much fat that would otherwise adhere to the skin may be left on the body. However the animal is held, it must be remembered *that all tension must be applied at the line of contact between the body and the loosened skin;* otherwise serious stretching will result, and A STRETCH IS FAR MORE SERIOUS THAN A CUT.

5. On reaching the front legs draw them out from the skin and treat exactly as has already been done with the hind legs.

6. Slip the skin off until it binds at the bases of the ears. Cut through these carefully (with knife) so as to injure neither skin nor bone. (It may be found that the ears can be more readily loosened with forceps or finger nails.) A short distance in front of the ears the eyes will be encountered. Work the skin as far forward as possible with the fingers of the left hand, and cut close to bone with knife held in right hand. The membranes will thus be divided without injuring the eyelids. Considerable practice will probably be necessary before this can be done rapidly and safely. Cut away the skin from the skull until the lips are reached. These are to be carefully separated from the jaws and gums until the skin finally hangs attached by the nose only. Cut through the cartilage of the nose, taking care not to injure the delicate nasal bones or the skin of the muzzle, and the operation of removing the skin is completed.

7. Examine inside of skin and remove scraps of flesh and loose tissue. Ordinarily nothing further will be necessary. The skins of many animals, however, are lined with a thick coat of fat. ALL FAT MUST BE REMOVED. This can be done only by thoroughly scraping the inside of the skin with knife and scraper. The free use of an absorbent such as corn meal or sawdust will facilitate the process and protect the fur from grease. Great care must be taken not to stretch the skin. After the inside of the skin is properly cleaned it is to be poisoned. Dip the skin in the box or paper containing the arsenic and turn it about so that *all parts are covered with the preservative.* Dampen the surface of the skin if it is so dry that the powder does not adhere freely.

When the skin is poisoned, turn it right side out. The simplest way to do this is to reach in from behind with forceps, seize the nose, and draw it out. Draw the feet and tail out to their natural length and see that the ears are in place. If any blood has soiled the fur it may be removed by washing, after which the hair is readily dried by the use of a stiff brush and an absorbent (preferably corn meal or sawdust). Small spots of blood can often be removed, when thoroughly dry, by brushing with a stiff brush (a toothbrush is best), without previous washing. Very bloody specimens, or those extensively soaked with fat, should be thoroughly washed both inside and out with soap and water before poisoning. They are then best dried by the use of hot sand or clean dry earth.

If for any reason it is not expedient to make up a skin, it may be laid flat and dried, after it is cleaned, poisoned, and turned right side out.

Such flat specimens should invariably be accompanied by the skulls, as well as by full data and measurements.

8. Cut and straighten five pieces of galvanized-iron wire,[1] one long enough to reach from tip of tail to middle of body and slender enough to fit into extreme tip of tail (file the point a little, if necessary), two long enough to reach from palm to middle of body, and two long enough to reach from back of hind foot to middle of body. The four leg wires should be just sufficiently heavy to give stiffness to the legs and protect the feet from injury when the skin is dry. The size of the wires needed can best be learned by practice, though the following notes will serve as a guide:

Mouse: legs, No. 23; tail, No. 23 or No. 20.

Rat or small squirrel: legs, No. 20 or No. 17; tail, No. 17.

Large squirrel, rabbit, woodchuck, skunk: legs, No. 17 or No. 15; tail, No. 15.

For very small mice and shrews, No. 23 wire may be used for the tail and No. 24 wire or Carlsbader insect pins No. 4 for the legs.

NO WIRES THAT WILL RUST SHOULD EVER BE USED; galvanized-iron wire is preferable to all others. Splinters of wood or bamboo are often a convenient substitute for wire.

9. Cut off the skull and remove any loose flesh, *but under ordinary conditions do not attempt to remove the eyes, tongue, large muscles, or brain of any animal smaller than a rat*, as these parts can be readily dried by artificial heat or direct sunlight. With larger specimens some of the flesh must be cut away to prevent decay.

In tropical countries or very damp climates, persons having sufficient skill to do so without danger of injuring the specimen should remove the eyes, tongue, brain, and all the large muscles, as the skulls will otherwise become very offensive. Inexperienced collectors should preserve the skulls in alcohol, formalin, or strong cane rum, taking care to label them with pencil or waterproof ink on stiff paper (not pasteboard). Now fasten the skull label securely and place the skull where it will dry *as quickly as possible.* Unless they are drying very rapidly it will be necessary to protect small skulls from flies. *Never put salt, arsenic, or alum on a skull.* The skull label may be fastened by seizing one end of its thread between the tips of a pair of fine-pointed forceps with which the thread is pushed through the flesh at the fork of the jaws and out at the mouth. Or it may be tied to a short piece of the neck left in place for the purpose. In either case the label should be tied close to the bone, leaving the least possible slack.

When many skulls are to be cared for at once they may be very conveniently treated by 'stringing' on a cord passed through the loops by which the labels are attached. The 'strings' can be hung before a fire

[1] When many skins are to be prepared it will be found a great convenience to keep on hand a supply of ready-cut wires of various lengths, which may be selected as required.

or in the sunlight—wherever the skulls will dry most rapidly and thoroughly. Care must be taken that they are not stolen by cats, rats, or dogs.

10. Tear off a piece of cotton slightly larger than the body of the animal. The exact size required can only be learned by practice. Roll it roughly into shape and grasp its whole length with the forceps. If the forceps are too short for this seize it by the end which is to go into the head. Holding the cotton body by the forceps in the right hand, slip the skin on with the left until the points of the forceps have reached the mouth. Then grasp the head with the fingers of the left hand firmly enough to hold the cotton filling in place. Remove the forceps and with the right hand work the skin back over the artificial body. This method of putting the skin onto the body obviates the risk of stretching invariably run in an attempt to push the body into a small skin. For animals larger than a squirrel, stuffing of excelsior or tow is preferable to that made of cotton, as it permits more rapid and thorough drying of the skin.

11. When the artificial body is in place the wires are to be inserted in the legs and tail. Tear off a bit of cotton large enough to fill the skin of the leg, and project well into the body cavity. Then lay a wire on it, letting one end project a short distance beyond the edge of the cotton. Now twirl the wire with the fingers of the right hand, at the same time pressing lightly with those of the left over the edge of the cotton nearest the free end of the wire. The fibers will soon become wrapped about the wire at this point so that the whole mass of cotton will revolve with the wire, though fastened to it in a narrow region only and elsewhere standing out in a light, elastic mass.

Insert the wire into the position formerly occupied by the leg bone (or alongside the bone if this has been left in) and drive the point securely into foot, *taking care not to distort heel.* If the cotton has been securely fastened, it will be carried with the wire so that it will now shape itself to the inside of the skin and fill out the leg to its original size. With animals the size of a skunk, woodchuck, or rabbit (in which the leg bone is invariably to be left in place) it will be found more convenient to insert the wire first and then wrap wire and bone together to the required size and form.

If the tail is bushy the tail wire may be inserted without wrapping; but *the wire must invariably be wrapped with cotton before insertion into closely furred or naked tails.* To wrap a tail wire requires considerable practice. The process is exactly like that of wrapping a leg wire, except that a long shred of *cotton of very good quality* must be selected, and this twisted about the wire, tightly at the end that is to go to the tip of the tail, more loosely toward the base, so as to produce a tapering form like that of the tail bone. The tail wire must project slightly beyond the cotton wrapping. Before inserting the wrapped tail wire it is well to dip it into the arsenic, first moistening it slightly. Great care is necessary in inserting a wrapped tail wire. If the wrapping is too dense and thick it may stretch or break the tail. If it is not sufficiently firm it may tear and leave the tail collapsed and unfilled at the base or near the middle.

12. Tie skin label securely to one hind leg close above the heel. Allow it enough play so that both back and front may be readily examined, but not enough to tangle with the labels of other specimens.

13. Now arrange the leg wires neatly, so that the legs will be held parallel with the body. The front feet are to be brought close to the sides of the neck, and the hind feet stretched out backward alongside the tail. Fill in with bits of cotton to shape the thighs, rump, and shoulders to their natural form. Lay the end of the tail wire along the middle of the artificial body, and over it (the skin lying on its back) place a sheet of cotton thick enough to fill out the belly without stretching it. Tuck the edges of this layer of cotton under the edges of the cut in the skin, so that all lies smooth. Arrange the cotton in the head, and staighten the skin about the eyes. Sew up the cut in the belly and take a stitch in the lips to hold the mouth shut. (This may be done before the skin is turned right side out, but it is often convenient to have the mouth open during the final shaping of the head.)

Do not force in all the stuffing that a skin will hold.

Do not leave a skin half filled and covered with wrinkles.

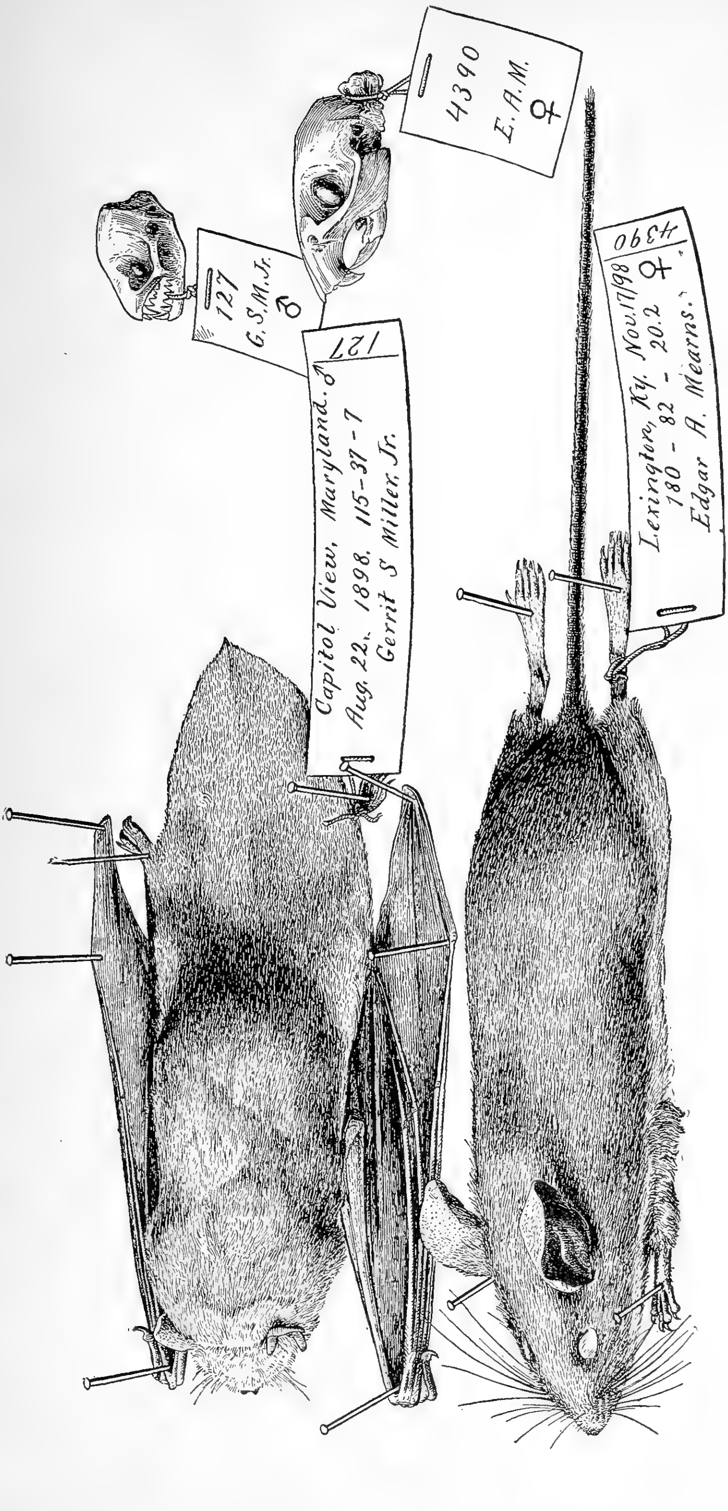
A properly made skin should give essentially the same measurements as those taken from the fresh specimen. Small skins should be filled out to the natural form of the animal, but those as large as a skunk or woodchuck should be flattened so that their greatest depth is not more than 2 inches (50 mm.). For this purpose a flat weight may be placed upon them while drying.

14. Lay the skin back upon a flat board to dry. Pin all four feet *soles down*, as shown in the illustration. If the tail does not lie in the proper position it may be held in place by pins driven into the board beside it, crossing one another just over the back of the tail. Use the smallest possible pins.

The final shaping is to be given as the skin is pinned down. See that the feet do not project at the sides beyond the line of the body. Also make the sides of the body parallel, so that the thighs are not broader than the shoulders.

15. When the skin is pinned down lay it away to dry. NEVER DRY A SKIN IN DIRECT SUNLIGHT OR BY ARTIFICIAL HEAT. An exception to this rule must be made in very damp climates. Here, however, the artificial heat employed should be as slight as possible. A swinging shelf hung near the ceiling of the room in which cooking is done will be found a convenient place for drying skins in damp, tropical countries. In hot climates skins must always be dried where there is a free circulation of air, otherwise they will probably spoil.

As soon as the skin is thoroughly dry remove it from the drying board, and the preparation of the specimen is completed. Specimens


4390
E.A.M.
♀
127
G.S.M.Jr.
♂
127
Capitol View, Maryland. ♂
Aug. 22. 1898. 115-37-7
Gerrit S Miller, Jr.
4390
Lexington, Ky. Nov. 17/98 ♀
180 - 82 - 20.2
Edgar A. Mearns.

may be shipped in any strong, light box. Wrap each one separately in a thin sheet of cotton, and pack closely and smoothly. In tropical countries, to lessen danger from attacks of insects, skins should not be boxed until ready to ship; and frequent examination for beetles and their young should be made.

Slight variations in the details of the foregoing directions will naturally suggest themselves. They need no special remark here. Some difficulty, however, may be found in preparing the skins of bats. These animals are to be skinned exactly as directed, except that the bones of the legs and wings must never be removed. Insert wires into the legs and wings. *Fold the wings of bats close to the sides of the body*, bending the wire forward at the elbow. Lay the skin in the position shown in the illustration. Bat skins from all localities are much needed. At least one-half of every series should be preserved in this way; the remainder may be kept in alcohol or formalin.

SKELETONS.

To prepare skeletons of small mammals in the field, remove the skin as already directed, but cut through the skin itself at ankles and wrists, leaving the feet attached to the legs. Then remove the viscera and larger muscle masses, but not enough to disjoint any part of the body. Make up the skin roughly and preserve it as an aid to identification. Dry the skeleton quickly and thoroughly.

SPECIMENS IN ALCOHOL OR FORMALIN.

Alcohol and formalin are not used at their full strength. Add to commercial alcohol (95 percent) one-fifth its volume of water. Add to commercial formalin[1] twenty times its volume of water. Label specimens with pencil or waterproof ink on *stiff paper* (not pasteboard). Open the abdominal cavity so that preservative fluid may penetrate freely, but do not remove any of the viscera. *Wet the fur thoroughly to base with water or alcohol before specimens are placed in formalin.* At first keep specimens covered by at least double their volume of fluid. Less is required after they are thoroughly preserved. Specimens that have been preserved for several weeks may be safely shipped in air-tight jars, tanks, or bladders, if wrapped (to prevent abrasion) in cloth, tow, or cotton batting, dampened with the preservative fluid.

In tropical countries where formalin may not be obtainable, and alcohol, if to be had at all, is very expensive, cane rum may be used as a substitute, though specimens preserved in it should be transferred to alcohol or formalin for permanent storage. Only the strongest grades of rum should be used.

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[1] This is a 40 percent (saturated) aqueous solution of formaldehyde gas. It is sometimes sold under the name formaldehyde.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR COLLECTING AND REARING DRAGON FLIES, STONE FLIES, AND MAY FLIES.

BY

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Lake Forest College, Lake Forest, Illinois.

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1899.

DIRECTIONS FOR COLLECTING AND REARING DRAGON FLIES, STONE FLIES, AND MAY FLIES.

By James G. Needham, Ph. D.,
Lake Forest College, Lake Forest, Illinois.

It is the purpose of this paper to outline briefly some simple and reliable methods of obtaining material illustrating the life histories of some of the commoner aquatic insects. Some knowledge of insects in general and of the apparatus universally employed by entomologists—nets, cyanide bottles, pins, papers, etc.—is assumed. It is proposed merely to supplement the accounts given in the general text-books and in Dr. Riley's excellent paper, Directions for Collecting and Preserving Insects,[1] with some new and more detailed methods of dealing with aquatic insects. While the simple apparatus here described has been devised or adapted for the purpose of studying insects of the orders named in the title, it will be found to work well for aquatic insects in general.

COLLECTING AQUATIC NYMPHS.

For collecting purposes the insect life of the water may be divided according to habitat into three groups, each requiring methods adapted to its situation.

1. *Forms living on the bottom.*—Here belong representatives of every order having aquatic species. The organic material which is continually falling upon the bottom of ponds and streams supports a teeming population and forms a stratum of great biologic richness. Few stone flies are found on the bottom in still water, but dragon flies and may flies are there abundant.

Where there is much loose material on the bottom, there is no better collecting instrument than a common garden rake. With it the débris may be drawn ashore and the insects picked by hand. Withdrawn from the water, they generally make themselves evident by their active efforts to get back. The rake is especially useful in the spring, while there is as yet no new growth of well-rooted waterweeds to interfere with hauling it. Its use is to be commended, because the places best adapted to it, such as small bays in the edges of ponds where aquatics grow abundantly, and eddies in streams, harbor also an abundant insect fauna.

[1] Bulletin No. 39, U. S. National Museum, Part F, 1892.

Even where the bottom of the pond seems bare, the rake will bring ashore much loose mud and silted material, containing the burrowing nymphs of dragon flies and may flies (*Gomphus*, *Hexagenia*, etc.); but, for collecting in such places, the sieve net shown in fig. 1 is much better. This is a net and a sieve combined. It has a long handle, and is so shaped that it can be easily used from the bank. The frame is of light

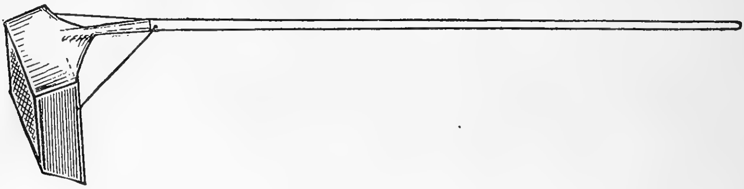

FIG. 1.—Sieve net for collecting nymphs from sand and mud.

steel rods; the sides are of galvanized iron; the bottom is of galvanized wire screen. It is especially adapted for scraping up from the bottom mud, fine silt, and sand, and for sifting out at the surface the nymphs therein contained. It may be used away from shore where a rake is almost useless, and it is much better than a rake for collecting burrowing nymphs (for which it was devised), but it is not so good as a rake where there is much material.

2. *Forms living above the bottom in still or slowly flowing water.*—The more agile nymphs of dragon flies and may flies are exceedingly abundant, clambering among the submerged branches of erect aquatic plants. All but a few of the smallest species are easily taken by "sweeping" the plants with any of the well-known forms of water net. There are, however, a few little nymphs of may flies that can hardly be dislodged with the net, and that are hardly discoverable on plants withdrawn from the water. These may be found by examining the plant stems, a small bunch at a time, in a white dish of clean water.

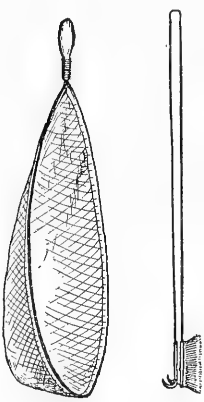

FIG. 2.—Sag net, hook, and brush for collecting in rapids.

3. *Forms living in the rapids of streams.*—Many of these may be obtained by simply picking them by hand from stones lifted out of the stream, but not all. Those which cling to swaying sedge and willow stems may be "swept" with a water net; but a net better adapted for collecting in rapids is shown in fig. 2. It consists of a ring of stout spring wire 3 to 4 feet in diameter, to which is attached a very shallow bag of coarse bobinet, and at one side is a handle only long enough to be held readily. It is intended to catch insects adrift in the stream, and is accompanied by an instrument for dislodging them. Such an instrument is figured at the right of the net. It consists of a handle

3 to 4 feet long, with a double hook at one side and a brush at the other side at its distal end. To illustrate the use of this apparatus, suppose we wish to collect the insects from the stones obstructing a brook. We place the net directly below the obstruction and in the current, and adjust it to the bottom by downward pressure on the handle with one hand, while with the other we rapidly overturn the stones and with the brush sweep free the clinging insects. These are driven by the current into the net, which is then lifted and emptied.

Most stone flies and many may flies and at least one dragon fly (*Argia putrida*) are found in such situations.

4. *Transporting live nymphs.*—In order to carry home a day's catch alive, a large quantity of water is not necessary. It is well to have a pail and to place within it a few smaller receptacles containing a little water and to pack wet waterweed between these. Then the smaller nymphs taken may be distributed among the receptacles so as to diminish the chances of their eating one another, and all the larger and stouter nymphs may be stowed away in the waterweed, which does not need to be submerged unless left long uncovered in the sun. Well-grown nymphs can breathe air directly, and entangled among the stems will be kept out of mischief. The canibalistic habits of certain species of the larger dragon flies (*Anax*, etc.), and the predatory habits of all of them need to be borne in mind while arranging receptacles for them, and specimens differing greatly in size should not be put together.

Great care is necessary, however, with some species, especially species of stone flies, which live in rapids where the water is well aerated. If these are to be transported, they must be kept in clean water and hurried home and into suitable permanent quarters.

COLLECTING AT TRANSFORMATION.

The easiest method of collecting life-history material is, doubtless, to pick specimens up when transforming. To be sure, this does not give the complete life history; but, since the cast skin preserves the form of the nymph, and the several nymphal stages are much alike except in size and length of wing cases, it gives the better part. To the general collector with but little time to give to these "unimportant" groups this method should appeal strongly, for by it he may, without apparatus, and with a minimum of time and trouble, obtain most valuable material. One may often find nymphs crawling from the water, imagoes emerging from their old nymph skins, others drying their wings, and others ready to fly, and all in large numbers, needing only to be picked up.

The value of this material may be wholly lost, however, unless attention be given to three points:

1. The maturing of the imagoes.
2. The preservation of the often delicate exuviæ.
3. The keeping of the imago and its skin together.

The following adequate and very simple method is commended: Take afield a pocket full of small paper bags, of the coarsest sort used by grocers, and finding imagoes emerging, slip them singly into the bags, each with its own cast skin, writing desired data on the outside of the bag. Before the skin is lifted from its support the claws should be loosened carefully with forceps, else legs will be broken off. Very delicate and easily broken skins may be slipped into envelopes of tissue paper before they are dropped into the bag; this will diminish the danger of breaking from being tumbled about; or, they may at once be put into vials of alcohol and numbered to correspond with their imagoes. The bags are closed by twisting the top. To the rough interior the imago clings easily, with plenty of room for expanding and drying its wings. Bags thus filled may be carried home loosely piled into a large basket or in a large sack. They should be left unopened for a day or two, until the mature coloration of the imagoes has appeared, and the form of all parts is well fixed by chitinization. With may flies, specimens of the subimago should of course be preserved on the approach of the time for the final molting.

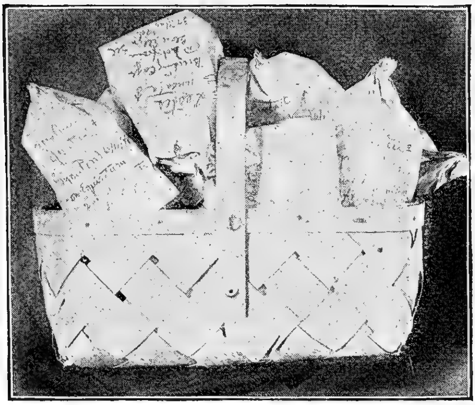

FIG. 3.—A morning's catch of dragon flies taken in transformation and properly fixed for maturing their colors.

While gathering such material one should endeavor to get besides males and females with their skins (only a few of which for each species need be kept separately for positive determination) also nymphs leaving or ready to leave the water and others transforming; and, as in other collecting, good series are very desirable.

As to the time and place for such collecting little need be said, since members of these three orders are transforming throughout the open season and live in all sorts of fresh water. Certain stone flies may, indeed, be found transforming abundantly in midwinter. In general, it may be stated that the nymphs all transform at the edge of the water. A few, like *Gomphus villosipes*, may clamber only far enough upon sloping banks to expose their backs, while others, like some of the larger *Libellulidæ*, may crawl several rods from the water, when this is necessary, to find suitable place to transform. The majority transform within a few inches of the water's edge. Some specie of these three orders transform habitually at night, many throughout the day, but a majority of the dragon flies, at least, transform early in the morning.

The resident collector who knows the season of flight for any common species may get nymphs of that species by going out at the beginning of its season and picking them up as they crawl from the water. If on going out the first time he finds the most recently emerged imagoes are ready to fly, he must go again at an earlier hour.

The invitation to collect by this method comes oftenest from the fluttering of a limp and half-colored imago before one's feet. Near to the place whence this one was flushed and in similar places one may look with some confidence for others still in process of transformation. This method alone will not satisfy the thoroughgoing collector, but, because he may sometimes accumulate a large amount of valuable material in a few minutes and with no more apparatus than may be carried in a single pocket, it deserves to be better known.

REARING NYMPHS.

The best way to rear nymphs is to let them rear themselves. Locate them, collect a few from time to time to watch their growth, preserve the young ones for specimens, and do not take any for rearing until about grown. Their development can be gauged by the length of the wing cases. For species that seem common, and that live in accessible places, there is no advantage in early collecting; they will seem to become more common as the season of their transformation approaches, because, first, they get larger and are more readily seen; and, secondly, they approach the margin of the water and are more easily taken.

The best rearing device is the one that keeps its inmates under conditions most nearly natural. A cage for aquatic insects that hardly disturbs such conditions at all consists of a cylinder of galvanized wire screen, open at both ends, having a loose screen cover with a rim of heavy wire. One end of the cylinder is pushed down into the mud of the bottom in shallow water, the cover is laid on and all is ready. Such a cage merely incloses a small water area with its natural vegetation, and nymphs placed inside live their natural lives and obtain for themselves their accustomed food. Of course the size of the mesh must be adapted to that of the insects to be reared—small enough to confine them and large enough to admit their prey. Fifteen inches is a convenient height.

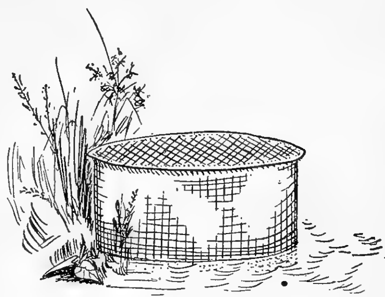

Fig. 4.—Cage for rearing nymphs under natural conditions.

For burrowing nymphs it will be necessary to set the lower edge of the cage down into the mud of the bottom 2 or 3 inches; this is easily done with a garden trowel.

It is better, owing to danger from freshets, not to plant such a cage in the rapids in the direct course of a stream, but to divert a small arm of the stream behind some sheltering rock or log, place the cage there and build miniature rocky rapids inside it. In quiet waters no such precautions are necessary, but where the rise and fall of the water level is great it may be necessary to move cages sometimes. In general, it is better to hide the cages among vegetation, away from the eyes of the untutored and irreverent. For aquatic insects which pupate on land a cage is easily planted half in the water and half out.

Nymphs placed inside will readily crawl up the sides to transform. Young imagoes should be taken out as soon as convenient after transformation is completed (otherwise some will fall into the water and die before they are mature) and placed in paper bags with their exuviæ until dry and well colored.

Collectors will find it convenient to have cages of this sort made up in "nests" to fit one inside the other, the size of the mesh decreasing with the size of the cage. A nest of a dozen such cages and covers will be found a slight transportation incumbrance.

One may wish to take nymphs far from their natural habitat and to rear them at home with no streams or ponds near. A simple breeding cage that may be used successfully under such conditions consists of a rough wooden kit, or pail, or tub, or half barrel, with a loose screen cover. It must be rough inside, so that the nymphs can crawl up its sides. It should be half filled with water, the nymphs put in, and some trash with them for them to cling to, the cover added, and the whole set in a place where it will not get overheated and yet will receive the direct rays of the morning sun. Conditions will be less natural in such a cage as this, but if only nymphs which are well grown and require little or no food are put into it, it will be found entirely satisfactory.

A very satisfactory way to rear some of the smallest and most delicate species of dragon flies and may flies, species requiring well aerated water, is to place the nymphs in shallow, flaring dishes of unglazed pottery before an open screened window in one's room. The water will need to be renewed daily or oftener, because of the rapid evaporation, but it will keep very sweet; and the imagoes emerging will go at once to the screen and stay there, and the danger of their falling into the water before maturing and dying is obviated.

COLLECTING IMAGOES.

The easiest way to get good specimens of the largest dragon flies is to rear them. It is idle to run after them with a net; but one may observe sometimes that they are flying upon a regular "beat" and may so station himself that they will once in a while come within reach. When a favorite resting place is discovered, one may wait beside it sometimes to good purpose. After a noonday shower specimens are frequently to be picked by hand from low bushes near the water, and at dusk, also, some of the large species may be found settled for the night in such places, though most of them settle so high as to be out of reach.

While all but the largest species are easily taken with a net, one may greatly economize time in gathering duplicates by "sweeping" the vegetation of the shores at sundown. Most desirable stone flies may be swept from the grasses and sedges overhanging small and rapid streams. One should, of course, take advantage of the "swarming" of may flies. The smallest of the stone flies are best picked up with a brush wet with alcohol and put directly into vials of the same preservative.

It may be worth while to suggest that subimagoes as well as imagoes of may flies should be collected, and that one should try to get both young and old imagoes of dragon flies of the family *Agrionidæ*, of these latter many species have been described as dimorphic, so striking are the differences of appearance at different ages. Males and females taken in pairs should be kept together for the certain identification of the females—often a difficult matter, otherwise.

Lepidoptera should be rigidly excluded from the cyanide bottles used for killing these insects, for the shed scales are an intolerable and altogether unnecessary nuisance.

PRESERVATION OF SPECIMENS.

Nymphs are best preserved in alcohol (about 80 per cent). The more strongly chitinized and impervious ones should be dropped first for a few minutes into water almost boiling; the thin-skinned nymphs of most stone flies and of may flies should be put directly into the alcohol. Imagoes also may be preserved in alcohol, and better, so far as preservation is concerned, than by any other method. If kept in the dark the colors will be well retained. Even if one be pinning specimens it is well to have a "stock bottle" of alcohol at hand to catch the large series of duplicates which would never be pinned; for the collector well knows that pinning is a time-consuming process.

Pinned specimens of dragon flies, at least, should have the body "wired," otherwise heads and tails are certain to fall off and be broken or lost. For this purpose it is well to use beheaded, japanned pins, cut to the proper length; one is inserted through the front of the head, pushed through the body lengthwise but not protruding; the body dries fast to it and is then not easily broken. If one be not long enough two may be used, one inserted from each end. Formerly a wire or bristle was used, but the pins being well pointed enter easily and effect a great saving of time and temper. Even if specimens are to be put away in envelopes it is better that they should be wired and pinned first, because specimens once dried do not thereafter stick well to the pins.

The foregoing simple methods and appliances have been abundantly tested in practical work. It is believed they will be found more effective and practical than others generally recommended hitherto. They are offered in the hope that these interesting orders of so much scientific importance may receive a little more attention at the hands of general collectors, and that materials needed for their study may be more rapidly brought together.

SMITHSONIAN INSTITUTION.
UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR COLLECTORS OF AMERICAN BASKETRY.

BY

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Curator, Division of Ethnology.

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The sallow knows the basket maker's thumb.—*Emerson.*

INTRODUCTION.

The following instructions are published for the great number of persons who are interested in the collection and preservation of American basketry. Besides the æsthetic elements involved and the pride of saving the best examples of a rapidly vanishing industry, there is a vast deal of culture study which ought not to be neglected.

In every collection, public or private, there are opportunities for special investigation that should not be in the possession of only a single individual. If all who are gathering baskets would preserve such information as they are able to obtain, the bringing together of the results of all this study would be a monument to our American aborigines. The perfect understanding of a basket involves a knowledge of the following subjects:

I. Materials.—Natural and prepared.

1. List of plants, animals, minerals, etc.
2. Indian name, giving the tribe.
3. Common name.
4. Scientific name.

The following label of a specimen in the Hudson basketry collection will serve as a model to guide the collector in saving information about his specimens.

BASKET JAR of the Čěčko Indians (Kulanapan stock). Made from the prepared root of Kahum, or California sedge (*Carex mendocinensis*), throat and scalp feathers of Katátch, or woodpecker (*Melanerpes formicivorus*), breast feathers of Jucil, or meadow lark (*Sturnella neglecta*), scalp feathers of Kayán, or mallard (*Anas borchas*), plumes of Tchikáka, or crested quail (*Lophortyx californicus*), neck feathers of Tsawálu, or jay (*Cyanura stelleri*), and Káya, or prepared clam shell (*Saxidomus gracilis*), in a style of coiled sewing called Tsai, in which a single rod constitutes the warp. The sewing passes over this rod, under the preceding one, and locks in the stitch immediately underneath. Ornamentation, a row of shell disks around the margin and another row serving as a handle.

Diameter, 5 inches.

RUSSIAN RIVER, CALIFORNIA, 1896. 203,415.

FROM THE BUREAU OF AMERICAN ETHNOLOGY, COLLECTED BY DR. J. W. HUDSON.

II. Basket making.—Under this head are included all the activities involved in construction, namely:

1. *Harvesting the materials.*—This embraces descriptions of places, the times and methods involved, as well as the tools and apparatus used in gathering.

2. *Preparing materials.*—Frequently the raw materials are stored away until required. When the time comes for their use special manipulations are necessary, such as peeling, splitting, making splints, yarning or twisting, twining, braiding, soaking, gauging, coloring. These should be noted carefully and described.

3. *Processes of manufacture.*—The materials being ready, the maker seats herself in the midst and begins the technic operations that should be minutely watched, and photographed, if possible. Collections should be made also of tools, apparatus, and patterns. The processes of basket weaving are making braid, checker, wicker, twilled, wrapped, twined, and coiled work, in checks, decussations, meshes, stitches, overlaying, etc.

III. Ornamentation.—This may be either in material, processes of making, or in added substances.

1. *Form.*—Especial attention should be paid to the aboriginal shapes, since they express the Indian mind, and everything possible should be done to discourage modern innovations.

2. *Color.*—This may be either natural or artificial. Since the introduction of modern dyes, the old methods of coloring are being abandoned. The raw material of basketry and the processes of adding color both demand attention.

3. *Designs.*—This refers to all figures on the surface, whether in color, in technic, or however produced. In fact, basketry is mosaic; the elements are always geometric figures, those of the coiled type are vertical, while those of other types are horizontal.

IV. Symbolism and patterns.—Students of basketry have shown that almost every design serves as a key to Indian lore. The story, if such exist, can not be made up from the elements as in hieroglyphics, but must be taken down from the lips of the basket maker. How important it is, therefore, that those collectors who are in touch with basket makers should secure from them the precious information.

V. Uses.—Baskets are used in food, dress, house, furniture, arts, and industries, as expressions of æsthetic culture, in social customs, and religion. From the cradle to the grave they are present. Only the observer on the spot can be trusted to gather such information fully.

VI. Ethnic varieties and culture provinces, ancient and modern.—It will be of great value to the student of technology to give the names of the tribes making basketry and to associate with each example the name and locality of its maker's tribe. Also a list of the varieties of basketry made by any tribe is of the utmost importance in arriving at a correct opinion concerning the simple or composite character of that tribe. The Pomo, the Twana, and the Hopi, make each half a dozen styles of baskets.

VII. COLLECTIONS.—Those collections that have been made with a view to permanence should be kept so that they will suffer least from damage. The dust may be blown from the specimens with bellows. Those containing remnants of vegetable matter, berries, food, and so forth, should be carefully scrubbed with soap and water, and rubbed down with a very small portion of oil and dryer. Above all they should be poisoned with a weak solution of corrosive sublimate or arsenic dissolved in alcohol. A card catalogue giving the legend and history of each piece would add much to the value of the collection.

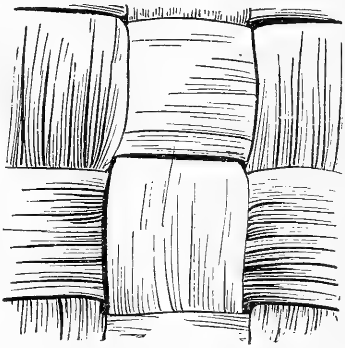

FIG. 1.
COARSE CHECKERWORK.
Report U.S.N.M., 1884, pl. 57, fig. 95.

VIII. BIBLIOGRAPHY.—Every contribution to the literature of the subject should be sent to the Division of Ethnology in the United States National Museum for safe-keeping and ready reference.

PROCESSES OF MANUFACTURE.

The various processes of manufacture will now be explained more definitely, and also illustrated.

A. *Checkerwork.*—This occurs especially in the bottoms of many North Pacific coast examples, and also in the work of eastern Canadian tribes (fig. 1); in matting its use is well-nigh universal.

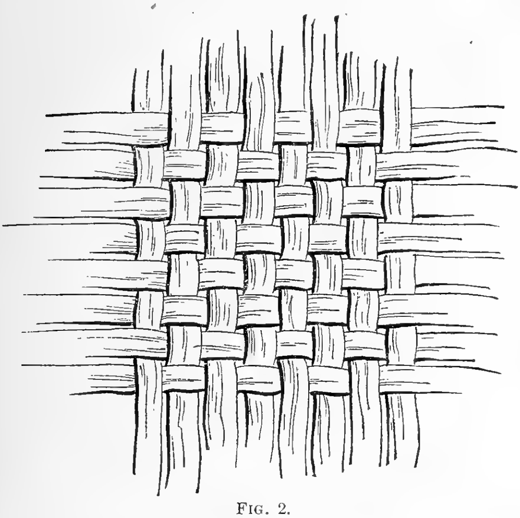

FIG. 2.
FINE CHECKERWORK.
Report U.S.N.M., 1884, pl. 57, fig. 95.

In this ware the warp and the weft have the same thickness and pliability. It is impossible, therefore, in looking at the bottoms of the cedar-bark baskets and the matting of British Columbia (fig. 2), or Eastern Canada, to tell which is warp and which is weft. In very many examples the warp and weft of a checker bottom are turned up at right angles to form the warp of the sides, which may be wicker or twined work. A great deal of bark matting is made in this same checkerwork, but the patterns run obliquely to the axis of the fabric, giving the appearance of diagonal weaving. When warp and weft are fine yarn or threads, the result is the simplest form of cloth in cotton, linen, piña fiber, or wool. The cheap fabrics of commerce are of this species of weaving. In art, latticework frequently shows the bars intertwined as in checker basketry (fig. 3).

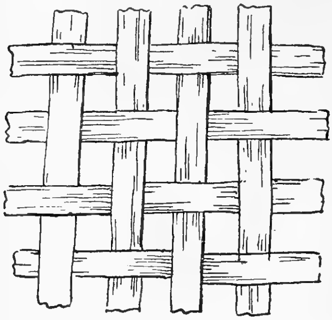

FIG. 3.

OPEN CHECKERWORK.

6th An. Rept. Bur. of Ethnol., fig. 291, after W. H. Holmes.

B. *Diagonal or twilled basketry.*—This is seen in those parts of the world where cane abounds. In America it is common in British Columbia, Washington, Southern United States, Mexico, and Central America, and of excellent workmanship in Peru, Guiana, and Ecuador. The fundamental technic of diagonal basketry is in passing each element of the weft over two or more warp elements, thus producing either diagonal or twilled, or, in the best samples, an endless variety of diaper patterns (figs. 4 and 5). See Sixth Annual Report of the Bureau of Ethnology, p. 216, figs. 316–318, for excellent examples of this.

The North Americans of antiquity were very skillful in administering the twilled technic. From examples reproduced by W. H. Holmes it will be seen that in the ancient

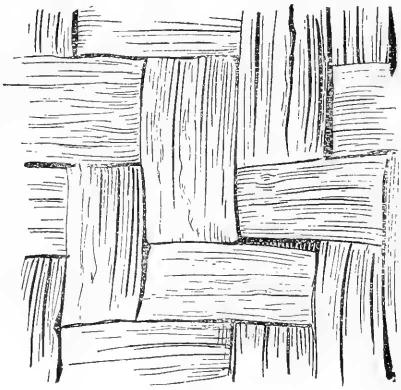

FIG. 4.

DIAGONAL OR TWILLED WORK.

Report U.S.N.M., 1884, pl. 15, fig. 28.

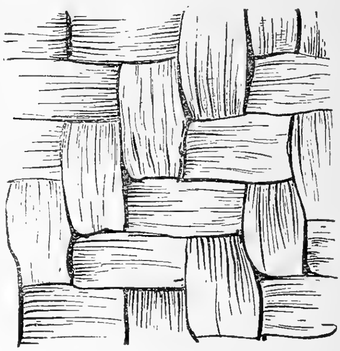

FIG. 5.

DIAGONAL OR TWILLED WORK.

Report U.S.N.M., 1884, pl. 57, fig. 93.

weaving of the Mississippi Valley, in its southern portions, the weft would not pass over the same number of warp elements that it passed under. On the specimens shown the weft goes over one and under three, or the opposite, each time and each way (figs. 6 and 7). Wonderful effects in this variation of the numbers of elements included are to be seen on Fijian basketry (fig. 8).

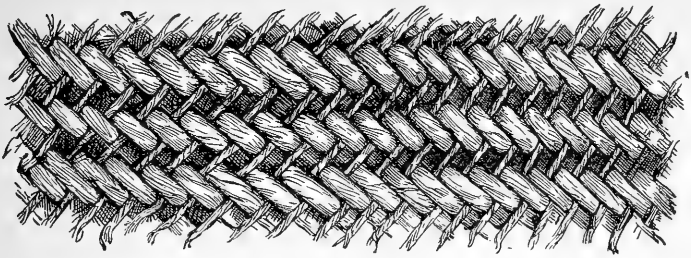

FIG. 6.

DIAGONAL OR TWILLED WORK.

Pressed on ancient pottery of Tennessee. 3d An. Rept. Bur. of Ethnol., fig. 98. After W. H. Holmes.

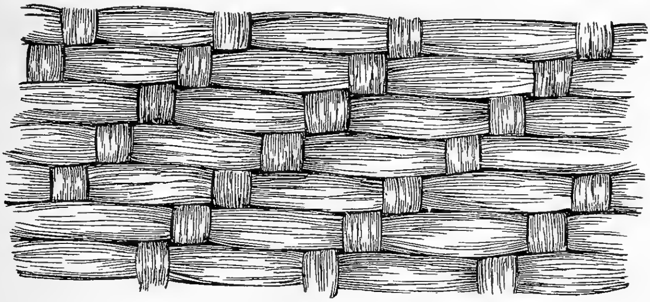

FIG. 7.

DIAGONAL OR TWILLED WORK.

Pressed on ancient pottery of Alabama 3d An. Rept. Bur. of Ethnol., fig. 99. After W. H. Holmes.

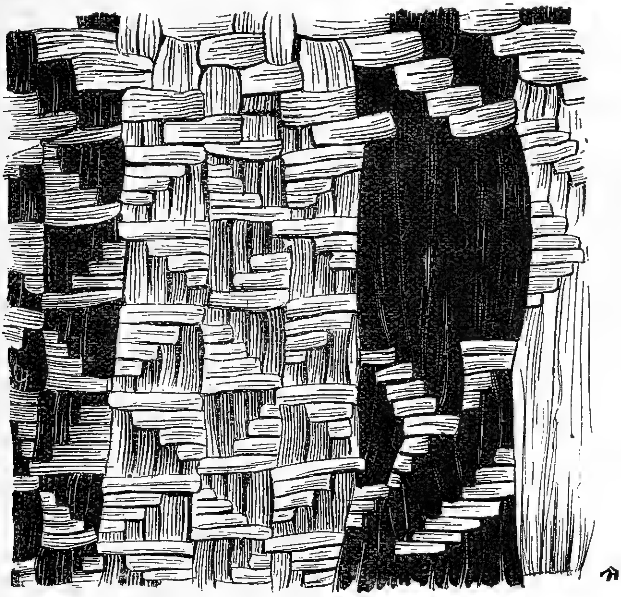

FIG. 8.

DIAGONAL WORK OF FIJI.

Report U.S.N.M., 1884, plate 55, fig. 91.

Excellent variety is produced in this kind of weaving by means of color. Almost any textile plant, when split, has two colors, that of the outer or bark surface and that of the interior woody surface or pith. Also the different plants used in diagonal basketry have great variety of color. By the skillful manipulation of the two sides of a splint, by using plants of different species, or with dyed elements, geometric patterns, frets, labyrinths, and other designs in straight line are possible (fig. 9). Examples from the saltpeter caves and modern pieces from the Cherokee, both in matting and basketry, are

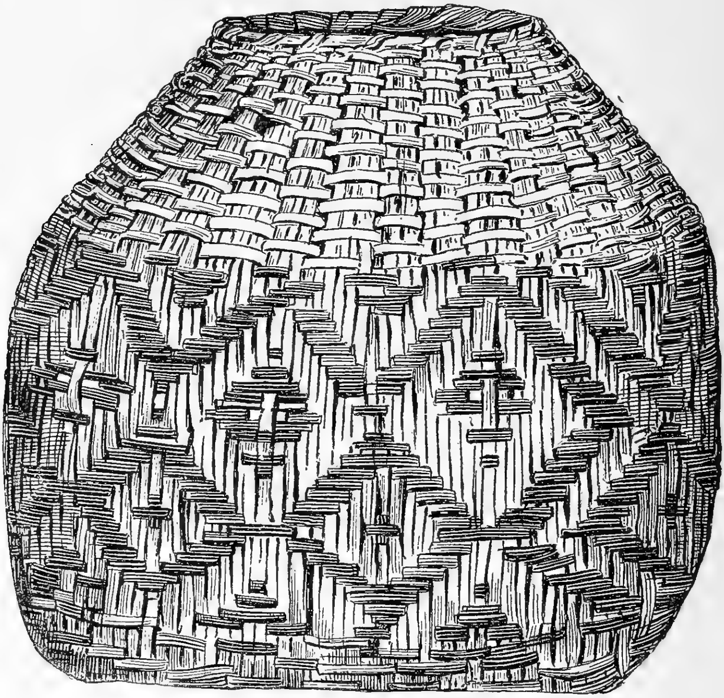

FIG. 9.
DIAGONAL WEAVING OF THE CHEROKEE.
Rept. U.S.N.M., 1884, pl. 53, fig. 89.

double. By this means both the inside and the outside of the texture expose the glossy siliceous surface of the cane.

C. *Wickerwork.*—Common in eastern Canada, it is little known on the Pacific coast and in the Interior Basin, excepting in one or two pueblos, but is seen abundantly in southern Mexico and Central America. It consists of a wide or a thick and inflexible warp, and a slender flexible weft (fig. 10).

The weaving is plain and differs from checkerwork only in the fact that one of the elements is rigid. The effect on the surface is a series of ridges. It is possible also to produce diagonal effects in this type of weaving.

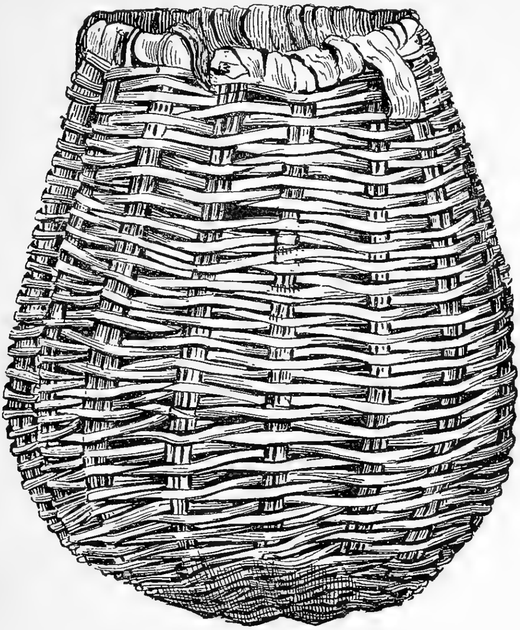

FIG. 10.

WICKER BASKET OF THE ZUÑI.

Rept. U.S.N.M., 1884, pl. 48, fig. 80.

Wickerwork must have been a very early and primitive form of textile. Weirs for stopping fish are made of brush, and wattled fences for game drives are set up in the same manner. A great deal of the coarse basketry in use for packing and transporting is made in this fashion. The Zuñi Indians make gathering baskets of little twigs after the same technic, the inflexible warp being made up of a small bundle of twigs of the same plant. The transition from checker to wicker in some examples is easy. The moment one element, either warp or weft, is a little more rigid than the other, the intersections would naturally assume a wicker form.

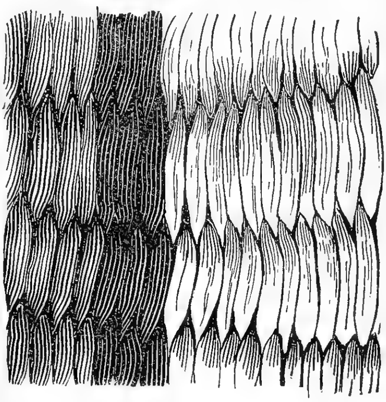

FIG. 11.

CLOSE WICKER WORK OF THE HOPI.

Rept. U.S.N.M., 1884, pl. 42, fig. 74.

The finest specimens in America are the very pretty Hopi plaques made of *Bigelovia graveolens*. Short stems are dyed in various colors, worked into the warp, and driven tightly home so as to hide the ends and also the manner of weaving (fig. 11).

Various patterns are effected on the surface—clouds, mythical birds, and symbols connected with worship. Wickerwork has pleasing effects combined with diagonal and other work (fig. 12). It has passed into modern industry through the cultivation of osiers, rattan, and such plants, for market baskets, covers for glass bottles, and in ribbed cloth, wherein a flexible weft is worked on a rigid warp. Also, good examples are now produced by the Algonkin tribes of New England and eastern Canada.

For commercial purposes, wicker baskets precisely like those of the Abenaki Indians are thus made.

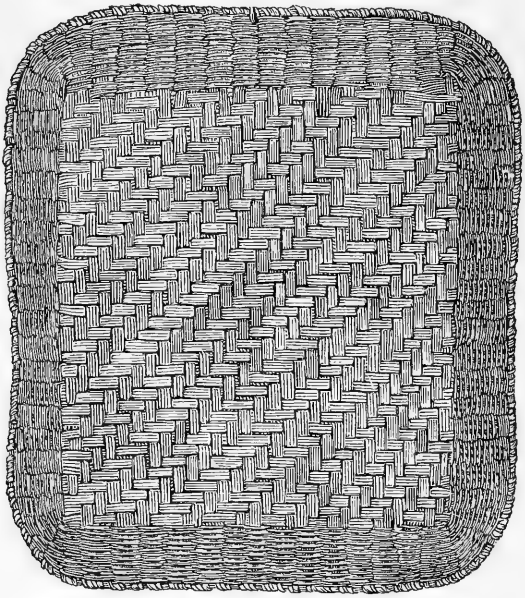

FIG. 12.
MAT OF THE HOPI IN DIAGONAL AND WICKER.
6th An. Rept. Bur. of Ethnol., fig. 286, after W. H. Holmes.

The white-oak timber is brought to the yard in sticks running from 6 to 40 inches in diameter, and from 4 to 18 feet long. It is first sawed into convenient lengths, then split with a maul and wedges into fourths or sixteenths. The bark is then stripped off with a drawing knife.

The next process is cutting it into bolts at what is called the splitting horse. These are taken to the so-called shaving horse, to be shaved down with a drawing knife into perfectly smooth, even bolts, of the width and length desired. These are then placed in the steam box and steamed for a half hour or so, which makes the splints more pliable; they are taken thence to the splint knife, which is arranged so that one person, by changing the position of the knife, can make splints of any desired thickness from that of paper to that of a three-fourth inch hoop.

The oyster baskets and most small baskets have the bottom splints laid one over another, and are plainly woven.

But the round-bottomed baskets, used for grain and truck, are made by taking from 10 to 18 ribs and laying them across each other at the middle in radiating form, and weaving around with a narrow thin splint, until the desired size for the bottom is reached, when the splints are turned up and set in other baskets, about a dozen in a series, for twenty-four hours.

They are then woven around with a fine splint and placed on a revolving drum or form and filled up the required height and set in the sun to dry for six hours. They are then shaken hard by striking the bottom on the floor, which causes the splints to settle tight together, and prepared for the rim. They next proceed to fasten the handles to the sides and put the rims or hoops on by fitting them into the notches made in the handles and binding them tightly with fine splints. The different styles are made by using different shaped drums and variously colored splints, the latter being done by dipping the splints, before weaving, into dyes.

The more curiously made baskets are those for the charcoal and eelpots.

The charcoal baskets are shaped like a tray and are carried on the head by the coal carriers.

The eelpots are used as traps for catching eels. The wood is prepared for them in the same manner, and they are made on a form about 40 inches long and in the shape of a bottle minus the bottom, and have a funnel arrangement at either end which is detachable.

D. *Wrapped weft.*—Wrapped basketry consists of warp and weft. Examples of this technic are to be seen in America at the present time among the Indians of southern Arizona, the Mohaves, for their carrying frames (fig. 13). The warp extends from the rigid hoop, which forms the top, to the bottom where the elements are made fast. The weft, usually of twine, is attached to one of the corner or frame pieces at the bottom and is wrapped once around each warp element. This process continues in a coil until the top of the basket is reached. In some of its features this method resembles coil work, but as a regular warp is employed and no needle is used in the coiling, it belongs more to the woven series. This method of weaving was employed by the mound builders of the Mississippi Valley.

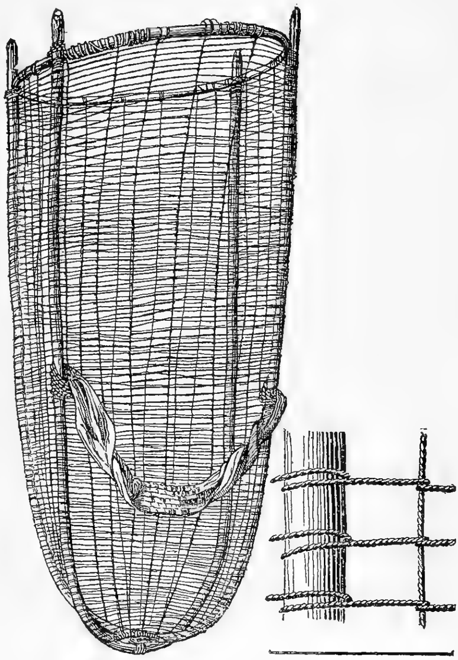

FIG. 13.

CARRYING-BASKET, WRAPPED WEAVING, USED BY THE MOHAVE INDIANS OF ARIZONA.

Cat. No. 24145, U.S.N.M. Collected by Edward Palmer.

Markings of wrapped weaving on pottery are to be seen in the Third Report of the Bureau of Ethnology (fig. 14). This style of weaving had not a wide distribution in America, and is used at the present day only in a restricted region. When the warp and the weft are of the same twine or material and the decussations are drawn tight the joint resembles the first half of a square knot. The Mincopies of the Andaman Islands construct a carrying basket in the same technic.

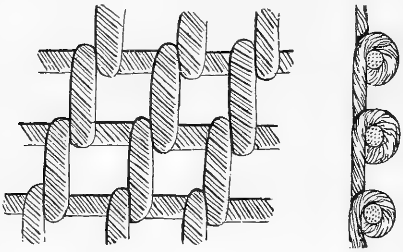

FIG. 14.

WRAPPED WEAVING.

Pressed on ancient pottery, from a mound in Ohio. 3d An. Rept. Bur. of Ethnol., fig. 70. After W. H. Holmes.

E. *Twined or wattled basketry.*—This is found in ancient mounds of Mississippi Valley, in bagging of the Rocky Mountains, down the Pacific coast from the island of Attu, the most westerly of the Aleutian chain, to the borders of Chile, and here and there in the Atlantic slope of South America. It is the most elegant and intricate of all in the woven or plicated species. Twined work has a set of warp rods or rigid elements, as in wickerwork; but the weft elements are commonly administered in pairs, though in three-ply twining and in braid twining three weft elements are employed. In passing from warp to warp these elements are twisted in half-turns on each other so as to form a two-ply or three-ply twine or braid. According to the relation of these weft elements to one another and to the warp, different structures result as follows:

1. *Plain twined weaving, over single warps.*
2. *Diagonal twined weaving or twill, over two or more warps.*
3. *Wrapped twined weaving, or bird-cage twine, in which one weft element remains rigid and the other is wrapped about the crossings.*
4. *Latticed twined weaving, tee or Hudson stitch, twined work around vertical warps crossed by horizontal weft element.*
5. *Three-ply twined weaving and braiding in several styles.*

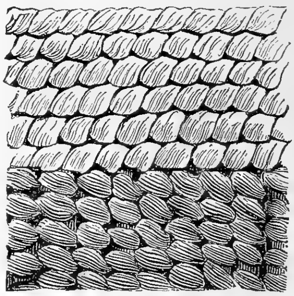

FIG. 15.

TWINED WEAVING IN TWO COLORS.

Rept. U. S. N. M., 1884, pl. 20, fig. 39.

1. *Plain twined weaving.*—Plain twined weaving is a refined sort of wattling or crating. The ancient engineers, who built obstructions in streams to aid in catching or impounding fish, drove a row of sticks into the bottom of the stream, a few inches apart. Vines and brush were woven upon these upright sticks which served for a warp. In passing each stake the two vines or pieces of brush made a half-turn

on each other. This is a very primitive mode of weaving. Plain twined basketry is made on exactly the same plan; there is a set of warp elements which may be reeds, or splints, or string, arranged radially on the bottom and parallel on the body. The weft consists of two strips of root or other flexible material, and these are twisted as in forming a two-ply string passing over a warp stem at each half turn (fig. 15). Pleasing varieties of this plain twined weaving will be found in the Aleutian Islands. The Aleuts frequently use, for their warp, stems of wild rye or other grasses, in which the straws are split and the two halves pass upward in zigzag form; each half of a warp is caught alternately with the other half of the same straw and with a half of the adjoining straw, making a series of triangular instead of rectangular spaces (fig. 16). A still further variation is given to plain twined ware by crossing the warps.

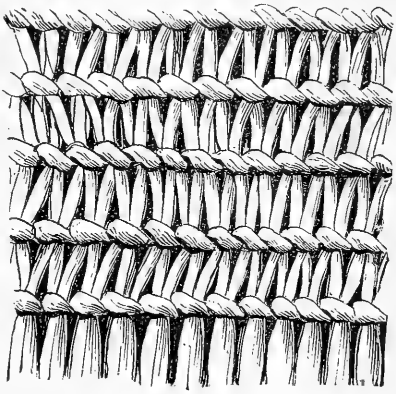

FIG. 16.

TWINED OPENWORK OF THE ALEUTS.

Rept. U.S.N.M., 1884, pl. 1. fig. 2.

In bamboo basketry of eastern Asia these crossed warps are also interlaced or held together by a horizontal strip of bamboo passing in and out as in ordinary weaving. In such examples the interstices are triangular, but in the twined example here described (fig. 17) the weaving passes across between the points where the warps intersect each other, leaving hexagonal interstices. This peculiar combination of plain twined weft and crossed warp has not a wide distribution in America, but examples are to be seen in southeastern Alaska and among relics found in Peruvian graves.

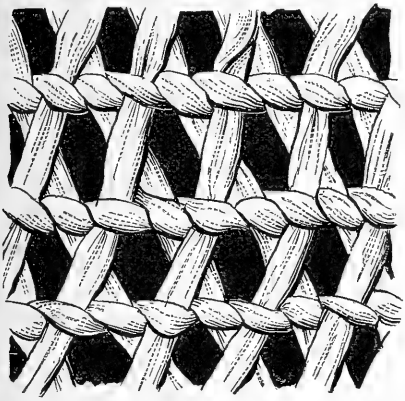

FIG. 17.

CROSSED WARP TWINED WEAVING OF THE MAKAH INDIANS, WASHINGTON STATE.

Rept. U.S.N.M., 1884, pl. 16, fig. 31.

2. *Diagonal twined weaving.*—In diagonal twined weaving the twisting of the weft filaments is precisely the same as in plain twined weaving. The difference of the texture on the outside is caused by the manner in which the wefts cross the warps. This style abounds among the Ute Indians and the Apache, who dip the bottles made in this fashion into pitch and thus make a

water-tight vessel, the open meshes receiving the pitch more freely. The technic of the diagonal twined weaving consists in passing over two or more warp elements at each half turn; there must be an odd number of warps, for in the next round the same pairs of warps are not included in the half turns. The ridges on the outside, therefore, are not vertical as in plain-twined weaving, but pass diagonally over the surface, hence the name (fig. 18).

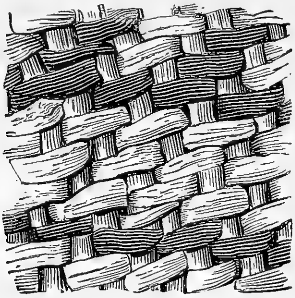

FIG. 18.
DIAGONAL TWINED WEAVING OF THE UTE INDIANS, UTAH.
Rept. U.S.N.M., 1884, pl. 21, fig. 41.

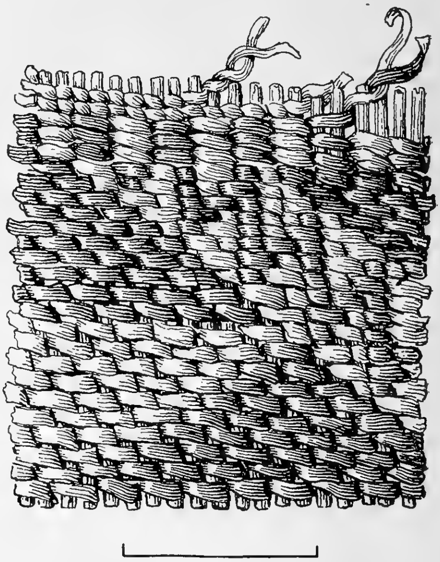

FIG. 19.
VARIETY OF TWINED WORK, OUTSIDE.
Am. Anthropologist, new. ser. 3, 1901, fig. 18.

This method of manipulation lends itself to the most beautiful and delicate twined work of the Pomo Indians. Gift baskets holding more than a bushel and requiring months of patient labor to construct are thus woven.

Fig. 19 shows how, by varying the color of the weft splints and changing from diagonal to plain weaving, the artist is enabled to control absolutely the figure on the surface.

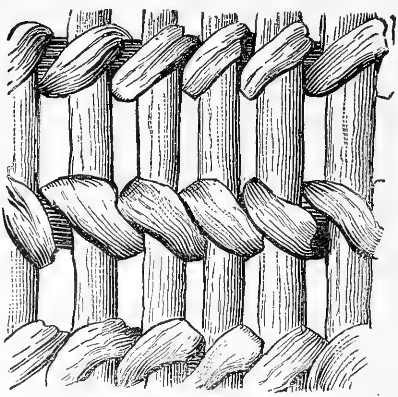

FIG. 20.
WRAPPED TWINED WEAVING.
Rept. U.S.N.M., 1884, pl. 13, fig. 23.

3. *Wrapped twined weaving.*—In wrapped twined weaving one element of the twine passes along horizontally across the warp stems, usually on the inside of the basket. The binding element of splint, or strip of bark, or string, is wrapped around the crossings of the horizontal element with the vertical warp (fig. 20). On the outside of the basket the turns of the wrapping are oblique; on the inside they are vertical. It will be seen on examining

this figure that one row inclines to the right, the one above it to the left, and so on alternately. This was occasioned by the weaver's passing from side to side of the square carrying basket, and not all the way round as usual. The work is similar to that in an old-fashioned bird cage where the upright and horizontal wires are held in place by a wrapping of finer soft wire. The typical example of this wrapped or bird-cage twine is to be seen among the Indians of the Wakashan family living about Neah Bay, Vancouver Island, and southwestern British Columbia (fig. 21).

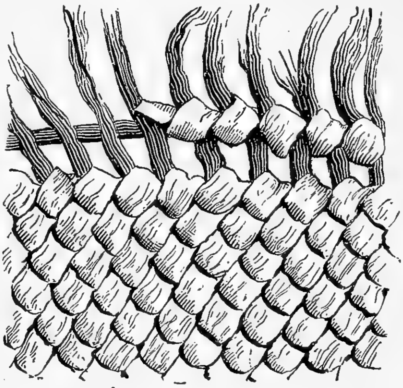

Fig. 21.

WRAPPED TWINED WEAVING.

Rept. U.S.N.M., 1884, pl. 14, fig. 25.

In this type the warp and the horizontal strip behind the warp are both in soft cedar bark. The wrapping is done with a tough straw-colored grass. When the weaving is beaten home tight the surface is not unlike that of a fine tiled roof, the stitches overlying each other with perfect regularity.

Fig. 22 shows a square inch of the inside of a basket, with plain twined weaving in the two rows at the top; plain twined weaving in which each turn passes over two warp rods in four rows just below. In the middle of the figure, at the right side, it will be seen how the wrapped or bird-cage twined work appears on the inside, and in the lower right-hand corner is the inside view of diagonal twined weaving. In the exquisite piece from which this drawing was made, the skillful woman has combined four styles of two-ply twined weaving. On the outside of the basket these various methods stand for delicate patterns in color (fig. 19).

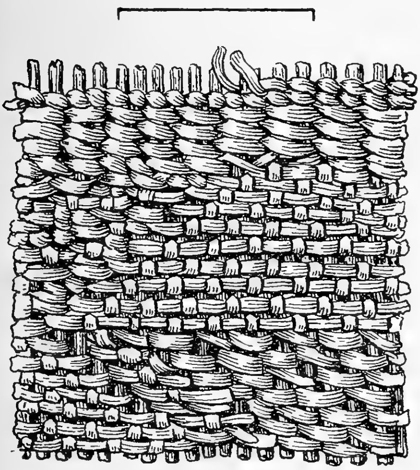

Fig. 22.

TWINED WEAVING, INSIDE.

Am. Anthropologist, new ser. 3, 1901, fig. 21.

4. *Lattice-twined weaving.*—The lattice-twined weaving, so far as the collections of the U. S. National Museum show, is confined to the Pomo Indians, of the Kulanapan family, residing on Russian River, California. Dr. J. W. Hudson calls this technic *tee*. This is a short and convenient word, and may be used for a specific name. The *tee* twined weaving consists of four elements—(*a*) the upright warp

of rods, (*b*) a horizontal warp crossing these at right angles, and (*c*, *d*) a regular plain twined weaving of two elements, holding the warps firmly together (fig. 23).

In all the examples in the U. S. National Museum the horizontal or extra warp is on the exterior of the basket. On the outside the *tee* basket does not resemble the ordinary twined work, but on the inside it is indistinguishable. Baskets made in this fashion are very rigid and strong, and frequently the hoppers of mills for grinding acorns, and also water-tight jars, are thus constructed. The ornamentation is confined to narrow bands, the weaver being greatly restricted by the technic.

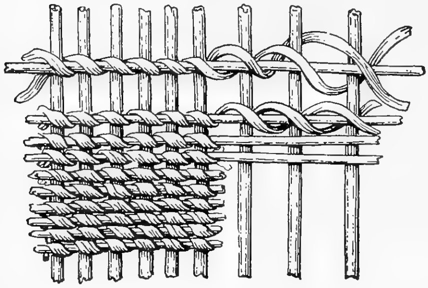

FIG. 23.

TEE LATTICE OR TWINED WEAVING

Of the Pomo Indians, California.

Am. Anthropologist, new ser. 3, 1901, fig. 22.

5. *Three-ply twined weaving.*—Three-ply twined weaving is the use of three weft splints and other kinds of weft elements instead of two, and there are four ways of administering the weft:

a. *Three-ply twine.*
b. *Three-ply braid.*
c. *Three-ply, false embroidery, Tlinkit.*
d. *Frapped, Skokomish.*

(*a*) *Three-ply twine* (figs. 24 and 25).—In this technic the basket-weaver holds in her hand three weft elements of any of the kinds mentioned. In twisting these three, each one of the strands, as it passes inward, is carried behind the warp stem adjoining; so that in a whole revolution the three weft elements have in turn passed behind three warp elements. After that the process is repeated. By referring to the lower halves of figs. 24 and 25, the outside and the inside of this technic will be made plain.

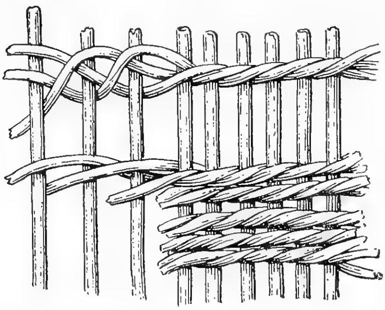

FIG. 24.

THREE-PLY BRAID AND TWINED WORK, OUTSIDE.

Am. Anthropologist, new ser. 3, 1901, fig. 23.

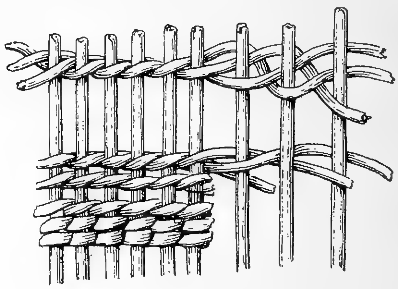

FIG. 25.

THREE-PLY BRAID AND TWINED WORK, INSIDE.

Am. Anthropologist, new ser. 3, 1901, fig. 24.

On the outside there is the appearance of a two-ply string laid along the warp stems, while on the inside the texture looks like plain twined weaving. The reason for this is apparent, since in every third of a revolution one element passes behind the warp and two remain in front.

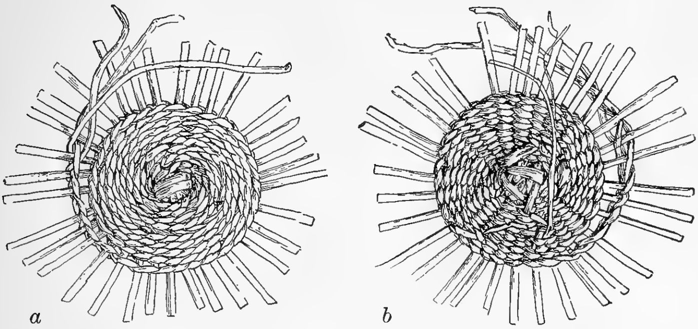

FIG. 26.
THREE-PLY BRAID; *a*, OUTSIDE; *b*, INSIDE.

(b) *Three-ply braid.*—In three-ply braid the weft elements are held in the hand in the same fashion, but instead of being twined simply they are plaited or braided, and as each element passes under one and over the other of the remaining two elements, it is carried inside a warp stem. This process is better understood by examining the upper parts of figs. 24 and 25, and 26 *a* and *b*. On the surface when the work is driven home, it is impossible to discriminate between three-ply twine and three-ply braid. The three-ply braid is found at the starting of all Pomo twined baskets, no matter how the rest is built up.

Fig. 27 shows a square inch from the surface of a Hopi twined jar. The lower part is in plain twined weaving; the upper part is in three-ply twine. Philologists have come to the conclusion that the Hopi are very mixed people. The three-ply work shown in this figure is a Ute motive. The U. S. National Museum collections represent at least seven different styles of basketry technic practiced among the Hopi people of Tusayan.

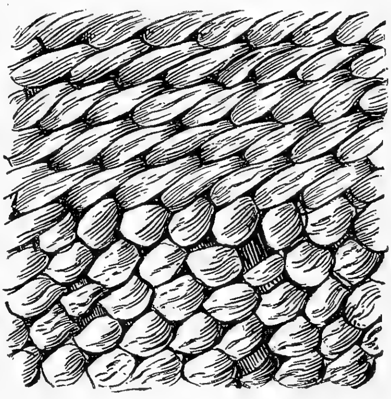

FIG. 27.
THREE-PLY AND PLAIN TWINED WORK.
Report U.S.N.M., 1884, pl. 38, fig. 67

(c) *Three-ply, false embroidery.*—In Tlinkit basketry the body is worked in spruce root, which is exceedingly tough. The ornamentation in which mythological symbols are concealed consists of a species of false embroidery in which the figures appear on the outside of the basket but not on the inside. In the needlework of the civilized woman the laying of this third element would be called embroidery, but the Indian woman twines it into the textile while the process of basket making is going on; that is, when each of the weft elements passes between two warp rods outward, the colored or overlaid element is wrapped around it once. Straws of different colors are employed (fig. 28).

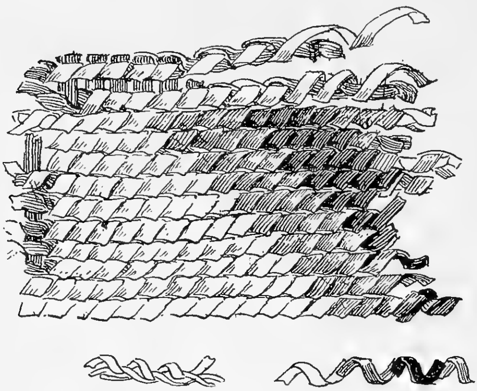

Fig. 28.
OVERLAID TWINED WEAVING.
6th An. Rept., Bur. Ethnol., p. 230, fig. 336, after W. H. Holmes.

(d) *Frapped basketry*, Skokomish type.—An interesting modification of this Tlinkit form of overlaying or false embroidery occurs occasionally among the Pomo Indians under the name of *bog* or *bag*, and it is fully explained and illustrated by James Teit in his Memoir on the Thompson River Indians.[1] In this Thompson River example the twine or weft element is three-ply. Two of them are spun from native hemp or milkweed, and form the regular twined two-ply weaving. Around this twine the third element is wrapped or served, passing about the other two and between the warp elements, and then the whole is pressed down close to the former rows of weaving. On the outside of this bag the wrapping is diagonal, but on the inside the turns are perpendicular. The fastening off is coarsely done, leaving the surface extremely rough. I am indebted to Dr. Franz Boas for the use of Mr. Teit's figure. This combination is extremely interesting. The author says that it "seems to have been acquired recently through intercourse with the Shahaptins." A little attention to the stitches will show that the bags and the motives on them are clearly Nez Perces or Shahaptian, but the wrapping of corn husk outside the twine are not done in Nez Perces fashion, but after the style of the Makah Indians of Cape Flattery, who are Wakashan (fig. 29).

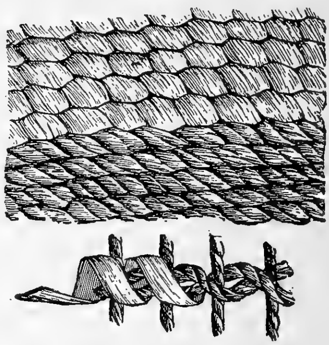

Fig. 29.
FRAPPED TWINED WORK.
Thompson River Indians, British Columbia, after James Teit.

[1] Memoirs of the American Museum of Natural History, II, New York, 1900, fig. 132, p. 190.

II. COILED BASKETRY.

Coiled basketry is produced by an over-and-over sewing with some kind of flexible material, each stitch interlocking with the one immediately underneath it. The exception to this is to be seen on Eskimo and Digger baskets, in which the passing stitch is driven through the wood of the stitch underneath and splits it. The transition between lace work and coiled basketry is interesting. In the netted bags of pita fiber, common throughout middle America, in the muskemoots or Indian bags of fine caribou skin thong from the Mackenzie River district, as well as in the lace-like netting of the Mohave carrying frames and Peruvian textiles, the sewing and interlocking constitute the whole texture (fig. 31, A), the woman doing her work over a short cylinder or spreader of wood or bone, which she moves along as she works.[1] When the plain sewing changes to half-hitches—or stitches in which the moving part of the filament or twine is wrapped or served one or more times about itself—there is the rude beginning of point lace work. This is seen in Fuegian basketry as well as in many pieces from various parts of the Old World (fig. 41).

The sewing materials vary with the region. In the Aleutian Islands it is of delicate straw; in the adjacent region it is spruce root; in British Columbia it is cedar or spruce root; in the more diversified styles of the Pacific States every available material has been used—stripped leaf, grass stems, rushes, split root, broad fillets, and twine, the effect of each being well marked. In all coiled basketry, properly so called, there is a foundation more or less rigid, inclosed within stitches, the only implement used being originally a bone awl.

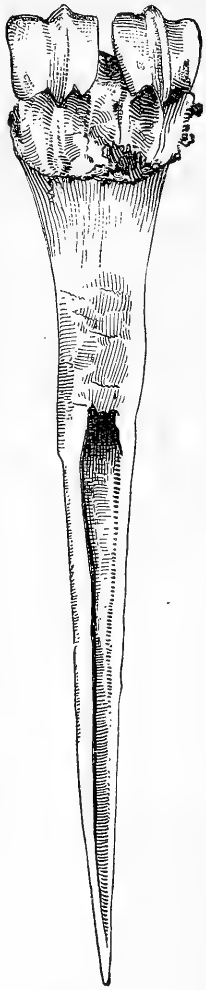

FIG. 30.

BONE AWL FOR COILED BASKETRY.

Report U.S.N.M., 1884, pl. 64, fig. 108. Collected by Edward Palmer.

Fig. 30 shows the metatarsal of an antelope, sharpened in the middle and harder portion of the column, the joint serving for a grip to the hand. Mr. F. H. Cushing was of the opinion that the bone awl was far better for fine basket work than any implement of steel; the point, being a little rounded, would find its way between the stitches of the coil underneath and not force itself through them. The iron awl, being hard and sharp, breaks the

[1] See Scientific American, July 28, 1900, and American Anthropologist (new ser.), April, 1900.

texture and gives a very rough and clumsy appearance to the surface, as will be seen in fig. 37. In every culture province of America wherever graves have been opened the bone stiletto has been recovered, showing the widespread use of threads or filaments employed in joining two fabrics, or for perforating those already made to receive coil work and other embroideries.

Coiled basketry in point of size presents the greatest extremes. There are specimens delicately made that will pass through a lady's finger ring, and others as large as a flour barrel; some specimens have stitching material one-half inch wide, as in the Pima granaries, and in others the root material is shredded so fine that nearly 100 stitches are made within an inch of space. In form, the coiled ware may be perfectly flat, as in a table mat, or built up into the most exquisite jar shape, in design the upright stitches lend themselves to the greatest variety of intricate patterns.

VARIETIES OF COILED BASKETRY.

Coiled basketry may be divided into nine varieties, based on structural characteristics. The foundation may be (1) a single stem or rod; (2) a stem with a thin welt laid on top of it; (3) two or more stems over one another; (4) two stems laid side by side, with a welt; (5) three stems in triangular position; (6) a bundle of splints or small stems; (7) a bundle of grass or small shreds.

The stitches pass around the foundation in progress (1) interlocking, but not inclosing the foundation underneath; (2) under one rod of the coil beneath, however many there may be; (3) under a welt of the coil beneath; (4) through splints or other foundation, in some cases systematically splitting the sewing material underneath. With these explanations it is possible to make the following nine varieties of coiled basketry, matting, or bagging:

A. *Coiled work without foundation.*
B. *Simple interlocking coils.*
C. *Single-rod foundation.*
D. *Double-stem coil, two-rod foundation.*
E. *Packing inclosed, rod and welt foundation.*
F. *Packing inclosed, two-rod and splint foundation.*
G. *One rod inclosed, three-rod foundation.*
H. *Splint foundation.*
I. *Grass-coil foundation.*
K. *Fuegian coiled basketry.*

These will now be taken up systematically and illustrated (fig. 31).

A. *Coiled work without foundation.*—Specimens of this class have been already mentioned. The sewing material is babiche or fine rawhide thong in the cold north, or string of some sort farther south. In the Mackenzie Basin will be found the former, and in the tropical and subtropical areas the latter. If a plain, spiral spring be coiled or hooked into one underneath, the simplest form of the open coiled work will result. An improvement of this is effected when the moving thread in passing upward after interlocking is twined one or more times about its standing part (fig. 31 A).

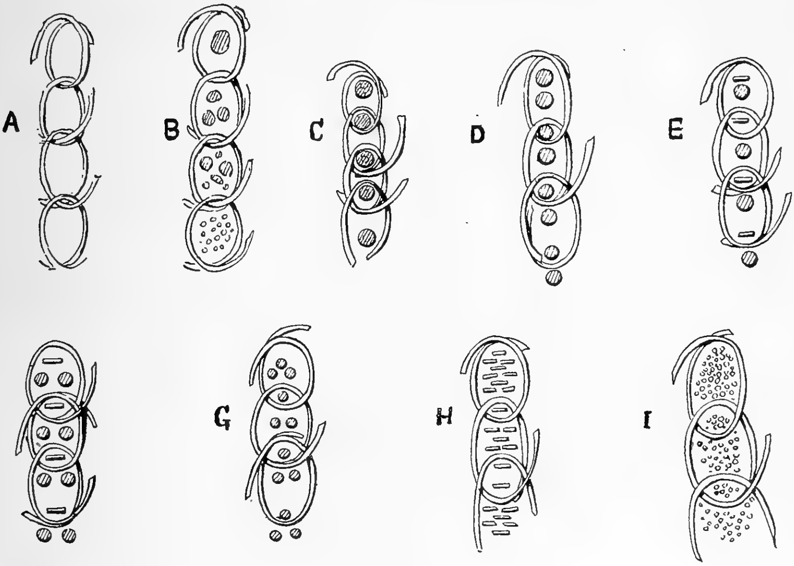

FIG. 31.
CROSS SECTIONS OF VARIETIES IN COILED BASKETRY.

B. *Simple interlocking coils.*—Coiled work in which there may be any sort of foundation, but the stitches merely interlock without catching under the rods or splints or grass beneath. This form easily passes into those in which the stitch takes one or more elements of the foundation, but in a thorough ethnological study small differences can not be overlooked (fig. 31 B). Fig. 32 represents this style of workmanship on a coiled basket in grass stems from Alaska, collected by Lucien M. Turner. The straws for sewing merely interlock without gathering the grass roll.

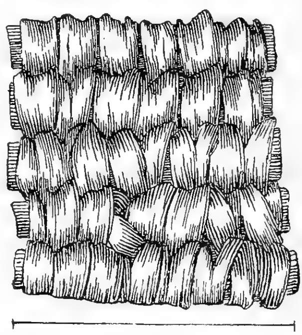

FIG. 32.
DETAIL OF INTERLOCKING STITCHES.

C. *Single-rod foundation.*—In rattan basketry and Pacific coast ware, called by Dr. J. W. Hudson *Tsai* in the Pomo language, the foundation is a single stem, uniform in diameter. The stitch passes around the stem in progress and is caught under the one of the preceding coil, as in fig. 31 C. In a collection of Siamese basketry in the U. S. National Museum the specimens are all made after this fashion; the foundation is the stem of the plant in its natural state, the sewing is with splints of the same material, having the glistening surface outward. As this is somewhat unyielding, it is difficult to crowd the stitches together, and so the foundation is visible between.

In America single-rod basketry is widely spread. Along the Pacific coast it is found in northern Alaska and as far south as the borders of Mexico. The Pomo Indians use it in some of their finest work. The roots of plants and soft stems of willow, rhus, and the like are used for the sewing, and being soaked thoroughly can be crowded together so as to entirely conceal the foundation (fig. 33).

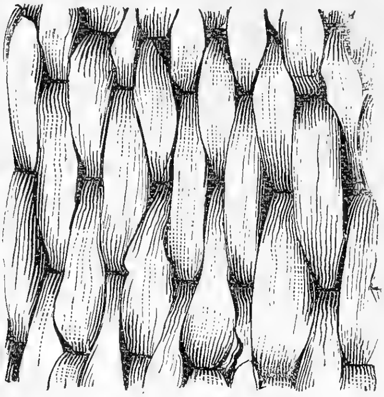

FIG. 33.

DETAIL OF SINGLE-ROD COIL IN BASKETRY.

Rept. U.S.N.M. 1884, pl. 5, fig. 8.

D. *Two-rod foundation.*—One rod in this style lies on top of the other; the stitches pass over two rods in progress and under the upper one of the pair below, so that each stitch incloses three stems in a vertical series. A little attention to fig. 31 D will demonstrate that the alternate rod or the upper rod in each pair will be inclosed in two series of stitches, while the other or lower rod will pass along freely in the middle of one series of stitches and show on the outer side. Examples of this two-rod foundation are to be seen among the Athapascan tribes of Alaska, among the Pomo Indians of the Pacific coast, and among the Apache of Arizona. An interesting or specialized variety of this type is seen among the Mescaleros of New Mexico, who use the two-rod foundation, but instead of passing the stitch around the upper rod of the coil below, simply interlock the stitches so that neither one of the two rods is inclosed twice. This Apache ware is sewed with yucca fiber and the brown stems of other plants, producing a brilliant effect, and the result of the special technic is a flat surface like that of pottery (fig. 34). The U. S. National Museum possesses a single piece of precisely the same technic from the kindred of the Apache on the Lower Yukon.

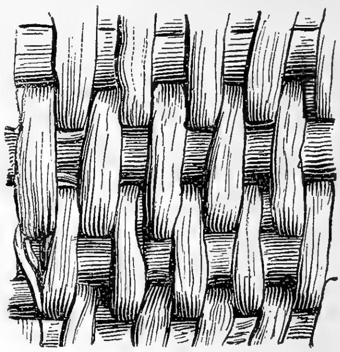

FIG. 34.

FOUNDATION OF TWO RODS, VERTICAL.

Rept. U.S.N.M. 1884, pl. 50, fig. 84.

E. *Rod and welt foundation.*—In this kind of basketry the single-rod foundation is overlaid by a strip or splint of tough fiber, sometimes the same as that with which the sewing is done; at others a strip of leaf or bast. The stitches pass over the rod and strip which are on top down under the welt only of the coil below, the stitches interlocking. The strip of tough fiber between the two rods which serves for a welt has a double purpose—strengthening the fabric and chinking the space between the rods (fig. 31 E and fig. 35). This style of coil work is seen on old Zuñi basket-jars and on California examples. The type of foundation passes easily into forms (fig. 31) C, D, and F.

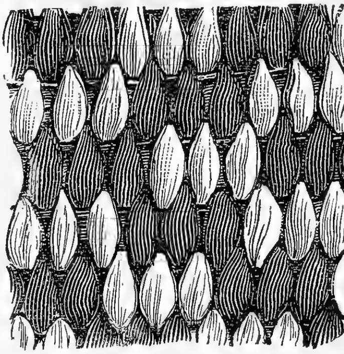

Fig. 35.
ROD AND WELT COILED WORK.
Rept. U.S.N.M. 1884, pl. 49, fig. 82.

F. *Two rod and splint foundation.*—In this style the foundation is made thicker and stronger by laying two rods side by side and a splint or welt on top to make the joint perfectly tight. The surface will be corrugated. Tribes practicing this style of coiling generally have fine material and some of the best ware is so made up.

G. *Three-rod foundation.*—This is the type of foundation called by Dr. J. W. Hudson *bam-tsu-wu.* Among the Pomo and other tribes in the western part of the United States the most delicate pieces of basketry are in this style. Dr. Hudson calls them the "jewels of coiled basketry." The surfaces are beautifully corrugated, and patterns of the most elaborate character can be wrought on them. The technic is as follows: Three or four small, uniform willow stems serve for the foundation, as shown in fig. 36; also in cross section in fig. 31 G. The sewing, which may be in splints of willow, black or white carex root, or cercis stem, passes around the three stems constituting the coil, under the upper one of the bundle below, the stitches interlocking. In some examples this upper rod is replaced by a thin strip of material serving for a welt (see fig. 31 F). In the California area the materials for basketry are of the finest quality. The willow stems and carex root are susceptible of division into delicate filaments. Sewing done with these is most compact, and when the stitches are pressed closely together the foundation does not

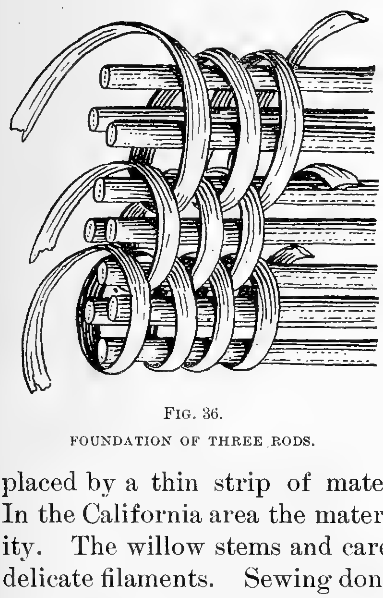

Fig. 36.
FOUNDATION OF THREE RODS.

appear. On the surface of the bam-tsu-wu basketry the Pomo weaver adds pretty bits of bird feathers and delicate pieces of shell. The basket represents the wealth of the maker, and the gift of one of these to a friend is considered to be the highest compliment.

H. *Splint foundation.*—In basketry of this type the foundation consists of a number of longer or shorter splints massed together and sewed, the stitches passing under one or more of the splints in the coil beneath (fig. 37). In the Pomo language it is called *chilo*, but it has no standing in that tribe. In the Great Interior Basin, where the pliant material of the California tribes is wanting, only the outer and younger portion of the stem will do for sewing. The interior parts in such examples are made up into the foundation (fig. 31 H). Such ware is rude when the sewing passes carelessly through the stitches

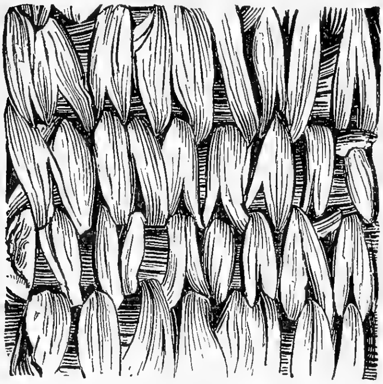

FIG. 37.

FOUNDATION OF SPLINTS.

Rept. U.S.N.M., 1884, pl. 4, fig. 6.

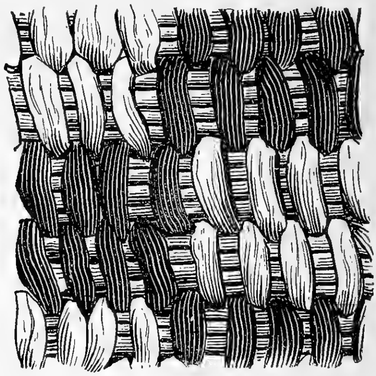

FIG. 38.

INTERLOCKING COILS, STRAW FOUNDATION.

Rept. U.S.N.M., 1884, pl. 27, fig. 51.

below; in others the splitting is designed and beautiful. In the Klikitat basketry the pieces of spruce or cedar root not used for sewing material are also worked into the foundation.[1]

I. *Grass-coil basketry.*—The foundation is a bunch of grass or rush stems, of small midribs from palm leaves, or shredded yucca. The effect in all such ware is good, for the reason that the maker has perfect control of her material. Excellent examples of this kind are to be seen in the southwestern portions of the United States, among the pueblos and missions, and in northern Africa. The sewing may be done with split stems of hard wood, willow, rhus, and the like, or, as in the case of the Mission baskets in southern California, of the stems of rushes (*Juncus acutus*), or stiff grass (*Epicampes rigidum*). (See fig. 38 and the cross section given in fig. 31 I). In the larger granary

[1] Memoirs of the American Museum of Natural History, Anthropology, I, p. 189, fig. 131 a.

baskets of the Pima a bundle of straws furnishes the foundation, while the sewing is done with broad strips of tough bark, as in fig. 39. In the Fuegian coiled basketry, of which a figure is given, the sewing is done with rushes, but instead of being in the ordinary over-and-over stitch it consists of a series of half hitches or buttonhole stitches (fig. 41).

Among the basketry belonging to the grass-coil foundation type are the Hopi plaques, built upon a thick bundle of the woody stems of the yuccas, which furnish also the sewing material from the split leaf (fig. 40). If this be examined in comparison with a style of basketry found in Egypt and in northern Africa as far as the Barbary states, great similarity will be noticed in the size of the coil, the color of the sewing material, the patterns, and the stitches. The suggestion is here made that this particular form of workmanship may be due to

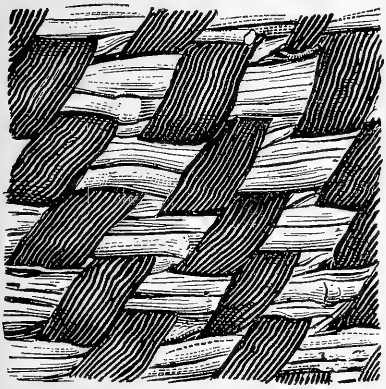

Fig. 39.

OPEN COIL INCLOSING PART OF FOUNDATION.

Rept. U.S.N.M., 1884, pl. 37. fig. 38.

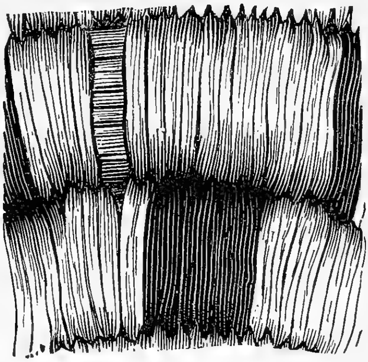

Fig. 40.

INTERLOCKING COILS, SHRED FOUNDATION.

Rept. U.S.N.M., 1884, pl. 39, fig. 69.

acculturation, inasmuch as this type of basketry is confined in America to the Hopi pueblos, which were brought very early in contact with Spaniards and African slaves.

K. *Fuegian coiled basketry.*—In this ware the foundation is slight, consisting of one or more rushes; the sewing is in buttonhole stitch or half-hitches, with rush stems interlocking. The resemblance of this to Asiatic types on the Pacific is most striking (fig. 41).

In a small area on Fraser River, in southwestern Canada, on the upper waters of the Columbia, and in many Salishan tribes of northwestern Washington, basketry called "Klikitat" is made. The foundation, as said, is in cedar or spruce root, while the sewing is done with the outer and tough portion of the root; the stitches pass over the upper bundle of splints and are locked with those underneath. On the outside of these baskets is a form of technic, which also constitutes the ornamentation. It is not something added, or overlaid, or sewed on, but is a part of the texture effected in the progress of the manufacture (fig. 42).

The method of adding this ornamentation in strips of cherry bark,

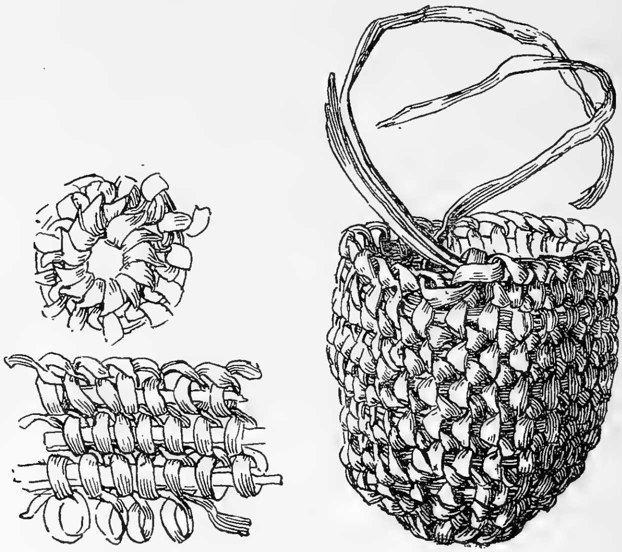

FIG. 41.
FUEGIAN COILED BASKET AND DETAILS.

cedar bast, and grass stems, dyed with Oregon grape, is unique, and on this account I have applied the term imbricated to the "Klikitat"

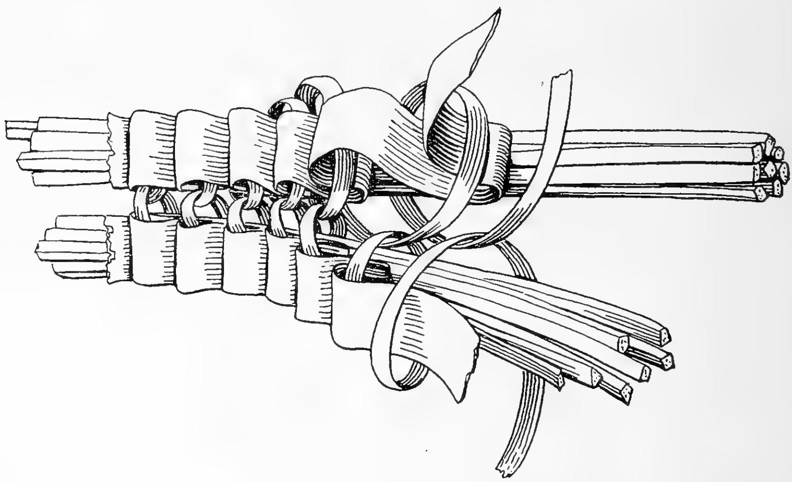

FIG. 42.
IMBRICATED WORK DETAIL, CALLED KLIKITAT.
Showing method of concealing coil stitches.

basket, as shown in fig. 44. The strip of colored bark or grass is laid down and caught under a passing stitch; before another stitch is taken this one is bent forward to cover the last stitch, doubled on itself so as to be underneath the next stitch, and so with each one it is bent backward and forward so that the sewing is entirely concealed, forming a sort of "knife plaiting." In some of the finer old baskets in the National Museum, collected sixty years ago, the entire surface is covered with work of this kind, the strips not being over an eighth of an inch wide. Mr. James Teit describes and illustrates this type of weaving among the Thompson River Indians of British Columbia, who are Salishan. The body of the basket is in the root of *Thuja gigantea*, and the ornamentation in strips of *Elymus triticoides* and *Prunus demissa* (fig. 43).

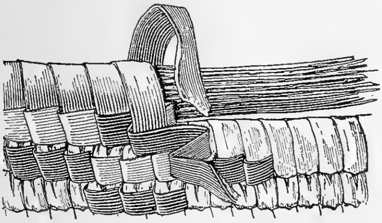

FIG. 43.
IMBRICATED BASKETRY DETAIL, FROM THE THOMPSON RIVER INDIANS, BRITISH COLUMBIA.
After James Teit.

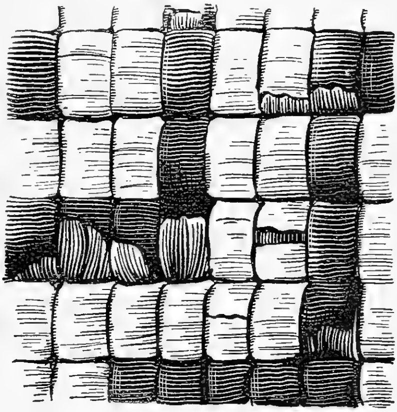

FIG. 44.
IMBRICATED COILED WORK, CALLED KLIKITAT.
Rep. U. S. National Museum, 1884, pl. 6, fig. 10.

Imbrication is one of the most restricted of technical processes. Eells says that some women in every tribe on Puget Sound could produce the stitch, and he names the Puyallups, Twanas, Snohomish, Clallam, Makah, Skagit, Cowlitz, Chehalis, Nisqualli, and Squaxon. It is understood that here it is a modern acquirement. It is the native art of the Klikitat, Yakima, and Spokanes, all of whom are of the Shahaptian family. The Thompson River Indians, who are Salishan, have long known the art.

LIST OF BASKET-MAKING TRIBES.

The following list includes the names of those tribes known to the author as makers of any kind of basketry, especially in North America, together with the linguistic families to which they belong, and their locations.

In a much fuller work, to be subsequently published, a larger list will be given, and it is desirable that those who are interested in the subject will supply to the author the names of those tribes not to be found here.

Tribe.	Family.	Locality.
Abnaki	Algonquian	Point Pleasant, Maine.
Aleut	Eskimauan	Aleutian Islands.
Algonkin	Algonquian	Northern frontier and Canada.
Apache tribes	Athapascan	Arizona and New Mexico.

Tribe.	Family.	Locality.
Arapaho	Algonquian	South Dakota.
Arikara	Caddoan	Fort Berthold, North Dakota.
Ashochimi	Yukian	near Healdsburg, California.
Attacapa	Attacapan	Southern Louisiana.
Attu Island, *see* Aleut.		
Auk	Koluschan	Gastineaux Channel, Alaska.
Bilhoola, Bellacoola	Salishan	Northwest British Columbia.
Calpella	Kulanapan	Ukiah, California.
Carriers, *see* Thompson River.		
Cayuse	Waiilatpuan	Walla Walla and Columbia River.
Chaves Pass Ruin	Hopian	Arizona.
Chehalis	Salishan	Washington State.
Chemehuevi	Shoshonean	Arizona and California boundary.
Cherokee	Iroquoian	North Carolina.
Chetimacha	Chetimachan	Louisiana.
Chevlon ruin	Hopian	Northeastern Arizona.
Chilcotin	Athapascan	British Columbia.
Chilkat	Koluschan	Southeastern Alaska.
Chinook tribes	Chinookan	Lower Columbia River.
Choctaw	Muskhogean	Louisiana.
Chuk Chanci	Mariposan	Sierra region, California.
Clallam	Salishan	Washington State.
Clatsop	Chinookan	Pacific Coast, Washington.
Coahuilla	Shoshonean	Southern California.
Coconinos, *see* Havasupai.		
Colville	Salishan	Colville Agency, Washington.
Concow	Pujunan	Round Valley, California.
Couteau, *see* Thompson River.		
Cowlitz	Salishan	North of Mount St. Helen.
Coyotero	Athapascan	Southern Arizona.
Creek	Muskhogean	Southern States and Indian Territory.
Diegueño (includes many scattered bands)	Yuman	Southern California.
Digger	Pujunan	Northern California.
Esak-tellar	Eskimauan	E. Prince William Sound, Alaska.
Eskimo	Eskimauan	Arctic America.
Flonho	Athapascan	Eel River, California.
Gallinomero	Kulanapan	Cloverdale, California.
Garotero	Athapascan	Same as Coyotero.
Gualala	Kulanapan	Gualala, Mendocino County, California.
Guthleuk	Koluschan	N. of Prince William Sound, Alaska.
Haida	Skittagetan	Alaska and British Columbia.
Hat Creek	Palaihuihan	Northeastern California.
Havasupai	Yuman	Cataract Canyon, Arizona.
Hoh	Chimakuan	Neah Bay, Washington.
Homolobi, ancient ruin		Near Winslow, in Arizona.
Hoochnom	Yukian	Round Valley, California.
Hoonah	Koluschan	Cross Sound, Alaska.
Hootzahtai	Koluschan	Admiralty Island, Alaska.
Hopi	Hopian	Northeastern Arizona.
Hualapai, *see* Walapai.		
Huicholes	Nahuatlan	Zacatecas, etc., Mexico.

Tribe.	Family.	Locality.
Hupa	Athapascan	Trinity River, California.
Iroquois tribes	Iroquoian	Northern frontier and Canada.
Jicarilla Apache	Athapascan	Northern New Mexico.
Kabinapo	Kulanapan	Clear Lake, California.
Kalispel	Salishan	Flathead Agency, Montana.
Karok	Quoratean	Klamath River, California.
Kaviagmiut	Eskimauan	Kadiak Island, Alaska.
Kawia, *see* Coahuilla.		
Klamath	Lutuamian	Northern California.
Klikitat	Shahaptian	Yakama Reservation, Washington.
Kohonino, see Havasupai.		
Kutenai	Kitunahan	Idaho and British Columbia.
Lillooet	Salishan	British Columbia.
Little Lakes	Kulanapan	Round Valley, California.
Lolonkuh	Athapascan	Eel River, California.
Luiseño	Shoshonean	San Luis Rey, California.
Lummi	Salishan	Northern Puget Sound.
MacCloud	Copehan	Northern California.
Maidu	Pujunan	E. of Sacramento River, California.
Makah	Wakashan	Washington State.
Makhelchel	Copehan	Clear Lake, California.
Maricopa	Yuman	Near Maricopa, Arizona.
Mattoal	Athapascan	California.
Maya	Mayan	Yucatan.
Melicite	Algonquian	New Brunswick.
Menominee	Algonquian	Northeastern Wisconsin.
Mescalero	Athapascan	Southern New Mexico.
Mexican, *see* under various families.		
Micmac	Algonquian	Nova Scotia.
Mission, a great many villages.	Shoshonean and Yuman.	Southern California.
Miwok	Moquelumnan	California.
Modoc	Lutuamian	Klamath River, California.
Mohave	Yuman	Between Arizona and California.
Moki or Hopi	Shoshonean	Northeastern Arizona.
Mono	Shoshonean	Middle California.
Muckleshoot	Salishan	Puget Sound, Washington.
Napa	Copehan	Sacramento River, California.
Natano, band of Hupa.		
Navaho	Athapascan	Northern N. Mexico and Arizona.
Nez Percé	Shahaptian	Northern Idaho.
Nishinam	Pujunan	Sacramento Valley, California.
Nisqualli	Salishan	Puget Sound.
Nu cha a wai i	Mariposan	Tule River, California.
Numlaki	Copehan	Round Valley, California.
Nutka	Wakashan	Vancouver Island.
Ojibwa or Chippewa	Algonquian	Michigan.
Opata ruin	Sierra Madre	Sonora and Chihuahua.
Oraibi	Shoshonean	Hopi pueblo.
Paiute	Shoshonean	Western Nevada.
Panamint	Shoshonean	Death Valley, California.
Papago	Piman	South of Tucson, Arizona, and Sonora, etc.

Tribe.	Family.	Locality.
Patawat	Wishoskan	California.
Patwin	Copehan	Sacramento River, California.
Pawnee	Caddoan, *see* Arikara.	
Penobscot	Algonquin	Old Town, Maine.
Peruvian	Kechua	Highlands of Peru.
Pima	Piman	Southern Arizona.
Pit River	Palaihuihan	Pit River, NE. California.
Pomo (many subdivisions).	Kulanapan	Ukiah Valley, California.
Potter Valley	Kulanapan	Round Valley, California.
Pueblos	Tanoan, Keresan Zuñian, Shoshonean	New Mexica and Arizona.
Puyallup	Salishan	Puget Sound.
Queeto	Chimakuan	West Washington.
Quileute	Chimakuan	West Washington.
Quinaielt	Salishan	Western Washington.
Quinault, same as Quinaielt.		
Salishan tribes, great variety of technic.		
San Carlos (Apache)	Athapascan	Southeastern Arizona.
San Felipe Mission	Yuman	Southern California.
Santa Rosa.		
Santa Ysabel.		
Seminole	Muskhogean	Florida.
Shasta	Sastean	In Shasta and Scott valleys, California.
Shoshoni	Shoshonean	Great Interior Basin.
Shushwap	Salishan	British Columbia.
Sia	Keresan	New Mexico.
Sikyatki, ruin, ancient Tusayan.		Northern Arizona.
Sitka	Koluschan	Alaska.
Skagit	Salishan	Northern Puget Sound.
Skokomish	Salishan	Upper Puget Sound.
Snohomish	Salishan	Upper Puget Sound.
Solano, *see* Napa.		
Spokan	Salishan	Montana and Washington.
Squaxon	Salishan	Puget Sound.
Suisin, *see* Napa.		
Tarku	Koluschan	Tarku Inlet, Alaska.
Tatu	Yukian	California.
Tenaskot		Washington, border of British Columbia.
Thompson	Salishan	British Columbia.
Tinne	Athapascan	Alaska.
Tlinkit	Koluschan	Southern Alaska.
Tolowa	Athapascan	Crescent City, California.
Tonto Apache	Athapascan	Southern Arizona.
Tsinuks	Chinookan	Columbia River.
Tulare	Moquelumnun	Middle California.
Tule Rivers	Mariposan	Southern California.
Twana	Salishan	Puget Sound, Washington.

Tribe.	Family.	Locality.
Umatilla	Shahaptian	Oregon.
Utes, many divisions	Shoshonean	Utah.
Viard	Wishoskan.	Eel River, California.
Waiam	Shahaptian	Des Chutes River, Oregon.
Wailaki	Copehan	Round Valley, California.
Walapai for Hualapai	Yuman	Northwestern Arizona.
Wappo	Yukian	Alexander Valley, California.
Wasco	Chinookan	The Dalles, Cregon.
Washoe	Washoan	Carson and elsewhere, Nevada.
White Mountain Apache	Athapascan	Eastern Arizona.
Wichumni	Mariposan	Sierra Region, California.
Wintun	Copehan	W. of Sacramento River, California.
Wushqum	Chinookan	Columbia River, Oregon.
Yakima	Shahaptian	Washington State.
Yakutat	Koluschan	About Yakutat Bay, SE. Alaska.
Yana or Nozi	Yanan	Near Redding California.
Yaqui	Piman	Sonora, Mexico.
Yo al man i	Mariposan	Tule River, California.
Yo er kal i	Mariposan	Tule River, California.
Yokaia	Kulanapan	Russian River, Ukiah Valley, California.
Yokut	Mariposan	Middle California.
Yolo		Northern California.
Yuki	Yukian	Round Valley, California.
Yuma tribes	Yuman	Southern Arizona and Lower California.
Yurok	Weitspekan	Klamath River, California.
Zuñi	Zuñian	Zuñi River, New Mexico.

O

SMITHSONIAN INSTITUTION.

UNITED STATES NATIONAL MUSEUM.

INSTRUCTIONS TO COLLECTORS OF HISTORICAL AND ANTHROPOLOGICAL SPECIMENS.

(ESPECIALLY DESIGNED FOR COLLECTORS IN THE INSULAR POSSESSIONS OF THE UNITED STATES.)

BY

WILLIAM HENRY HOLMES,

Head Curator, Department of Anthropology,

AND

OTIS TUFTON MASON,

Curator, Division of Ethnology.

Part Q of Bulletin of the United States National Museum, No. 39.

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1902.

INSTRUCTIONS TO COLLECTORS OF HISTORICAL AND ANTHROPOLOGICAL SPECIMENS.[a]

By William Henry Holmes,
Head Curator, Department of Anthropology,
AND
Otis Tufton Mason,
Curator, Division of Ethnology.

The Smithsonian Institution desires to obtain for the National Museum from the islands recently brought under the jurisdiction of the United States two principal classes of objects: (1) Those relating to persons and events connected with our *National History* and (2) those included under the general head of *Anthropology*. The former are derived from a wide range of sources, but a majority relate to the progress of military and naval operations at home and abroad. The latter illustrate the peoples, and especially the more primitive tribes, with whom civilized men come only occasionally in contact. It is clear that the Army and the Navy, and the diplomatic service are the best equipped agencies of the Government for the gathering of historical materials, and at the present time, as a result of the occupation of remote and little known territory, they are also the agencies to which the country must largely look for additions to its anthropological treasures.

Museums in other countries are engaged in amassing collections, and are so enterprising that unless prompt measures are taken by our Government much will be lost to us. The need of action is therefore immediate.

In prosecuting the work it is important that the collector should note that there are some classes of objects having great museum interest, yet not available for museum purposes on account of their bulk, such as heavy ordnance, boats, and vehicles of large size, heavy machinery, houses, etc. The limitations of space in the National Museum have always to be considered. Large objects may be represented by models (houses, $\frac{1}{24}$, boats, $\frac{1}{12}$), and these can be constructed by Museum

[a] Specially designed for collectors in the insular possessions of the United States.

experts if photographs, sketches, and notes are secured. It is not unusual, however, that native artisans are clever at making models on a small scale.

Where there is doubt regarding the advisability of sending large objects, or such as may duplicate former sendings, it is well to await advices from Washington.

As the amount of money at the disposal of the National Museum for the increase of its collections is extremely small, it is desirable that the authorities be consulted by the collector before transmitting to it objects whose acquisition or transportation would involve the expenditure of sums of money other than nominal charges.

HISTORICAL COLLECTIONS.

Historical collections may consist of a wide range of objects, representing not only America, but the nations with which the United States happens to have relations, and particular interest attaches to such things as have been associated directly with prominent national personages or with great national events; these are of lasting interest to our people. Among appropriate specimens may be mentioned weapons and munitions of all kinds—cannon, rifles, pistols, projectiles, torpedoes, swords, knives, etc.; all kinds of minor devices and appliances employed in navigation, land transportation, signaling, engineering, etc.; banners, uniforms, costumes, and separate parts of costumes; medals, coins, badges, books, documents, maps, and photographs, and in fact anything that may serve as a representative of historical personages or events.

Of more than usual interest are the weapons and other warlike appliances and paraphernalia of the Philippine peoples, representing as they do several races of men and many grades of culture, from civilization to savagery.

ANTHROPOLOGICAL COLLECTIONS.

Anthropological collections are of three kinds, to wit: Objects or specimens; photographs and drawings; narratives and descriptions. The specimens form the cabinet, the pictures give life to the specimens and show them in their true environment, the descriptions form the basis of all labels and of the literature of anthropology.

All of these have reference, first, to man himself (in this case chiefly to the Filipinos), and, second, to man's works. The former belong to *somatology*, the latter to *ethnology*.

A.—SOMATOLOGICAL COLLECTIONS.

No other people in the world presents a more important field for thorough anthropological research than the Filipinos, in whose veins runs the blood of all the varieties of mankind: Negrito, Papuan, and

African negro; Polynesian and Malay; Japanese, Chinese, and Cambodian; Hamite, Semite, and Aryan; and, according to some ethnologists, a still older stream of Caucasian; finally, since uninterrupted commerce went on between the Philippines, Mexico, and Peru for two hundred years, there is not lacking evidence of a small rill of American Indian blood. The following-named classes of observations and specimens are especially desirable:

1. Observations on the Living.—Concerning color in the skin, hair, and eyes; amount and quality of the hair (whether tufted, woolly, straight, or wavy); form of the head, hands, feet, and other parts; deformations and mutilations; stature and other measurements, especially upon the head; in general, such outward marks as strike the observant traveler as peculiar to any group having a name of its own. To these observations should be added specimens of hair from various tribes, scrupulous care being taken to procure them from persons of unmixed blood. All of this is with reference to untangling the snarl of races in the Philippine archipelago.

2. Anatomical Collections.—These consist of crania, pelves, long bones, whole skeletons, abnormal bones, results of rude surgery, trephining, head flattening, or deformations due to design or to undesigned custom. Crania from caves are particularly desired at this time with reference to questions concerning the prehistoric inhabitants of the islands. Special instructions will be furnished to medical practitioners and others who wish to devote themselves to anthropometry in any of its branches.

3. Physiological Processes.—Including vital processes in health and disease, and physiological psychology. The former has reference to race adaptability to climate, immunity from disease, and all such idiosyncrasies as will be useful in colonization. An excellent opportunity is here afforded of studying the relations of a tropical climate to the races. Physiological psychology has reference to accurate measurement of the time and momentum of vital processes with reference to the nervous system. It studies the relation between sensation, perception, feeling, action, thought, etc., and the anatomy and physiology of the body. (Consult Cattell and Farrand, "Physical and mental measurements of the students of Columbia University," Psychol. Review, New York, III, 1896, pages 618–648.)

B.—ETHNOLOGICAL COLLECTIONS.

Before enumerating in detail the objects and information sought, a few words of explanation will be helpful.

(*a*) Inasmuch as it is intended to present comprehensively and accurately the culture of the native peoples of the islands, specimens are not to be excluded because they are rude and homely. The very best that a people can do is never to be rejected, but the commonplace is more expressive of their daily lives.

(*b*) A little patience at the outset will go a great way in straightening out the confusion of nomenclature. It is most desirable to assign each specimen to its proper tribe, and to ascertain whether the name refers to race or blood, to language, to tribal or political considerations, to location, or to some caprice.

(*c*) Everything depends upon the label. At least the use of the object should be told. The common shipping tags are good enough for all purposes. Each object should bear a collector's number and this should correspond with a number in the collector's notebook. On the tag should be given the common and the native name of the object, the locality, the tribe, the use, and the collector. Much more will be written in the notebook.

(*d*) The crowded condition of the National Museum makes it difficult to show large objects. Moreover, in making comparisons the student and the visitor pass in review a number of small objects more readily. It is therefore desirable to secure small lay figures in costume, models of clothing, dwellings, machines, land conveyances, water craft, and even of villages. But the true forms and parts and relations should always be preserved. In every case, whether full size or model be secured, it is most desirable to have the whole costume, mechanical device, carriage, boat, or whatever it may be. It is very instructive to present a prominent native art from the raw material to the finished product. In many countries the natives themselves are clever at making small models and costumed figures in native dress, but, where this art is lacking, the National Museum has skilled workmen who from photographs, drawings, measurements, and descriptions are able to make reproductions.

To avoid repetitions under each head, let it be said once for all that for every art there should be procured the materials, receptacles, tools, apparatus, and products, together with the best available pictures and description of processes and activities involved. The collector may not always be able to secure every detail, but completeness should be aimed at in every case. The fullest possible information should accompany each specimen.

I.—ARTS AND ACTIVITIES RELATING TO—

1. Food.—Tribal dietaries. Lists of mineral, vegetable, and animal substances eaten, pictures and models of storage places and receptacles, apparatus and vessels for preparing and serving foods. This class includes all that answers to kitchen, storeroom, pantry, and dining utensils, dishes, and cutlery.

2. Drinks.—Semicivilized tribes in all parts of the world have invented processes of fermenting. In the Philippines it is *tuba*, from

palm blossoms. It is desirable to procure the apparatus employed in the manufacture, the vessels for holding, packing, transporting, and serving. The student of folklore will find in this class opportunity for gathering a vast amount of material.

3. Narcotics, Drugs, and Medicines.—Raw materials of these, and products in various degrees of preparation, if possible, in native packages, with native names, always with apparatus and utensils. Betel outfits, surgical instruments in common use, medicine men's drugs, and sorcerers' healing paraphernalia. Poisons for men or for animals.

4. Dress and Adornment.—This large and interesting class includes all that is worn upon the person; even tattooing and fashionable deformations must not be neglected, such as filing the teeth, etc. Clothing for men, women, and children, and for each season or occasion, finds place in this series. Whole costumes are preferable to separate pieces, and the clothing for a family or group is greatly to be prized. But every piece of native dress will be valued in proportion to the knowledge concerning it. In tropical countries clothing is not abundant; for that reason the little that is worn is the more significant. If practicable, models of figures, correctly dressed, should be secured on the spot. For comparative studies, collections of head gear especially, shoes, etc., made from island to island and from tribe to tribe, would be appreciated.

5. Accessories to Dress.—By this term are meant those additions to dress that are thought necessary to its completion on common or uncommon occasions, head dresses of occasion, paints, cosmetics, perfumes, washes, dyes, unguents, jewelry for various parts of the body, umbrellas, fans, staffs, and all such like things.

6. Habitations and other Buildings.—Descriptions, pictures or models of all structures associated with the word "home." This will include materials, ground plans, framing, walls, roofs, porches, galleries, and other structural details, groupings of buildings to form the home, decorations (outside and inside), partitions, ceilings, doors, windows, screens, ladders, bolts, locks, and other hardware and modes of fastening parts together. The place and uses of fire and smoke should be shown and described. Models of houses for men, for women, for boys, for assemblies; of fences, gardens, inclosures for animals, and villages are most desirable. In the United States National Museum the standard ground plan unit for models is 20 by 30 inches, and if practicable this may be followed.

7. Furniture.—This class embraces all those appliances which, in primitive form, take the place of kitchen utensils, cellars, lockups, packing receptacles, dining-room and guest-room tables, chairs, sofas, divans, matting, racks, furniture of the bedroom, in more cultured homes. Models will suffice in the case of bulky objects.

8. Mechanics' Tools.—Already the finished tools of American and European manufacture have obtruded themselves into the Philippines; but the native hammers, saws, perforators, rasps, axes, knives, adzes, clamps, pincers, and binders are most interesting as representing a stage of invention between the stone age and our own. To add to their ethnological value, descriptions of the peculiar ways in which tools are held and used should accompany the specimens and photographs of the mechanics at work. The National Museum has already a rich collection of fire-making devices from the New World. Examples of this class of apparatus from the Orient will be most acceptable.

9. Primitive Engineering.—No other problem in ethnology has excited more lively interest than that relating to the overcoming of vast weights and difficulties in labor. Every ingenious use of the mechanical powers—the inclined plane, simple or compound levers, rollers, wedges, parbuckles, pulleys with or without sheaves, shear poles, wheel and axle, rope, and other devices for lifting and moving among the Filipinos should be shown in specimens and pictures, and accurately described.

10. Machinery.—Every tool, however simple, consists of two parts, the working part and the manual part. The former has undergone little change in form and method of working, but in the latter lies the field of invention. All rude devices for taking the place of the human hand in producing or changing motion and subduing the powers of nature—the waters, the air, gravity, elasticity, etc., should be carefully noted and secured.

11. Stone Working.—The very beginnings of artificial industry and the grandest expressions of artistic skill are in stone. Appliances for quarrying, chipping, flaking, sawing, grinding, boring, and polishing stone and stone-like substances, together with stone implements for all purposes, to show the manner of their manufacture and use may be gathered exhaustively to illustrate one of the most interesting chapters in human progress.

12. Ceramic Art.—Collect all the implements, processes, and products of quarrying clays, of working them up for the potter, of the potter's art in molding, coiling, hammering, modeling, decorating, and firing, with specimens of pottery and any other manufacture from soft materials, such as rude glass, enamel, inlaying, etc.

13. Metallurgy.—Any addition to the knowledge of those early arts through which the working of metals passed before the later methods of fusing were invented will help to complete a most interesting chapter in human history. Collections of implements, processes and products of mining, cold-hammering, forging, casting, soldering, smelting, smithing, and the finer old hand processes, will be most acceptable. Photographs of the artisans at work would give life

to such specimens. The Malay race are skillful metallurgists in their way, practicing some of the very oldest methods in their craft.

14. Woodcraft.—The working of wood is essentially the occupation of men. It embraces the cutting down of the tree or shrub, that is, the harvesting of the material and treatment for seasoning, straightening, etc.; after that comes working it up for a thousand uses in canoe building, cabinet work, carving of weapons and ornaments. Woodworkers' tools of all classes and of the simplest forms may be found among the ruder tribes in the Philippines.

15. Textile Industries.—To this class belong all works in fiber and all interlacing of material from the coarsest hedge to the finest piña embroidery, including bark cloth, fiber, string, sennit, rope, matting, basketry, cloth woven in frames, knots, lace, and needlework. It is important to know the native name, the common name, and the scientific name of every plant and apparatus. While any example would be valuable in a museum, there is scarcely another art which lends itself so handily to exhibiting all its materials, apparatus, processes, and products. There are some of these processes in which the Filipinos excel.

16. Agriculture.—The domestication, cultivation, training, harvesting, storing, and marketing of plants all belong under the general head of agriculture, beginning with those primitive processes by which native plants are somewhat protected, and including also horticulture, floriculture, and arboriculture. Models of larger objects will often suffice, while the camera will be of excellent service in this art.

17. Milling Arts.—Including all processes which take the grain and other ripened portions of the plants from the gleaner's hands and prepare them for the cook. Here belong mortars, hand mills, taro graters, grinding devices of every sort, mills run by beast or water power for rice and other plants, especially the machinery involved; sifters, packing, and receptacles.

18. Hunting.—In continental areas this forms an immense class of industrial objects, and even in the Philippines hunting vermin and larger animals has developed ingenuity especially in traps, a full set of which is desired. The Negritos use bows and arrows of excellent quality, of their own manufacture, and ingenious harpoon arrows procured in trade. (A. B. Meyer, Die Negritos, IX, folio publications of the Royal Dresden Museum, Dresden, 1893, Stengel.)

19. Fishing.—The inventions included in this class are for seizing, killing, and trapping aquatic animals of all species. No other series would be more attractive and instructive than a collection of specimens and models of clubs, knives, piercing devices, nets, traps, weirs, pounds, boats, costumes, etc., illustrating the pursuit of animals in the fresh and salt waters of the Philippine Archipelago.

20. Animal Products.—Here belong those intermediary industrial arts practiced on the parts of animals—their skins, bones, shells, teeth, hair, scales, feathers, etc. In the lower forms of culture an enormous amount of time is expended on these arts, especially in decorations and jewelry.

21. Curing Flesh.—One of the earliest steps in the artificialities of living is the drying, salting, and smoking of fish and flesh. Specimens of such art products are difficult to preserve in a museum, except hermetically sealed, but the apparatus and processes may be photographed and described.

22. Paints and Dyes.—This class includes the arts of coloring, varnishing, cementing, and cleansing with mineral, vegetal, and animal paints, dyes, lacquers, resins, gums, cement, wax, used in the arts. A collection of any one of these classes in various stages of preparation and use, together with examples, would be prized.

23. Transportation on Land.—By this is meant all aids in land travel, whether they be the peculiar costume and accessories of going afoot, including pack, staff, and scrip of the burden bearer, or such devices as are employed in harnessing animals. The entire subject of the water buffalo, as a pack and traction beast, is new to the National Museum, so harness and photographs of the animal in all its customary pursuits are desired.

24. Transportation by Water.—This is the most interesting of all native arts in the Philippines. When it is remembered that the predominant race on the islands is the one that discovered and settled every archipelago in the Pacific Ocean hundreds of years before Columbus, without compass or any other pilots than those natural guides so near to the savage navigator, it will be seen at once how important every fact and specimen connected with water transportation becomes. To officers of the Navy the National Museum makes a special appeal for a complete collection to illustrate the sailor's art in the Philippines.

All devices for getting about or transportation on the water should be included—floats, rafts, hulls, outriggers, paddles, rudders, masts, rigging, sails, sailing rules and charts, artificial waterways, sea lore and craft. Descriptions of the art and rules of navigation, accompanied with models, photographs, and descriptions which only a skilled expert could prepare would become of the treasures of the Museum.

25. Metrics and Commerce.—In comparison with the delicate and intricate processes and devices for counting, weighing, and measuring used in civilization, the simpler ones among the lower races are most instructive. Here may be placed counting scores, records, tallies, arithmetical devices, standard measures of length, of surface, of capacity (liquid and solid), of weight, of time (dials, clocks, and calendars), of value (every substitute for money), commercial rules, forms, and packages.

II.—COMMUNICATION.

1. VOCABULARIES.—There are a multitude of languages spoken in the Philippines, and it is highly important to procure good vocabularies of them in a standard alphabet. Already a few languages have been reduced to writing by missionaries and others, but the systematic gathering of linguistic materials should be prosecuted. (See Blumentritt, in Report of the Smithsonian Institution for 1899.)

2. WRITING.—This term must be taken to include all forms of fixing language on or in things, of sending messages or preserving records in knots or strings, of painting legends on surfaces, of scratching thoughts on bamboo, as well as the methods of making and binding books. The first European travelers in the Philippines were astonished to find that the great majority of Filipinos were literary; but even the nonliterary black and brown tribes have some rude graphic method. A collection of these and of all kinds of books and writing material is greatly desired.

3. SIGN LANGUAGE.—Collections under this head embrace all things and processes other than vocal speech for conveying information—gestures of the body, the peculiar way of laying objects, use of mirrors, flag talk, drum language, ciphers. Among all cultured peoples a host of interesting actions are in this line.

4. PEDAGOGICS.—Objects and apparatus associated with literary education. This is also a sociological topic, but in this class belong the schoolroom, the books, and other apparatus for teaching. Photographs of schools are specially desired.

III.—SOCIAL LIFE.

All that is done by human beings in groups is included in the term sociology, which may be set forth for museum purposes in the following classes: Collections of objects, photographs and other pictures of the groups, and good descriptions of their structures and functions.

1. THE FAMILY.—The National Museum has made strenuous efforts to secure materials, pictures, and information useful in preparing lay-figure groups of various peoples, and now desires to extend this work to the tribes of the Philippines. Photographs of family groups, together with an account of family structure and family life, are most necessary. Polygamy and slavery exist in various forms in the islands, affording an excellent opportunity to investigate certain patriarchal types of the family that existed at the beginning of history. Wedding paraphernalia, birth customs and costumes, weaning, coming of age, all belong in this category, with their thousand and one pretty things and observances not to be overlooked.

2. POLITICAL ORGANIZATION.—Among the American Indians the tribe was the political unit. A tribe was made up of gentes, or kinship

groups, tracing consanguinity through the mother or the father; a number of tribes formed a confederacy, and a roving section of the tribe was a band. A careful study of the black and the brown peoples of the Philippines will reveal also their mode of union. Of each tribe the collector should obtain accounts of organization, tribal marks, tattooings, paintings on the body, badges, insignia, costumes of chiefs and other officers, assembly places, either in pictures or in specimens. The whole group is of radical importance. This class of observations is of the utmost consequence in the future government of the islands.

3. Army and Navy.—This includes the whole art of war, offensive and defensive, on the land and on the water—military education, engineering, strategy, tactics, weapons, armor, uniforms, official badges, flags, banners, trophies, artillery, fortifications, and organization both of the army and of society with reference to it. The custom of head-hunting allies itself to American Indian scalping and should be thoroughly investigated.

4. Lawmaking.—No tribe of mankind is without a code of laws, written or unwritten, telling what to do, what to avoid. In any tribe, who make the laws? Where and when do they meet? Is their assembling coupled with ceremonies? Collections should be made of dress, regalia, and emblems, and photographs taken of meetings. Copies of codes would be highly prized.

5. Courts of Justice.—Criminal codes and the manner of securing justice is a most interesting study in the history of comparative jurisprudence. It is wrong to suppose that lower races lead a lawless life. Among the peoples of the Philippines, how are courts appointed and constituted? How are they administered? Describe and photograph meetings. Collect paraphernalia. Give list of crimes.

6. Administration.—Under this head collect specimens, photographs, and descriptions relating to the executive government of the tribe—its organization and police; methods of arrest and punishment; of collecting revenues; of treating the dependent, delinquent, and defective; the relation of administration to public works.

7. Customs and Unions.—This topic opens the whole vast field of society and folklore, of the sayings and customs of the people and their unions for every purpose. Collections under this head embrace all sorts of costumes and things connected with games and gambling, with the seasons, with going and coming, with downsitting and uprising. [See J. Lawrence Gomme, Handbook of Folklore.]

IV.—ÆSTHETIC CULTURE.

Under this general head may be gathered all the arts of pleasure, commonly called æsthetic arts. In the uncivilized areas art for its own sake has scarcely emancipated itself from other notions; it must be looked for on and in other classes of objects. The categories named below will show sufficiently the lines in which collections are to be made:

1. Fine Costume.—Etiquette of dress and its accessories.

2. Music.—The National Museum already possesses one of the best cabinets of musical instruments. Collect instruments and scores, photographs or drawings of the player performing. Add name of tribe and of the instrument.

3. Graphic Arts.—Collections in this line include the whole range of making pictures by any process whatever. Examples should be secured not only of the pictures but of graphic materials and utensils, together with descriptions and photographs of the artists and their studios. Frequently graphic representations are made on surfaces too large to be removed; in these cases pictures of them will suffice.

4. Sculpture and Carving.—The cutting of images in wood, or stone, or other hard material, is here meant. The aboriginal art of the Philippines in this particular is exceedingly meager being overlaid or replaced with Indian, Muslim, Chinese, and Christian motives. Collect, if possible, from head-hunting tribes, the apparatus and products of purely native workmanship.

5. Ceramic Art.—All work in clay, glass, and enamels belongs to this class. Especial attention should be paid here to form and decorations; more also to the artistic motives in them than to the technique, which belongs elsewhere. An æsthetic collection of pottery includes specimens of the best of every kind and form from every tribe. Such an exhibit from any area forms one of the most attractive features in a museum.

6. Textile Art.—Here belong masterpieces of bark, cloth, matting, basketry, plaiting, weaving, lace making, and embroidery. Each piece should bear on the label the name of the tribe, of the plant, and of the finished product. The patterns have nearly always a pictorial meaning.

7. Art in Metal.—The Negritos are not workers in metal at all, but the brown peoples brought the art with them to the islands. In this class belong the fine art of the jeweler and the smith. The latter put his finest efforts into weapons, which should be collected not merely for their effectiveness but also for the beautiful work on them.

8. Gardening.—Art in trees, flowers, and foliage plants. Many of the most attractive plants in our gardens are from the Orient, and pictures of walks, roads, etc., among the bamboo and imposing tropical trees are among the most impressive attractions.

9. Formalities.—Here belong etiquette, or the fine art of conduct, and ceremony, or the fine art of public life. In the practice of etiquette objects are used, and these should be secured on account of their associations. Photographs and descriptions of correct mode in

shoes, hats, buttons, jewelry, umbrellas, fans, and posture of the body, belong here.

10. Dramas.—This is an important element in the life of all Malayan and other southeastern Asian peoples. The theater and all the pantomime and small play that belong with it, so different in method from our own, is a fascinating topic for the collector. It is desirable, if practicable, to secure sets of masks, costumes, and paraphernalia for a single play. A collection of native pictures of their dramas would throw much light on the drama itself.

11. Oratory.—A great deal is thought of public speaking among primitive peoples. Ascertain whether a class of such persons exists, also what their functions are, what occasions call them forth, and what are their ideals in eloquence.

12. Literature.—Since the invasion of the Philippines from India in the few centuries before our era, the brown race have been a literary people. Collections of native efforts in poetry, proverb, and prose should be secured now. Already, three centuries of contact with Europeans have obliterated and modified a great deal of the native literature, but the preservation of what remains will form an excellent body of material for comparative studies.

V.—KNOWLEDGE.

It is now known that knowledge and science have not sprung up suddenly, but have been acquired through long efforts. All peoples have their lore and their wise men. The intellectual status of a tribe truly rests on their progress in this direction. This class of studies must not be confounded with the rest. What does this or that tribe really know about nature and the nature of things? How do they explain nature and forces other than by reference to sorcery?

1. Traditions.—These are tribal memories, often mixed with other things, but they are the beginnings of history. It is important to know who keeps them, how and when they are recited, whether any paintings, knotted cords, notched or framed sticks are used as aids to the memory, and to secure these as well as the stories themselves.

2. Sayings.—Commonly called proverbs. They are accumulated tribal wisdom about practical matters. The maxims of life, at home and abroad, in the field, on the waters, about the daily task, are the best ways of acting, found out by many efforts and failures.

3. Knowledge.—This is the beginning of science. In this class belong the knowledge and use of numbers; observations on the heavenly bodies, not in a mythical sense, but really; knowledge of rocks, plants, animals, waters, winds, mechanical powers; aside from the fabulous, there exists among even the lowest tribes a certain amount of actual useful observation.

4. PHILOSOPHY.—Called also sophiology, or explanation of phenomena. It is the search for causes and allies itself more and more as we descend the steps of culture progress with personality. What causes the sun to shine, the winds to blow, life and death, and all the infinite variety of changes going on in nature.

VI.—RELIGIONS.

From the point of view of anthropology, religion is what is believed concerning a spirit world and what is done in consequence of such beliefs. The former is creed, the latter is cult, or worship. For the museum, collections are needed of specimens, pictures, and descriptions in the following topics:

1. THE PANTHEON.—In the lowest stage of religion, personality belongs to all phenomena, everything is somebody. In the Philippines the Negritos are said to practice ancestor worship, but no scientific study of the subject has been made among them. The brown race has its own native pantheon and, in addition, that of Buddhism, Mohammedanism, and Christianity. Images and native pictures of the inhabitants of their spirit world are desired, in their proper associations if possible.

2. PRIESTHOOD.—Under this term include the whole ecclesiastical organization of the tribe with reference to religion. The first thing to ascertain is how society is organized under this head. Who are the priests? How are they appointed and trained? How do they dress and act? Are they organized and influential? What is their function in disease, death, and sorcery? Collect costume and paraphernalia relating to the priesthood.

3. SACRED PLACES.—In the higher forms of religion the temples occupy the loftiest position in the estimation of the people. No cost is spared in their erection or furniture. To profane these sacred precincts is the most heinous offense. Every tribe has its building, grounds, groves, tabooed places devoted to religion. Connected with these are innumerable costly objects and furnishings to please the gods. Collections of these in proper association are of priceless value. To secure them or correct representations of them requires the greatest friendliness.

4. WORSHIP.—The social conduct in the presence of the gods. For this there is an elaborate calendar, rich costumes, processions, music, decorations, incense, offerings, and sacrifice. Collections in this single particular from one area would form one of the most attractive exhibits in the National Museum. There are many social duties intimately allied to religion—circumcision, naming, etc.—belonging to this class.

5. PRIVATE RELIGION.—Here should be classed all that brings the individual into relation with the divine, including talismans, charms,

fetiches, wayside offerings, attitudes, and all that mass of personal conduct which is ever going on under the suggestion of the presence of spiritual beings and influences. Collections in this class are not so difficult to obtain, and are secured through charming personal friendships.

6. Religious Literature.—The higher Oriental religions have all left in the Philippine Islands books and other writings. Collections of these should be made, together with information concerning the native use of them.

VII.—ENVIRONMENT.

The culture of any people is the result of the people and their environments. It is necessary, therefore, that the Philippine Islands be studied in relation to the inquiries here raised.

1. Celestial Environment.—Herein must be studied the heavenly bodies not only in their true relations to this area, but as they appear to native eyes in their daily activities. The length of the day is an important factor in culture.

2. Geologic Environment.—The physiography of the archipelago is largely responsible for the present dispersion of the inhabitants, and it everywhere affects life and activities. Here also may be placed hydrography, which depends partly on the earth and partly on the atmosphere, and the study of volcanoes.

3. Meteorologic Environment.—All that is studied in a weather bureau falls into this class, including winds, temperature, pressure, moisture, malaria, storms, trades, cyclones, tornadoes, and whatever else of aërial phenomena in these islands affects the happiness or welfare of the inhabitants.

4. Mineralogic Environment.—Collections of industrial minerals, with their locations, are essential to an intelligent study of native industries.

5. Botanic Environment.—The plant world lies very near to human culture everywhere. A collection of Philippine native plants, with the native names, common names, and scientific names, coupled with the uses to which they are applied, would be a museum treasure.

6. Zoologic Environment.—Finally, the culture of a people is conditioned to the animals of the land and the water, friendly and inimical, their migrations and local habits. The food and raiment of the natives, their shelter and employments, their family names and worship, all are attached to the animal kingdom. The native and common names and their scientific identification should be carefully secured, together with that of the tribe in each case.

O

SMITHSONIAN INSTITUTION.

UNITED STATES NATIONAL MUSEUM.

DIRECTIONS FOR COLLECTING INFORMATION AND SPECIMENS FOR PHYSICAL ANTHROPOLOGY.

BY

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NOTE.

The Smithsonian Institution, whose first scientific memoir related to the subject of anthropology, being the work of Squier and Davis on Ancient Monuments of the Mississippi Valley, through the efforts of field workers and friends, early undertook to collect materials for anatomical anthropology. In the earlier years, with the growth of the Army Medical Museum, it was deemed fitting that these collections should be deposited there. More recently they, and with them all the accumulated normal osteological material of the Army Medical Museum, were transferred to the U. S. National Museum. In view of this and the growing importance and educational possibilities of the science of man, a Division of Physical Anthropology was established in the National Museum and placed in charge of Dr. Aleš Hrdlička, who is organizing and arranging the material thus far acquired and has already secured considerable accessions. The present instructions, prepared by him, are designed to increase these collections and fill up the many gaps still existing, with a view of facilitating and advancing the study of the human race, and more especially of those divisions of it inhabiting the United States.

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DIRECTIONS FOR COLLECTING INFORMATION AND SPECIMENS FOR PHYSICAL ANTHROPOLOGY.

By Aleš Hrdlička,
Assistant Curator, Division of Physical Anthropology.

These instructions, with introductory notes, are addressed to regular and special collectors, and also to those who by their opportunities for travel may help the science of physical anthropology.

The notes have been restricted to what is of most importance. Should further information be desired, it will be cheerfully furnished.

INTRODUCTION.

Physical, i. e., anatomical, anthropology is one of the main branches of the extensive science of mankind. It is that part of anthropology in which are studied variations in the human body and all its parts, and particularly the differences of such variations in the races, tribes, families, and other well-defined groups of humanity. Physical anthropology accumulates facts concerning these variations in every part of the earth, and seeks their causes and significance. On the basis of such knowledge and with the help of other sciences it endeavors to trace man's evolution, to show his biological history, as well as the processes of differentiation actually going on in him, and to outline the tendencies of his physical life for the future.

Physical anthropology was specialized from general anatomy mostly during the second half of the nineteenth century; its beginnings, however, date much earlier. Its pioneers and promoters included all the great naturalists and anatomists, as Blumenbach, Buffon, Camper, Daubenton, Hunter, Retzius; with its later workers were Allen, Broca, Busk, Milne-Edwards, Flower, Morton, Quatrefages, Virchow, Welcker; while among the many living men of science who have rendered prominent services to or are now active in physical anthropology are Anutshin, Beddoe, Boas, Dwight, Haddon, Hamy, Kollman, Lombroso, Manouvrier, Martin, Matiegka, Myers, Pfitzner, Pierson, Ranke, Retzius, Schmidt, Schwalbe, Sergi, Tarenetzki, Topinard, Turner, Waldeyer, etc. It is evident that physical anthropology deserves, has received, and is now receiving widespread scientific attention of the highest order.

The work carried on by physical anthropologists consists of investigating and teaching. For both these, a part of the work has to be done on living and a part on dead representatives of races, tribes, or other groups of mankind.

The living are examined, measured, photographed, and cast, either in laboratories or in the field; but dead bodies or any parts of them can be studied or prepared for study, demonstration, or exhibition, only in laboratories specially fitted for the purpose. They must be gathered from hospitals, morgues, and dissecting rooms; cleaned, catalogued, and numbered; and then properly stored for preservation, reference, or further investigation. It is plain that such material can be utilized profitably only in large institutions which can furnish and maintain laboratories, give proper care to the material, and have space for exhibition and storage.

The number of even the more important races, tribes, and other groups of mankind is large, and for proper research, instruction, or exhibition, each group must be represented by many individuals. The better any group is represented in numbers the more valuable will be the results in every direction. It is for these reasons that great collections in physical anthropology are needed and sought by such institutions as the United States National Museum and other establishments where this branch of science is pursued.

The necessity for large and comprehensive assemblage of proper material for physical anthropology has been recognized since the times of Blumenbach (1753–1840), with the result that to-day every important museum or institution of natural history or anatomy has a racial collection of skulls, bones, etc. There are a number of such in Europe, headed by that of the School of Anthropology in Paris; and there are several in the United States, principally that in the United States National Museum (a larger part of which was, up to 1898, preserved in the Army Medical Museum); and those in the Academy of Natural Sciences, Philadelphia; in the Peabody Museum, Cambridge, Massachusetts, and in the American Museum of Natural History, New York City. The number of specimens in each one of these collections reaches into the thousands, and yet not only individually, but even collectively, they are far from properly representing even the more important actual groups of mankind; while the representatives of the man of the past are few indeed. Leaving other than American collections out of consideration, these are as a whole fairly rich in North American and Peruvian skulls; poor in whole skeletons; very poor in material from Alaska, the Antilles, Central and South America, as well as from all parts of the world outside of America; and almost absolutely wanting in such parts of the body as the brain, or other soft organs and in racial fetal material.

All parts of the body, from all stages of life, are fit subjects for physical anthropology, because racial, tribal, or other group differences are found in all of them. Thus far, however, but little attention has been paid in the United States to anything besides the racial, particularly Indian, skeletal constituents, and especially the skull, objects which are of more general interest, more abundant, and comparatively easy of collection and transportation. But even with the skulls and skeletons no systematic collection on a large scale, or a collection comprehending all the important elements of the population, has ever been attempted. All of this explains the condition of our collections and should indicate the way to their improvement.

There are two lines along which it will be necessary to proceed in order to improve the efficiency of American collections in physical anthropology, namely:

(1) The introduction of systematic, comprehensive gathering and exchanges; and

(2) A general bettering of the method of collecting.

Systematic gathering and exchanges are functions of the men in charge of the collections, and can be brought to a proper degree of efficiency by an association and collaboration of these. A general bettering of the method of collection requires, in the first place, a good, handy, and generally available manual of advice and instruction to those collectors who can not be reached and taught personally.

A number of "Instructions" for travelers and anthropologists are in existence,[a] but there is none, especially in the English language, strictly or sufficiently devoted to collectors for physical anthropology. The majority of these "Instructions" are mainly systems of questions in ethnology, while others approach more the character of text-books on anthropometry. There is need for a guide to show all that physical anthropology needs, where and how the specimens can be secured, how they are to be taken care of before they are received by the Museum, and also what collateral observations are of importance in connection with the specimens.

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[a] Broca, Pierre-Paul, Instructions craniologiques et craniométriques de la Société d'anthropologie de Paris. Mém. Soc. d'anthrop. de Paris, 2d series, II; also 1 vol. in 8vo, Paris, 1875.—Broca, Pierre-Paul, Instructions générales pour les recherches anthropologiques à faire sur le vivant, 2d éd., 1 vol. in 8vo, Paris, 1879.—Instructions for Research Relative to the Ethnology and Philology of America, by George Gibbs, Smithsonian Miscellaneous Collections, No. 160, March, 1863.—Notes and Queries on Anthropology, published by the British Association for the Advancement of Science, London, 1874; 3d ed., 1899.—Hints to Travelers, published for the Royal Geographical Society, London, 1883 (5th ed.).—Anthropology, by E. B. Tylor.—Instruction für ethnographische Beobachtungen und Sammlungen in Central-Ostafrika, published for the Königliche Museum für Völkerkunde, Berlin, 1896.—W. H. Holmes and O. T. Mason, Instructions to Collectors of Historical and Anthropological Specimens, Part Q of Bulletin 39 of the United States National Museum, Washington, 1902.

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Such a guide is here presented. Nothing has been included concerning measurements of the specimens or the living subjects, for the reason that this requires much detail and personal instruction. Beginning with the present year (1904), such instructions can be obtained free at the Laboratory of Physical Anthropology in the United States National Museum.

COLLECTIONS.

CRANIA AND SKELETONS.

The skull and skeletal parts of man are relatively easy to obtain, and are of great aid to anthropology.

The skull, besides many other interesting features, preserves best the zoological as well as the racial characteristics of the individual, and also the general form and size of by far the most important human organ, the brain. The other parts of the skeleton, particularly the pelvis, scapulæ, and the long bones, besides aiding in zoological and racial determination, render it possible to estimate the stature and peculiarities of muscular activity in the individual and offer opportunities for investigating growth, decline, and numerous other physiological conditions.

Moreover, skull and skeletal remains are the only physical remnants of man's most ancient to his most recent predecessor; hence the only objects from which it may be hoped to trace the biological evolution of man and of his varieties, and to learn the changes that have taken place in peoples still represented, or even in special families.

In addition, the osteological remains of peoples, particularly the less civilized, preserve marks, such as artificial deformation, painting, staining, carving, trephining, dental or other mutilation, etc., which throw light on a number of interesting phases in the ethnology of these groups of humanity.

These brief remarks show the value to anthropology of ample and comprehensive skeletal material, including that of the whites, often neglected; but they also embody the conditions—to be dealt with below—regarding the proper methods of gathering this material.

Skeletal remains are widely distributed. This subject has to be approached with the greatest delicacy and with profound respect for those reverential beliefs concerning the dead to be found among all peoples, the savage as well as the civilized. The sources of collection are numerous and may be considered under three headings:

(1) Those among the whites and other civilized peoples;
(2) Those among primitive peoples; and
(3) Those of extinct peoples and early man.

I.—THE SOURCES OF SKELETAL REMAINS AMONG THE WHITES AND OTHER CIVILIZED PEOPLES.

As a large number of human bodies are annually utilized for the purposes of teaching and advancement of the medical sciences, the dissecting room becomes a rich and convenient source of more or less normal osteological material. If collection of this be supplemented with data concerning the sex, age, color, nativity, occupation, and mode of death of the individual, and the specimens be properly labeled and cared for (as is being done in at least one large American medical institution), the material becomes most suitable for many anthropological comparisons.

In recent ossuaries, or depositories of skeletons of large quantities, such as are often found in Latin countries, there is usually a mixture of too many elements in the population for the material to be of much value. But there may be ossuaries in which all the bones are of individuals belonging to one race. In that case at least the skulls are as good for anthropological study as those of the same people preserved in any other way. Opportunity to secure such material can often be gained through proper authority.

Ordinary cemeteries still in use offer little opportunity for acquiring good crania or skeletons for anthropological purposes. But, when an old grave is opened, permission might be obtained to examine an interesting skull or skeleton.

It is to be hoped that as interest in the knowledge of our own physical progress advances, old families whose remains have been carefully preserved will be willing to contribute to the study of heredity by permitting the measurement of these remains.

As physical anthropology must deal not only with man's evolution and development, but also with his decline, and with arrested or recessive as much as with normal and progressive characteristics, it must look to asylums, particularly those for the aged, and institutions such as those for idiots, insane, criminals, etc., for materials of this class. The physicians connected with such establishments, under proper advice, have it in their power to furnish specimens, photographs, and descriptions of much value to science.

Catacombs, old ossuaries, and abandoned cemeteries of known date and character contain invaluable osteological series for comparison with recent remains of the same people. There are in the United States many such burial places, which are being destroyed by progress, and the crania and other bones from such places, if collected on a sufficiently large scale, would furnish data, the lack of which is felt keenly. By the aid of such remains the development of the American population in various parts of this country could be well elucidated.

If on a battlefield the bodies are left unburied, in hot countries or seasons three or four weeks suffice to either decompose and remove, or to dry up, the soft parts to such a degree that the saving of the skeleton or the whole body is quite easy. If the bodies are interred the rapidity of disintegration in the soft parts differs much according to the soil, moisture, depth of burial, amount of clothing, etc. At the least, it takes about a year before the bones can be removed without much discomfort. There is, it appears from experience, no danger of infection from a body that has lain that long in the earth; but if any clothing remains in the grave of a recently buried individual, dead from an infectious disease, it better not be handled before a thorough disinfection.

It is to be understood that in all cases the collector should be provided with the proper consent or legal authorization.

II.—SOURCES OF SKELETAL REMAINS AMONG MORE PRIMITIVE PEOPLES.

These sources comprise mainly burials; bodies that have been abandoned; the specially preserved skulls of relatives or enemies; and occasionally, bodies to be found after executions, or in some hospital, morgue, or dissecting room.

The modes of burial and the care taken of, or sentiments attached to, the dead vary greatly with different tribes, and a good local knowledge of the same as well as judgment and tact are quite essential to successful collection.

Some care almost as a rule is attached by the relatives or the community to graves comparatively recent, but there are exceptions. Older burials, particularly those of individuals not remembered and the burials of individuals not belonging to the tribe that occupies the territory at the time, are cared for much less or not at all, or are even feared or hated, and thus offer good opportunities.

Bodies of those slain in battle are often abandoned by the defeated tribe and either left exposed or buried in a heap. As most or all of the fallen were men in good physical condition, such material, if not mixed, is particularly valuable.

Those who died of certain diseases, more rarely the aged or helpless, and in some instances new-born children, are abandoned by their people and may afford some opportunity to the collector.

There are still tribes on this continent, but particularly in the Philippines, Borneo, Formosa, Andaman Islands, New Guinea, certain parts of Africa, etc., among whom the skulls or all skeletal parts of relatives, or the skulls of the enemies, are cleaned, not seldom decorated, and at least for a time guarded. Generally such material is not easy to obtain, yet limited collections of it had been made by a number of travelers or explorers, showing that the acquisition is not impossible.

Executions of criminals or captives belonging to primitive tribes are not rare, and the opportunities should be fully utilized for the benefit of science. And the same is true of individuals of other races than white, who die in the public institutions or are relegated to the morgue or dissecting room.

The question in all these cases is the utilization of inert and otherwise useless remains for the best interests of humanity in general.

III.—SKELETAL MATERIAL OF ANCIENT PEOPLES AND OF EARLY MAN.

Under this heading we approach a field in which are demanded from the collector freedom from preconceived opinions, the utmost care, and often considerable knowledge and experience. The further back in time we recede from the actual period, the more essential become the preservation of the specimens and of all objects associated with them, and the correct localization of all with reference to geological formations. The very existence, besides the period, of early man, in any part of the world, depends on proofs of geological character.

The osteological remains of tribes or peoples who lived within the last three or four thousand years, are met with in fair abundance, at least in certain localities. They are found in tombs, in the rooms or under the floors of ruined dwellings, in mounds, caves, rock crevices, or mines, and in more or less ordinary burials.

The bones are best preserved in dry caves, least so in exposed graves. When the latter are opened the bones are often found in such condition that it is impossible to preserve them; but occasionally with special care something of value can be saved.

Not seldom the indications of the presence of old human remains, particularly in our Southwest, are protruding slabs of stone, or numerous potsherds of better class of pottery. Mounds and caves always demand exploration, for if they have not been disturbed there is usually no surface sign to show whether or not they contain burials. Where there are signs of sedentary people, it may be expected to find at least a part of the burials somewhere near, and clustered. The existence of the custom of cremation in a certain region does not preclude the possibility of finding limited numbers of non-cremated remnants of bodies in the same region and from the same people.

All exploration for the skeletal remains of early man should be intrusted to thoroughly trained men only. The value of such remains depends entirely upon the circumstantial evidence of the find. Yet any educated man can, if an opportunity arises, do a great service to science by calling the attention of trained anthropologists or geologists to finds that seem to indicate the presence of early man.

It is impossible to indicate with any degree of probability the locations of such early remnants. The bones of paleolithic man of Europe are mainly discovered in caves. In such a case it becomes of importance to examine all the caves in the region, or at least all those dating from the same epoch. In general, all older wind, alluvial, and glacial deposits deserve attention.

As to earliest man, and his predecessors, their skeletal remnants must be patiently looked for in countries that have been most fit for the constitution and life of such beings at the time they came into existence. If it were possible to trace and explore the vicinities of the lakes and rivers in the semitropical regions of the later tertiary and quaternary periods and find their caves undisturbed, a great deal could be expected. As it is, science is reduced to the necessity of awaiting and following up accidental discoveries. But in order that opportunities for making such discoveries be not lost, an intelligent watch should be kept over all excavations, such as wells, cellars, railroad cuts, canals, etc., in regions where, from geological and climatological reasons, early man could possibly have existed, and especially where some finds pointing to him have already been made.

DIRECTIONS FOR COLLECTING, EXCAVATING, MARKING, PACKING, AND SHIPPING OSTEOLOGICAL MATERIAL.

The main rules for the collector are:

Handle all skeletal material with care; secure all the identification possible; where other parts of the body besides the skull are collected, and there are more skeletons, assure the separability of each individual; if at all feasible, take every part and fragment of the skeleton found in a given place; gather everything of archeological and ethnological value that can be conveniently moved; supplement your finds with notes and photographs or sketches. If there is reason to believe that the remains may be those of early man, let everything discovered remain *in situ* until an expert can take charge of the excavation; or, if the calling or coming of an expert be impossible, have every step of the work witnessed and supplemented by photographs.

The collector must exercise due care in order to preserve the various parts of the skeleton as near as possible entire. A damaged or broken skull or bone is not useles, but, even if repair be possible, it is mostly less useful than it would have been if not injured.

The implements for excavation are a shovel, hoe, one or more trowels, a small, sharp stick, and a rather stiff brush. The sharp-pointed pick and bar are to be avoided, unless the hardness of the surface makes their use imperative. As soon as any part of the body is reached, it is best to finish the exposure with the trowel and brush only.

If the bones found are in a bad condition and tend to crumble, some attempt at the preservation of at least the skull may be tried; but such attempts are seldom fully successful. At times a free exposure of the specimen hardens it remarkably. Some melted paraffin or a solution of shellac in alcohol may be tried, if convenient; the skull is to be cleaned with the brush and the liquid then poured over it, to infiltrate the bone. Glue is of little value except perhaps where the bone tends to peel off in scales. A fairly good method is the inclosing of the cleaned skull or bone within a moderate layer of plaster of Paris (after the surface of the skull shall have been covered and all interstices filled with fat or cotton or suitable rags). When a skull thus treated dries, the earth that fills the cavity may be emptied through the foramen magnum to diminish the weight; but the plaster must not be disturbed until after the specimen has reached its destination.

It is essential to identify the tribe or people of the individuals to whom the recovered bones belonged. Such identification may be obtained by the collector himself through direct knowledge, or arrived at from data and specimens furnished by him from the ethnological or archeological features of the burial. Keeping the individuals separate, where other parts of the skeletons than the crania are collected, is highly important, and very simply achieved by marking with an aniline pencil each part of every skeleton with a serial number. Such marking avoids the often inconvenient or even impracticable packing of each skeleton in a separate package.

It is an error to collect only the crania, or even only the best or adult crania, when more could have been secured. It is best to save every piece of each skeleton and leave elimination of the useless to those in charge of the material in institutions. Where skulls or bones are merely broken, it is often possible to reconstruct the specimen. The collection of ethnological objects found associated with the skeletal material serves not only for purposes of identification, but also throws light upon the age of the burial and upon the culture of the people.

Supplement all finds by notes taken on the spot, and let them be as accurate and circumstantial as possible. Note the location, character, and all learned of the burial place; its relative position with respect to ruins, if such be near; the manner of burial, the depth of graves, and the position of bodies; ethnological or archeological articles found, and where, etc. The circumstances of each find naturally determine the points of most importance.

The packing of bones and skulls in good condition is quite easy. Almost any light and elastic material may be used, such as papers, hair, rags, cut straw, leaves, twigs, sawdust, etc., and any box, barrel, basket, or crate will do for transportation or until something better can be provided. Bags should be avoided as much as possible, for bones are easily broken in them. It is well to pack the skulls apart from the rest of the bones. Place a pad between the teeth, to prevent their breaking or loss. Surround each skull with cloth or papers and pack tightly. A number of soap or other smaller boxes may be inclosed in a case, which diminishes the chances of breakage, but it is seldom possible to do this in the field. An excellent but not often practicable method is to have little boxes made especially for that purpose, each of which accommodates only one skull, and to place these in a large, strong case. If skulls are to be sent a long distance, the original boxes or crates should always be packed into large ones. Other bones of the skeleton need a less careful attention.

If the skulls and bones are fragile, their packing and safe transportation is often difficult. In such instances finely cut straw, or short hay, or very dry sawdust, are the most valuable packing, and each skull or small bundle of bones should be boxed separately or well separated from others. Every delicate skull should be tied in a piece of cloth which insures the keeping together of the fragments if the specimen be broken.

With each skull or skeleton should be a piece of paper containing the collector's number, the locality, and the identification of the specimen.

The shipping of osteological material from foreign countries is fraught with few difficulties. Even where there are laws prohibiting the exportation of antiquities, as for instance in Mexico, human bones may be sent out. It is necessary in such instances not to include in the boxes with the bones any other specimens, and to plainly mark the contents as well as their destination on the box. In exceptional cases aid in exporting material can be obtained through the local or consular authorities.

There is no danger of transmitting contagion with bones; but some care must be exercised with the packing material.

If bones not yet fully devoid of smell are to be sent, they should be placed in very dry grass or sawdust, or into a mixture of these with salt; and it may be necessary to put the smaller boxes containing the specimens into a large case and surround them with charcoal. Steeping for a brief time in a stronger solution of formalin would obviate all smell, but would also render the bones, if they still had some soft parts adhering, very difficult of preparation.

BRAINS.

There is no other organ in the human body that differs more from a similar organ in the animal than the brain. The differentiation of the brain not only separates man widely from all other animals, but tends to place in different grades individuals and smaller or larger groups within the human species itself, all of which points to the interest in and necessity for a thorough investigation of this organ.

Within the last century a large amount of research has been made on the brain of the whites. With all that, there are many parts of the organ of which no one knows the function; there are many obscure points concerning the development and decline of the brain; the gyration of the surface requires further attention; the relation of convolutions and brain weight to age, sex, weight, and size of the body, and to functional, including mental, activities, needs further elucidation; and as to the investigation of histological and chemical differences and their signification, scarcely a beginning has been made.

As to the brains of other races but little is known. For instance, the brain of a North American Indian has never been described, nor is there, so far as known, a good specimen of such a brain in existence. And this is more or less the case with regard to all other primitive tribes. Even of such peoples as the Chinese, Hindoos, and negroes the number of brains well preserved or described is very limited.

As there is no ample and generally available collection of racial brains in existence and such a collection is particularly desirable in this country, an effort is being made to establish one in the Division of Physical Anthropology of the U. S. National Museum.

There are abundant opportunities in the United States for obtaining and preserving brains of American and foreign born whites of all grades of intellectual development, and those of the American negroes, which will be of increasing interest on account of the intellectual progress and mixture of this element in the American population. There is no doubt that there could also be secured, now and then, the brain of an American Indian, although the matter is more delicate and difficult. In the Philippines and other United States dependencies the opportunity is favorable, and exceptionally good occasions for acquiring negro and probably Indian and other brains will be presented during the construction of the Panama Canal.

With such prospects there is a substantial hope that if the proper persons can be acquainted with the wants of the National Museum there will before long be a most valuable gathering of brains in the collections there.

Through the present cooperation between the Departments of Anthropology and Biology in the National Museum, the racial brain collection is being supplemented by a similar one of zoological character. A good beginning has been made; at the end of the year 1903, five months after the beginning of the collection, the total number of preserved human and other brains in the Museum reached nearly one hundred, and at the end of July, 1904, this number has a little more than doubled.

DIRECTIONS TO COLLECTORS.

Answers to the following questions should accompany each brain:

a. Name and location of tribe?

b. Sex of the individual?

c. Pure blood or mixed?

d. Real or approximate age?

e. Cause of death?

f. Length of body?

The body length is the distance from the vertex to the heels in a straight line, the feet being, if possible, flexed at right angles to the legs. Mark the points and measure on whatever the body lies upon, not on the body itself.

In warm climates the brain, if it is to be of any value for investigation, must be taken out and placed in a preservative within twenty-four hours after death; in cold climate or season, if the body was more or less exposed to cold, the brain may be in good condition even several days after death.

In taking out the brain, make a scalp cut from ear to ear over the top of the head and push and dissect the skin backward and forward until most of the skull cap is exposed. Mark your proposed cut with a knife. Cut the bone right above the supraorbital ridges and low along the sides, finishing below the occipital protuberance. Use all care not to injure the brain (it will be of value, however, even if slightly injured). To avoid cuts of the brain substance do not saw the bone wholly through, but help to detach the cap with hammer and chisel. Any saw and chisel, if properly and patiently used, will accomplish the purpose. Circular cut of the skull is easier than the angular.

When the skull cap is lifted, cover the sharp edges of the back part of the skull with cloth or cotton, to avoid injury to the brain. Cut carefully the dura mater on each side of the middle line (with scissors). Cut and remove carefully that part of the dura that lies between the halves of the cerebrum. Begin to remove the brain from the front. Cut all nerves and, finally, the spinal cord. Open the tentorium as you come to it wholly, and, helping with one hand from within, receive the brain into the palm of the other hand.

If there is any possibility of doing so, weigh the brain immediately after extraction.

Place the specimen at once in a vessel, base downward, upon a thick layer of cotton. Introduce a thin layer of cotton between the cerebellum and cerebrum. See that the specimen rests evenly. Cover with another layer of cotton, but use no pressure, and pour in an excess of ten per cent formalin. Any large tin kettle or other vessel that can be closed and made tight with wax, gum, or other substance, so that it does not leak, will do for keeping and sending the brain in. To those who apply, the Museum will gladly furnish suitable metal receptacles.

The specimen can be sent, well covered with cotton, at once; but the better way is to send it after eight days, when it is already hardened. Upon receiving the specimen, the charges for transportation will be paid by the National Museum. Address: U. S. National Museum, Washington, D. C., Department of Anthropology. Inclose a copy and soon after mail a duplicate of the required information, and give your full name, title, and address, so that proper credit can be given.

The marks of the autopsy may be obliterated by making several opposite holes in the two parts of the skull with a drill; wire or tie the parts together, and sew the scalp with a small, continuous stitch, combing the hair over all. In that manner the signs left are less than those after some scalp wounds or operations.

Whenever possible all work connected with removing the brain may be obviated by sending the entire head. In winter, a head can be sent as it is, after being covered by cotton saturated with ten per cent formalin; in hot weather it is necessary to make in addition an injection of ten per cent formalin through the carotids.

In an emergency a specimen may be sent in alcohol or strong liquor.

EMBRYOLOGICAL MATERIAL.

The great value of embryological and infant material for physical anthropology has not yet received the attention deserved. It is this material alone from which may be learned racial differences or similarities in the early phases of human development, and it is this material alone which can give instructive developmental series of brains, bones of the skull and skeleton, teeth, etc., for Museum exhibits. There are undoubtedly many physicians who would be glad to furnish to the Museum this sort of material if made acquainted with its needs. A good start has already been made in the National Museum in this direction.

SUGGESTIONS TO COLLECTORS.

Embryos, fetuses, and other products, of both sexes and all ages, are desired. The fresher the product the better; but even if decomposition is advancing the body is still of undiminished value for the skeleton. The smaller specimens of this nature can be sent directly to the Museum; but in cases of premature birth or stillbirth, or an older body, it may be necessary to secure a permission to send the specimen from the local board of health. In the District of Columbia, in the case of a premature or stillbirth, it is by law necessary to fill out the regular return of a stillbirth, to specify as the "place of burial" the National Museum, and to make the following addition on the back of the certificate:

> I hereby authorize [name of the curator] to dispose of the within-described remains as he sees proper, only in accordance, however, with the laws of the District of Columbia.
>
> ——— ———.
>
> (Signature of father or, in his absence, of mother.)

The specimen and return are then sent through the regular channel, the body, if the permission of the board of health be granted, being delivered by the agent of the Board to the Museum.

If possible, the specimens that go directly to the Museum should be sent fresh. Where this can not be done they may be sent in a well-closed vessel in any antiseptic solution convenient (carbolic acid, arsenite of soda, chloride of zinc, strong salt solution, alcohol). Formalin must not be used, for it renders the maceration of bodies for skeletons almost impossible.

In all cases where the slightest difficulty might be encountered it is best to communicate at once with the Division of Physical Anthropology, National Museum, and all needed aid or information will be given.

PHOTOGRAPHS AND CASTS.

In demonstrations and Museum exhibits, as well as in original investigations, a very important part is played by good photographs and casts. A complete collection in physical anthropology ought to include a representation in excellent photographs and facial or whole head casts of every important branch and group of humanity. As it is, there is no institution that possesses photographs or casts of the various racial divisions of even the whites alone. Nor could there be made as yet in any institution with an anthropological section an exhibit of any one nation, illustrating physical types, or such groups as that of the most beautiful individuals, the greatest athletes, the foremost literary men, artists or inventors, in that nation. More has really been done in this respect on primitive peoples than on those more civilized; but there is everywhere an opportunity for doing better.

What is required, and of which nothing can quite take the place, is a systematic gathering of both photographs and casts. Such a desideratum will undoubtedly some time be realized. In the meanwhile all contribution of good photographs or casts, from whatever part of the world they may be, will be welcome and useful.

The most valuable photographs are those of nude, partly nude, or but simply dressed individuals, from glass negatives of at least 5 by 7 inches. If larger plates are used, well arranged groups of several persons of the same sex are of particular interest.

If an opportunity to make photographs or casts is limited, choose only adults of middle age; otherwise extend at least the photography to all. Very interesting series are afforded by whole families.

If individuals are photographed, it is well to take the full face and full profile; in groups only a full face is required. The best posture is that which is most natural to that person; but the eyes should always be directed to observe some object straight in front and about their level. The photographer should know the distance at which he can obtain the best portraits with his instrument, and all individuals photographed should be placed at the same distance from his camera.

It is more valuable to send negatives with prints, than prints alone; in a laboratory almost all negatives can be more or less improved, while the possible bettering of the prints is very limited. It is also much easier to make a good lantern slide or enlargement from a negative than from a print.

In rapid or extensive traveling it may be impracticable to use glass plates and recourse must be had to films. These do not often make as valuable negatives as the glass plates, yet if the camera and the process of photography are well understood the results may be very serviceable.

With each photograph or negative of an individual should be sent data as to the tribe or nationality, place of birth, name, sex, age, and tribe or nationality of father and mother. An identification mark should be scratched in a corner on the negative itself.

Facial or head casts are made from plaster of Paris. Efficiency in making casts is best acquired under an instructor. To the proper person an opportunity to learn the procedure will be provided at the National Museum.

The process of making a facial cast, given here for those who have a chance to practice it, is as follows:

Have the subject comfortably seated on a chair with a back and head rest. See that the face preserves throughout its most natural expression, the eyes being open, and warn the subject against moving, swallowing, coughing, sneezing, or spitting. The lips should not be held tight or puckered, or the mouth distorted. Fasten a wide, ample piece of muslin, like an apron, below the neck of the subject. Brush the hair backward, without pulling the skin, and fasten it by a moderately tightly applied muslin band about 2½ inches broad, leaving all around the forehead and temples a little of the hair exposed.

Work into this visible portion of the hair, and also into the eyebrows, mustache, and beard enough soap paste to prevent inclusion into the plaster. Use either the commercial green soap that comes in paste, or boil ordinary soap with water until the liquid thickens. Introduce a little cotton into each ear. Oil, by means of a camel's-hair brush, the whole face and neck with light paraffin oil (or any other oil that is not viscid); also oil the hair band. Care must be exercised that no excess of the oil is left anywhere and that nothing enters the eye. This finishes the preparation. No nasal tubes are required.

The next step consists in mixing the plaster. Only the best dental plaster should be used. Fill a small basin, of any kind, with lukewarm, or at least not too cold, water, add a pinch of common salt and some wash blue or other coloring matter. Sift the plaster onto the top of the water from your hand, without mixing, until the moment when it stops sinking—this exact stage must be learned from practice. Mix then, without churning, with a common spoon, gather the surface bubbles and any possible dirt and throw away, and the liquid, of cream consistency, is ready for use.

The first layers of the plaster are applied to the forehead, about the the eyes, and over the upper part of the face, with the help of a spatula or a little spoon. The excess of the plaster flows down over the face and onto the apron.

The success of the cast depends largely on the dexterity of the manipulator in this part of the procedure.

The upper part of the face being covered, advance rapidly to the ears and lower part of the face. At this stage it is of advantage to throw the plaster on, with short, gentle jerks, with the fingers. Fill one ear only, but carry the plaster around far enough to show the location of the other ear. If the plaster begins to thicken, strengthen what is already on, but without employing any pressure, and make or have made rapidly a new supply, slightly thicker than at first. Then by repeated throws, as well as with the help of the spatula or spoon, but avoiding pressure, cover the whole face. While the cast is drying add very gently more about the eyelids, taking again much care to use no pressure and especially not to get any of the plaster into the subject's eye, where it would produce severe burning. Add also, if necessary, more plaster about the nostrils. On the ear that is covered, carry the plaster just a little over the convex border.

Strengthen the cast over the forehead and median line of the face; the thickness should range from about one-fourth to three-eighths of an inch.

When through with the application of the plaster, post yourself behind the subject and gently support his head until the cast is sufficiently hard. During the hardening the plaster will generate warmth, but this never becomes too inconvenient or dangerous.

The proper hardness of the cast is learned through experience; it can be ascertained by tapping on it with a finger or some object.

The removal may begin before the hardening is complete, at the hair ribbon, which is drawn backward. Then proceed all along the edge of the cast and press the skin back from it. With the help of the fingers and perhaps of the spatula, free the helix of the ear and by this draw the ear backward. All this can be begun quite early, to occupy the subject's attention and satisfy him, and carried on so slowly that the plaster has ample time to harden. To take the cast off, lay the left hand on its top, grasp with the right its chin part, and manipulate slowly and carefully up and down, and push downward and forward, until it slips off.

There is occasionally some difficulty on account of the beard, or the subject may have tried to swallow or cough or have moved, and a part of the cast may be cracked or imperfect, or a portion may be broken off in removing it. All that can be advised in such contingencies is patient manipulation or careful repair by fitting of the separated parts and additions of plaster to the outside of the cast.

The orbits and nostrils in the finished cast are filled with plaster and the whole is allowed to dry, after which, if the cast is to shipped, it must be prepared for the positive. This is done by simply soaking the cast in a strong solution of common soda (sodium carbonate); or by the soaking and subsequent careful application of thin oil to the inner surface. These processes, with the staining of the negative cast, facilitate its subsequent chipping off from the positive.

The last step consists in carefully mixing a larger quantity of plaster, with addition of salt but not of coloring matter. Pour some of this into the negative, and by inclining the latter in all directions allow the plaster to form a good, thin covering of the whole inner surface. Then gradually add more plaster, persisting in the slow movements, and finally help with the spatula or spoon. It is desirable to make the positive at least half an inch thick. Mark then on the concave surface of the positive with some sharp point whatever data are essential to go with the casts, and allow the whole to dry thoroughly before packing.

In the manner just described, with a little preliminary practice and continual care, from eight to ten first-class facial casts can be made in a day. Different operators may use methods that vary more or less from the above, and there is no harm in adopting any modification that tends to facilitate the procedure or improve the result. Some operators try to secure a cast of the whole head, but this has no advantage. With a good facial cast and photographs the head can be modeled almost to perfection.

Casts of the body should never be undertaken except by one well practiced in the art, for the operation is not without danger to the subject.

Casts of the lowest part of the trunk and of the limbs can be made without any very great danger or difficulties, but they also need experienced hands.

The skin must in all instances be well oiled and the part must not be deformed by wrong position or pressure. A provision for the removal of the cast in sections must also be made, which is usually done by including in the first layer of plaster, along the line of intended separation, a linen thread, and by cutting the cast with this as it begins to harden. The preparation of the plaster and other details are practically the same as in facial casting.

In packing casts, pad well and tightly with very dry hay or other suitable substance, and use only small boxes or barrels.

ADDITIONAL OBJECTS FOR COLLECTION.

It is true that the variations of every organ in the human body are of anthropological importance; but to extend Museum collections to all these parts is at present hardly practicable. The skeletal, brain, and fetal materials claim the first attention. After these have been more thoroughly elaborated and exhibited, there is a good hope that later workers and additional means will make all needed extensions of physical anthropology possible.

The above does not imply that good opportunities to obtain especially valuable specimens for physical anthropology other than skeletal, brain, or fetal should be neglected. Some of the most interesting variations exist in the skin and its appendages, particularly the hair and teeth, and a good collection of any of these parts from any tribe or people is very desirable. Many revertive and other anomalies, some of which may eventually be found to be more or less racial in character, exist in the muscular system, the intestines, the liver, the circulatory apparatus, etc. But for the soft specimens of this category, the most suitable place at present is some representative museum of general anatomy.

The collecting of specimens of skin, hair, and teeth calls for but little instruction. Examples of skin can be obtained, best in small squares, from the dead. The squares should be alike in size and from the same region of the body. The unexposed parts of the back, chest, or limbs are suitable. The specimen should be stretched, with the help of pins, on a piece of board and dried.

Hair should be obtained from persons in good health, preferably children, and again from adults not differing much in age. The aim of the collector should be to obtain all the variations of hair in a particular people.

With both skin and hair it is necessary to have the supplementary data of race, purity of blood, sex, and age.

The opportunity to obtain teeth is limited to the dentists. Here, also, should be recorded with each specimen the race, sex, and age, besides its exact position.

THE COLLECTORS.

The nature of the material required by physical anthropology for the purposes of investigation and exhibition is such as most interests the physician, and therefore this appeal is addressed mainly to medical men, particularly to those who travel, or have charge of hospitals, colleges, dissecting rooms, and remedial institutions. As physical anthropology and anatomy are intimately related and largely interdependent, any service done to the former is also done to the latter, and is an aid to the advance of the medical as well as the natural sciences.

Yet there are other men, to whom science has often been indebted, whose good will, when opportunities arise, might result in much benefit to physical anthropology. Among these are foreign missionaries and teachers, particularly among other peoples than the whites; explorers, primarily interested in other sciences; miners, prospectors, and surveyors and engineers of railroads; men engaged in trades that take them into virgin regions; and travelers of means and leisure. But it lies in the power of every intelligent person to call attention to the discovery of an ancient burial place or cemetery, or to prevent destruction of specimens and direct them to where they can be made useful.

It is almost superfluous to repeat the well-known fact that all the collections of the U. S. National Museum are entirely for public instruction and freely accessible to all scientific workers.

The National Museum is always ready to respond to telegraphic or other requests for vessels or preservatives; and in return for their good will the Division of Anthropology is at all times ready to scientifically aid those who favor it with needed material.

OBSERVATIONS.

An observer trained in anatomy and physiology, or especially instructed, can collect many data of value to physical anthropology. As has been mentioned before, this science comprises the study not only of variations in well-defined groups of mankind, but also of their causes, and this opens a large field for inquiry. But the subject is so important that the utmost care must in every case be exercised, even by well-trained men, to avoid errors.

The desirable observations are those concerning the topography, geology, climatology, and quality of water supply, of the particular region whose people are studied; the nature and sufficiency of food; use, present and past, and abuse of alcoholic beverages or substances like coca, hashish, or arsenic; occupations; the dwellings and habits of life; prevalent diseases; sexual customs or habits, including the age at which sexual relations are established; polygamy, polyandry, and close intermarrying; occurrences of impotence or sterility, and perversion.

Among the most interesting points to ascertain is the proportion of sexes in the tribe.

Taking the woman over 50, one can ascertain, though much care is necessary, her age at the time of the first conception; the number of progeny living and the number that died; the number of abortions with causes; occurrence of twins or triplets; occurrence of blind, deaf, anomalous, or monstrous children.

With infants it is desirable to learn the periods of the beginning and their full ability in walking; the length of exclusive nursing and of nursing in addition to other food; the manner of feeding exclusive of nursing; the time of teething; and infant diseases with mortality.

Among people who keep account of their age, interesting facts may be obtained in regard to puberty, menopause, appearance of gray hair, and data as to longevity.

The occurrence and character of albinos should be noted in detail, giving the family history. The occurrence or prevalence of goiter, cretinism, idiocy, and insanity, as well as tuberculosis, is of anthropological as well as of pathological importance. The description of artificial deformations, mutilations, or operations, may aid in the elucidation of certain conditions found among the skeletons or brains from the region.

Description of hair and beard is desirable. Note the ordinary and the maximum length to which the hair or beard grows when not trimmed; the quantity and distribution of the beard; the character of both hair and beard, whether gross or fine, and whether straight, wavy, curly, or in tufts. The color of the hair and beard often differs. In noting the color it can be referred to the standards, but it is more convenient to use the terms light brown, dark brown, black, pale yellow, red and chestnut (red-black). When necessary these simple and generally well-understood terms may be supplemented by further description and when possible, with specimens.

If there be an opportunity, notes on the hair of the axillæ and pubis may be added, but these points are not of much importance.

The color of the eyes, or more properly iris, is of interest. This also should be recorded in simple terms. The usual colors are gray, greenish, pale blue, rich blue, light brown, and dark brown. The darkest shades of brown are usually classed as black. In anomalous cases the iris may show spots of other colors. The conjunctiva may be pearly white, bluish, or yellowish.

The color of the skin is an item of importance and one seldom properly reported. In this particular it is first of all necessary to choose for comparison the same parts of the skin, and among those who wear clothes, preferably those parts that are usually covered. The upper part of the arm or the back is especially suitable for this purpose. In this case the color should invariably be compared with and recorded by some well-known standard, and the observation should extend to both sexes and numerous individuals. It was largely a lack of precision in reporting the color of the skin that made a red man of our brown Indian, and there are other similar examples. One of the best-known arrangements of standard colors is that of Broca, a part of which, for easier comparison, is appended to these instructions.

Of measurements, only that of the height is fairly safe to be taken by an untrained observer. This measurement is secured by placing a subject against a vertical plane, without shoes or sandals, with the feet together, standing erect, and looking straight forward.

It is well to have fastened on the plane a graduated board or a tape, but the height can also be obtained by marking a point a meter or yard from the ground and measuring with a tape from this to the mark corresponding to the top of the head of the individual. The height is determined by the aid of a square or a piece of board held at right angles against the vertical plane and lowered until it encounters the resistance of the head when a mark is made. A square corner cut from any box will serve this purpose.

At least twenty, not deformed, fully adult individuals of each sex should be thus measured; but the larger the number of individuals the more correct will be the mean height, and the more valuable the general result obtained from the measurement.

Besides the above, it is possible, with appropriate aids or instruments and care, to test the special senses; the pressure or traction force (with dynamometer, Mathieu or Collin); to make, on healthy individuals (for this examine the tongue) valuable observations on pulse, respiration, and temperature; to test for swiftness or endurance in running; to observe the capacity for carrying burdens, enduring hunger and thirst, and capacity for excess in food.

Many of these data are purely physiological; the physiology of races, tribes, or other groups of mankind, however, goes hand in hand with physical anthropology and is equally important.

BROCA'S COLOR STANDARDS.

These color standards were originally published in Pierre-Paul Broca's Instructions générales pour les recherches anthropologiques à faire sur le vivant; 2 ed., Paris, 1879; and are printed after a copy of the original. They are retained in order that new observations may be compared with those made in the past. To facilitate determination, Broca's arrangement of the colors on the pages has been somewhat changed, but his numbers remain. To use the color scheme, choose a certain ordinarily unexposed part of the skin, as of the arm or the back, and match one color after another of the plates with the skin until the one is found which agrees most closely, and this you record by its number.

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BROCA'S COLOR STANDARDS.

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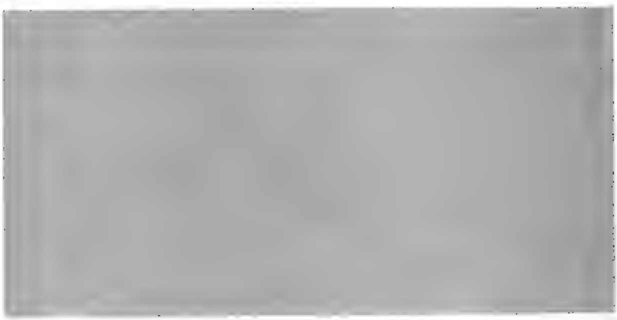

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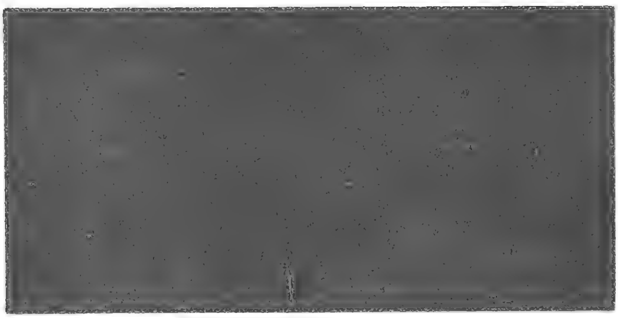

BROCA'S COLOR STANDARDS.

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BROCA'S COLOR STANDARDS.

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BROCA'S COLOR STANDARDS.

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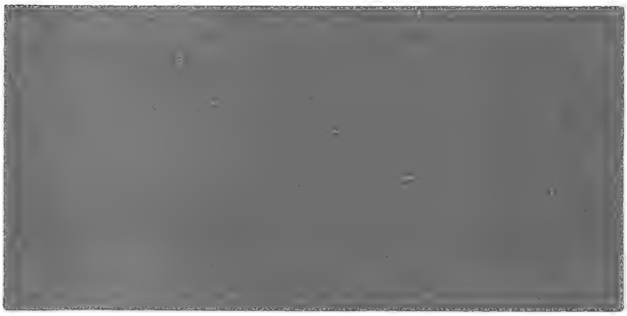

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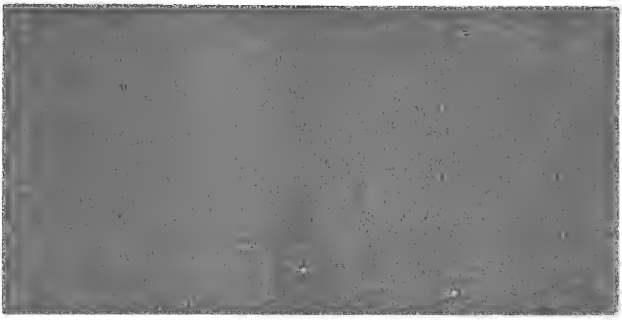

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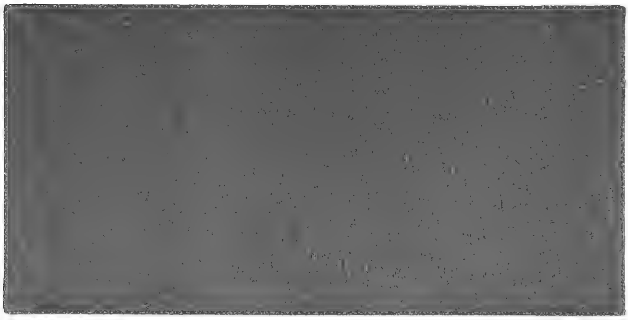

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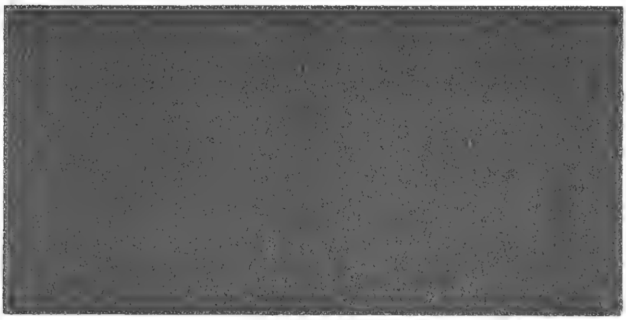

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BROCA'S COLOR STANDARDS.

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BROCA'S COLOR STANDARDS.

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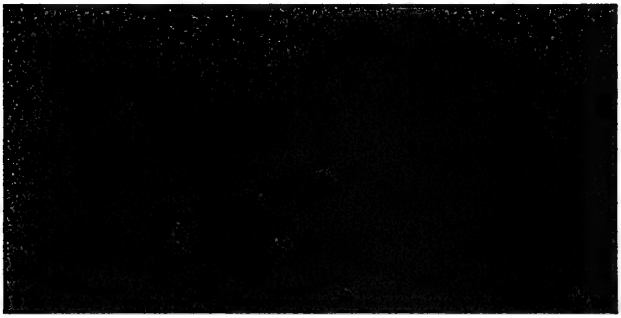

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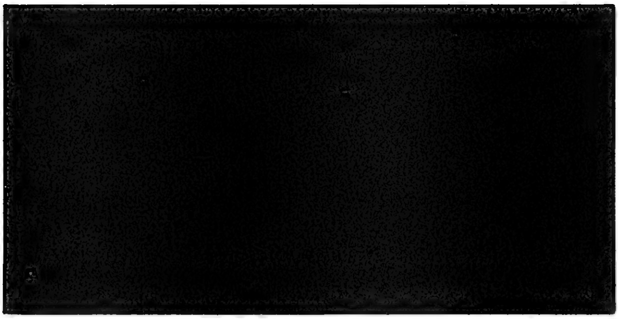

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BROCA'S COLOR STANDARDS.

DIRECTIONS FOR COLLECTING INFORMATION AND OBJECTS ILLUSTRATING THE HISTORY OF MEDICINE

BY

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DIRECTIONS FOR COLLECTING INFORMATION AND OBJECTS ILLUSTRATING THE HISTORY OF MEDICINE.

The Division of Medicine in the United States National Museum seeks to illustrate in the fullest possible manner the medical theories and practices of mankind in every part of the world and at all periods. For this purpose it asks aid of those who may be interested in this branch of anthropology in the collection of information and illustrative objects.

To make clear the subject which it is desired to investigate, the following provisional classification of theories of disease and remedial measures is presented:

THEORIES OF DISEASE.

(1) Disease, a malevolent spirit, assuming material form either animate or inanimate, attacking the victim with or without provocation. Primitive.

(2) Disease, a spirit, acting at the suggestion of a human enemy possessing supernatural powers (sorcery, witchcraft, conjury). Savage and half-civilized peoples.

(3) Disease caused by the angered spirits of the dead, either men or animals, or even plants. Savage and half-civilized peoples.

(4) Disease, a punishment inflicted by an offended deity. Ancient; persistent.

(5) Disease due to the influence of the planets or other heavenly bodies. (Astrology.) Arabians; persistent in Europe to the seventeenth century.

(6) Disease due to a variation in the relative activity of two controlling principles of life, namely, heat and moisture, or "yin" and "yung," or the male and female principles. Persian, Chinese.

(7) Disease due to a disturbance in the relative proportions or distribution of the fluids or "humors" of the body, namely, blood, phlegm, black bile, and yellow bile. Hippocrates, Galen. ("Humoralists.")

(8) Disease due to changes in the form, number, arrangement, or movement of the "atoms" of which the body is composed. Asclepias. ("Solidists" or "Methodists.")

(9) Disease due to the abnormal action of the dynamic or vital force ("spirit," "pneuma," "archæus"). Athenæus, Paracelsus, Hahnemann. ("Vitalists.")

(10) Disease considered only with respect to its manifestations or "symptoms," regardless of causes. Philenus, Sydenham, Hahnemann. ("Empiricists.")

(11) Disease due to various and complex modifications of normal structure and function resulting from the conditions of environment or inherent tendencies. Modern scientific medicine.

CLASSIFICATION OF REMEDIES.

A—Magic medicine.—Exorcism, invocation, incantation, amulets, talismans, fetiches, signatures.

B—Psychic medicine.—Laying on of hands, royal touch, music, metallotherapy, suggestion, hypnotism, Christian science, faith cure.

C—Surgical medicine.—Baths, massage, exercise, electricity, acupuncture, cautery, blood-letting, surgical operations and appliances.

D—Pharmacological medicine.—American Indian medicine, Egyptian medicine, Greek medicine, Arabian medicine, oriental medicine, Hindu medicine, modern medicine.

E—Preventive medicine.—Water, air, food, beverages and condiments, soils, habitations, sewage, clothing, climate, disposal of the dead, disinfection.

The class of remedial measures to which it is desired to call especial attention by this circular is that of magic medicine, or "folk medicine." Superstitions regarding disease and its remedies are everywhere prevalent, not only among the uncivilized and the unlearned, but also, to a greater or less degree, in the most cultivated communities. The horse chestnut for the prevention of rheumatism is not found exclusively in the pockets of the ignorant.

Those who are brought into close relations with the peoples of our island possessions have great opportunities for pursuing this line of investigation, and their assistance is earnestly sought. But there is also a wide field for the study of the subject and the collection of material in every town and hamlet in our country.

Magic is defined as the "pretended art of producing supernatural effects by bringing into play the action of supernatural or spiritual beings, of departed spirits, or of the occult powers of nature." Its application to the treatment of disease is magic medicine. The agents may be gods or demons, disembodied spirits of men, animals, plants, or minerals, or may be occult influences residing in, or exerted through, certain natural objects. These agents or influences are often brought into action by invocations, incantations, or ceremonials of various kinds.

The divisions of magic medicines, according to the foregoing classication, are:

1. *Exorcism.*—Casting out evil spirits by religious or magic formulas or ceremonies.

2. *Invocations.*—Prayers for the assistance of disembodied spirits of animals or men, or of mythological gods or heroes, or of the Deity.

3. *Incantations.*—Magical words said or sung.

4. *Amulets.*—Objects worn as a protection against disease.

5. *Talismans.*—Objects supposed to work wonders, whether kept in one's possession or not.

6. *Fetiches.*—Material objects believed to be the dwelling of a spirit, or to represent a spirit, that may be induced to help the possessor.

7. *Signatures.*—Some outward sign appearing upon plants, minerals, or other objects, believed to point to their appropriate medicinal uses.

Specifically, the Division of Medicine desires details of the ceremonies of exorcism said to be practiced extensively by the Indians and negroes of this country; the words used in the incantations over the sick, especially in the Pacific Islands and the East; amulets, talismans, and fetiches, all of which abound everywhere; medicines illustrating the "doctrine of signatures," much regarded in oriental and ancient European medicine; surgical instruments and appliances of all sorts; medicinal substances, giving source and uses of each.

The value of a museum specimen, as such, is largely proportionate to the amount of information which accompanies it, and to which it directs attention. Therefore, the facts regarding the nature, source, mode of preparation, attributed virtues, mode of use, and attendant ceremonials, together with the localities where used, and the class of people using it, should be given in the fullest possible detail.

Material which can be sent by mail should be addressed to the United States National Museum, Washington, D. C. (for the Division of Medicine). If packages are too large for the mail, write to the Museum for shipping instructions.

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