STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

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Bulletin No. 18

FIRST AID TO FOSSILS

or

What to Do Before the Paleontologist Comes

By

JOHN ELIOT ALLEN

Field Geologist of the Department

FOREWORD.

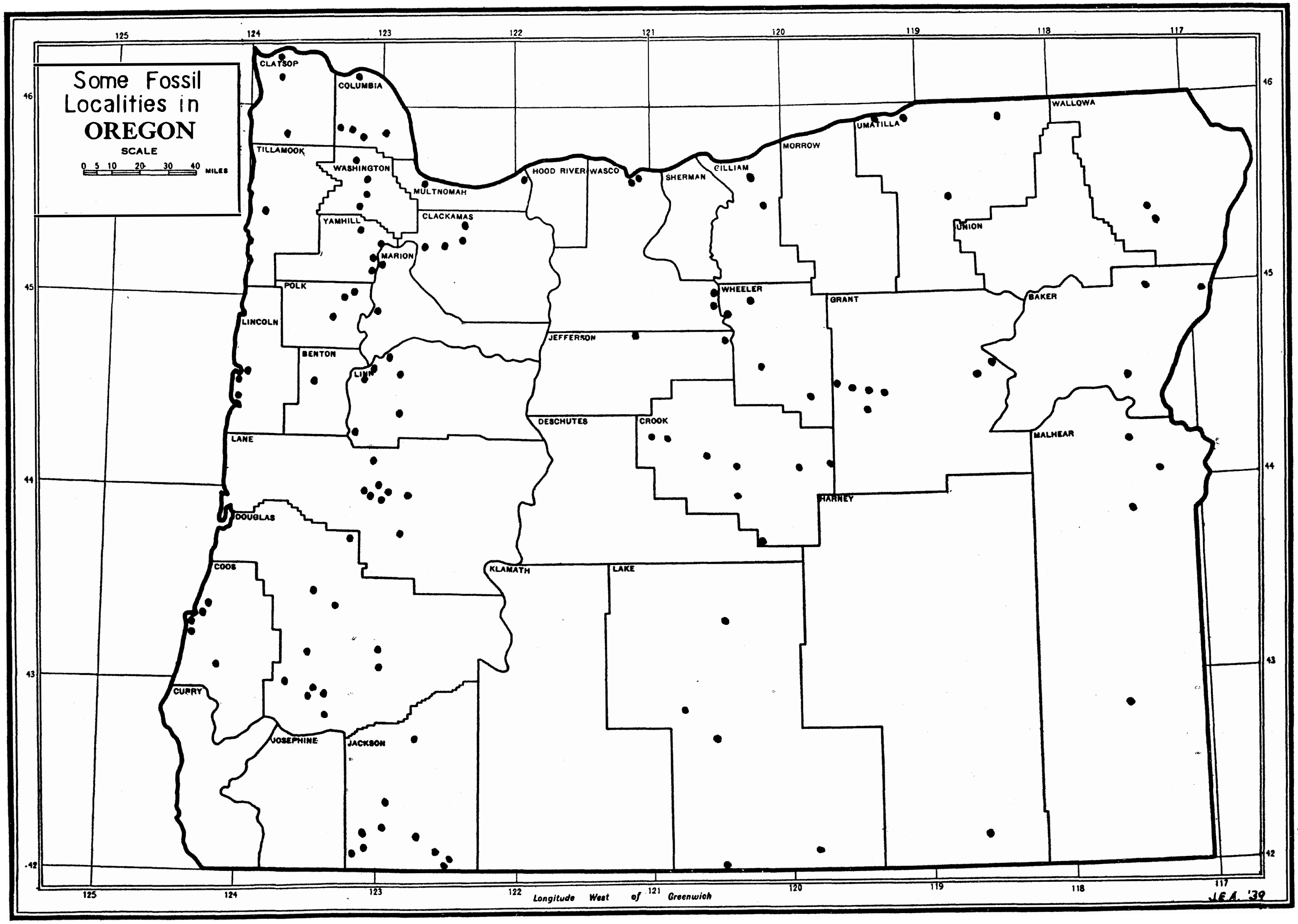
Judging by the condition of fossils shown us by amateur collectors, there is a definite need for instruction in regard to gathering, care, and preparation of these interesting and sometimes very valuable bits of geologic evidence. Many laymen have a habit of picking up fossils or parts of fossils, carrying them home and letting them lie about, considering them merely as curiosities, as one would a "funny shaped rock from Mount Hood." This custom is of course unfortunate. It is fair neither to the fossil nor to some geologist or stratigrapher who might come along and make some very valuable use of the specimen if he found it in place.

The point of this bulletin is to inform laymen and amateur collectors, so that they may give the proper care and attention to the gathering, labelling and the protection to such specimens as their real importance deserves.

There are some very famous fossil beds in this state. The localities are indicated on the index map and referred to in the appendix. Fossils of many types and sizes, from little fellows the size of a bean to the fossil remains of prehistoric elephants, have been found in this state and at points within a mile of a trans-state highway, so anyone may pursue the collecting of fossils with ease in Oregon and with reasonable expectation not only of finding specimens of interest to the collector, but possibly of finding specimens of real scientific value.

Earl K. Nixon, Director.

Portland, Oregon,
September, 1939.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Longitude West of Greenwich
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ABSTRACT.

Lack of general public knowledge of the simpler procedures used in the collection and care of fossil material has frequently led to the destruction of valuable specimens. This paper attempts to fill the need for an inexpensive non-technical handbook which will furnish the casual finder or the amateur collector of fossils with information on the proper methods for the collection and preservation of his finds.

A fossil is any evidence or record of past life. It may be original animal or plant matter; it may be carbonized or petrified material; or it may be only impressions, imprints, molds, or casts of the shape of the animal or plant. Fossils are most commonly found buried in rocks which were originally formed as sediments on the floors of shallow seas. They are of value in telling us what the animals that lived in the past were like, and in helping the geologist sort out the layers in the crust of the earth. Departments of paleontology at the various coast universities and colleges are always anxious to learn of new discoveries, and can sometimes help the amateur in his work.

Various tools can be used to remove the fossil from the rock, depending on the type of fossil and the rock itself, but a geologist's pick and some small punches and a brush are indispensable. The fossil is usually painted with shellac to preserve the surface as it is removed, and when especially delicate, it is taken out in a block and then cleaned in the laboratory. It is very important that the exact location of the specimen in the rock and on the map be recorded in a notebook or on cards, in the field at the time of location.

Invertebrate animals (shellfish, etc.) are the most common type of fossils found in western Oregon, and require the least careful treatment.

Vertebrates include all the higher types of animal life, and their skeletons are found preserved in volcanic ash in Eastern Oregon and in gravels in Western Oregon. The bones require more care in removal from the rock, and are usually shellacked as they are found. Large specimens require a special procedure, and the exact position of the bones must always be recorded.

Plant remains appear in clays or ash, and may be split out with chisels, and the surfaces shellacked.

Fossil remains of microscopic life are of greatest importance to the oil geologists, as they enable him to date the formations in the deep wells. The rock in which they appear is dried and crushed and the fossils screened out; the fossils then being mounted on microscope slides for study and identification.

The collector should not try to clean the fossil in the field, as this work should be done in the laboratory where proper tools and time are available. Large fossils can be mounted on convenient tables under bright light and can be delicately cleaned of the rock with small scratchers and needles. Fossil fragments can be fitted together and cemented to form a complete specimen, or lost pieces may be reconstructed with modeling clay. They may be then labeled and mounted for display.

Appendices to the paper include lists of "Don'ts for Diggers"; authorities in the various fields of paleontology upon the Pacific Coast; reference books for those who wish to go into the field of paleontology a bit farther, and a map of some of the fossil localities in Oregon.

INTRODUCTION.

Fossil hunting can be a hobby as well as a scientific pursuit. It supplies the adventure of travel in both time and space, and the possibility of new and important discoveries often made close to home. The collection, preparation, and identification of fossil forms, if pursued in the right way, offer an excellent opportunity for study and for the development of skill. Unskilled diggers, however, may do irreparable damage to valuable material.

Several times in the last year or so the author has seen excellent specimens of fossil material from various parts of Oregon, whose value has been lost either due to the collector's lack of skill, or to his failure to describe properly the locality or conditions where the specimens were found. Fossils that are carelessly taken care of often quickly break down in unrecognizable debris.

An admirable and authoritative handbook on the collection and care of fossils was prepared by C. L. Camp (of the University of California) and G. D. Hanna (of the California Academy of Sciences) and published in 1937 by the University of California Press. This book is the first to give comprehensive information in English on the technique of collection and preparation. With its help the student may inform himself of the proper treatment of a fossil at each stage from the original rock to the museum case. The discussion, however, is intended more for the professional than for the amateur, and although the book is a required part of the paleontology student's library, the writer feels that the beginning fossil collector or hobbyist needs a guide which is both less expensive and less detailed. It is also felt that the present bulletin may be of value to those who inadvertently discover important fossil localities and want to know "what to do about it."

For both inspiration and a large part of the material used the author wishes to acknowledge his great debt to Messrs. Camp and Hanna.

Dr. Ralph L. Lupher, at State College of Washington at Pullman, has given valuable criticism and suggestions, as has Dr. Warren D. Smith of the University of Oregon at Eugene.

CHAPTER I.

WHAT ARE FOSSILS ?

Definition:

Broadly speaking, a fossil is any evidence or record of past life, whether that evidence is direct or indirect. Any evidence, so long as one can tell something about the type and form of the life that once existed, can be considered a fossil. The word is derived from the Latin "fossa", a ditch, and literally means "something dug".

What are the different types of fossilization?

This record of past life may be in the form of original material of the plant or animal which has been preserved. Usually only the hard parts of animals are preserved; the flesh, skin, and even hair decompose rapidly, while the bones and teeth may last until they are buried and the decaying action of air and bacteria can no longer act upon them.

In rare cases the entire animal may be preserved. The more or less intact bodies of the wooly mammoth, an extinct elephant, are frequently found frozen in the perpetual ice of Siberia and Alaska. So well preserved are these carcasses that sled dogs have been known to feed upon them, and the hides and skeletons have been taken to museums and mounted for display. The mammoth became extinct many thousands of years ago, but he has been preserved in nature's cold storage.

The giant ground sloth, a great browsing animal who lived in the deserts of southwestern America many hundreds and perhaps thousands of years ago, has also been preserved in part, in this case by drying. Its dried-up skin and hair and portions of its mummified body have been discovered in caverns.

The more resistant teeth and bony structures of animals may be preserved in a fair state for millions of years, and the hard parts of now extinct shellfish are frequently found imbedded in the rocks. At Rancho la Brea (now Hancock Park in Los Angeles) a great pool of asphalt existed thousands of years ago. Water birds became entrapped upon its deceptive lake-like surface. Coyotes and wolves trying to feast upon the birds also became entangled. Mammoths bogged down upon its banks, and the saber-toothed tigers feeding upon their slowly sinking carcasses were also caught. All were engulfed in the tar and their bones were preserved. This pit is now one of the most prolific sources of vertebrate fossils known.

Wood that is buried under sediments gradually gives up its gases and liquids due to the pressure of the overlying rock, and is turned to more or less pure carbon. This is called preservation by carbonization. The best example of this is coal, consisting as it does of plant remains that have been carbonized to a greater or less degree. Anthracite coal and even graphite result when this squeezing process is aided by heat. The changes may go to such limits that little but carbon remains of the original material.

The bituminous and lignite coals (the coal of the Oregon Coos Bay region is a sub-bituminous grade) result from a less complete elimination of the volatile materials. The woody structures and leaves are better recognized in these types.

The original material of fossils is frequently replaced or petrified in such a way as to preserve beautifully the most delicate structures. Water percolating through the sediment dissolves out the original material, molecule by molecule, at the same time replacing it with the chemicals in the water, so that even microscopic structures may be preserved in the new material. Lime, silica, iron oxides, or iron sulfide, or even silver, may be the replacing material. In the case of replacement by silica, the raw material may be in the form of opal; opalized wood is frequently found in Eastern Oregon and whole petrified trees are common in the basalts of Washington. Bones and shells, as well as wood, are occasionally replaced, and the resulting material is not only as hard as rock, but actually is rock. Calcification (replacement by lime) usually occurs when there is limestone near, and the red iron oxide (rust) also acts as a replacing agent where much iron is present in the surrounding rocks or in solution.

Frequently the only record we have of a fossil consists of its imprint in the rock, the fossil itself having been dissolved by the ground waters or having rotted completely away. In the case of bones and shells, the hollow remaining is called a mold; in the case of flat fossils such as leaves, an impression. If the sediment in which the fossil was buried is fine-textured, the details of the mold can be sufficiently clear for accurate identification. The hollow mold may be filled in by the chemicals carried by the ground waters and form what is called a cast. A cast has the same outward appearance as the original fossil, but does not preserve the internal structures as does petrification.

Where are fossils found?

Fossils are most frequently found in marine sediments. This is due in part to the greater abundance of sea-living animals; the necessity for burial in order to be preserved as a fossil; and the predominance of sea-deposited sediments. The rivers are constantly bringing sand and silt and organic material into the sea, and the teeming life there is constantly dying and falling to the bottom to be covered up and preserved as the sediment hardens to shale, sandstone, or limestone. Members of the clam and snail groups are found buried in the rocks over a large portion of the earth. Corals, sand dollars, shark's teeth, and even hard parts of sponges are not uncommonly found, but remains of the soft jelly fish, sea cucumber, and sea anemone are very rarely preserved, and then only as imprints. Fossils appear less frequently in sediments laid down by rivers or in lakes than in ocean sediments, and are still more rarely found in sediments such as volcanic ash or sand dunes laid down on dry land. Tree leaves are sometimes found in ash, but probably only when the ash and leaves fell into small lakes and pools of water. Trees covered over with molten lava flows are frequently replaced by silica. If the wood is partially or wholly burned by the heat of the lava, a mold may be left in the solidified rock to show where the tree once lay. In numerous cases trees have been surrounded by lava and have remained upright in their original position.

Why are fossils valuable?

It would be impossible to trace the development of plant and animal types through the ages if it were not for the remains of past life on the earth. The fossils in different layers of rock in the crust of the earth can be compared and a story can be constructed, incomplete to be sure, of the growth and changes which took place in the life forms during the passage of millions of years in the history of the earth.

Although fossils do not tell their age in actual terms of years, they do tell their age in relation to other fossils; so that by their use, the paleontologist has built up the geologic calendar (Appendix E) of the events of the past.

The groups of animals that used to live together in any one place and time can be reconstructed, and will even tell (by comparison with present-day types) the sort of climate in which they lived. It would be impossible to explain how the horse came to run on its middle toe (hoof) or how the elephant developed its trunk if it were not for the study of primitive fossil types. Fossils, therefore, give us a key to the origin of the forms we see today.

Fossils also have their uses in economic fields. Oil geologists now almost universally use microscopic fossils (especially foraminifera) to determine the relationships between the rock formations cut in drill holes and to correlate oil-bearing rocks from place to place.

Who are most interested in fossils?

The study of fossils continues today. Numerous as are the specimens in the many museums and universities of the world, there are still gaps in the record which can only be filled in by continued investigations. The amateur can greatly help the professional paleontologist by discovering new localities where fossils appear, and by knowing how to take care of them so that they can be properly removed from the rocks and preserved for study. A fossil may lie in the rock for a hundred million years, and then by destroyed in five minutes by the digger whose enthusiasm is greater than his knowledge.

The departments of paleontology of the various state colleges and universities are always anxious to learn of the discovery of new fossil localities, and sometimes can send skilled men to help in digging them out. On the west coast there are departments of importance in the following cities:

Eugene, Oregon	Department of Geology, University of Oregon.
Corvallis, Oregon	Department of Paleontology, Oregon State College.
Seattle, Washington	Department of Paleontology, University of Washington.
Pullman, Washington	Department of Geology, State College of Washington.

Berkeley, California	Museum of Paleontology, University of California.
Stanford University, California	Department of Paleontology, Stanford University.
Los Angeles, California	Department of Paleontology, at both University of California at Los Angeles and University of Southern California.
Pasadena, California	Department of Paleontology, California Institute of Technology.
Ellensburg, Washington	Ellensburg State Normal School.

CHAPTER II.

HOW TO GO ABOUT IT.

What collecting tools are needed?

The tool most frequently used by the geologist and amateur collector of fossils is the "geologist's hammer" or pick, one end of which consists of a flat and usually square face for rock breaking, while the other end is elongated to a point for splitting and prying. This tool can be of great value, but for even the most simple fossil collecting it should be supplemented with a small punch or chisel (for more delicate work) and a soft paint brush (for cleaning the surface as it is exposed). A sharp punch has been found to be much more effective than a cold chisel by Lupher (39) as it can be set at various angles and tapped slightly so that it will break away almost any desired piece of rock. Chisels can perhaps be used to advantage in splitting well stratified rocks, but for extraction of fossils imbedded in a solid rock mass they are very dangerous, since with the vigorous pounding usually needed to drive the chisel into the massive rock, unsuspected planes of weakness are liable to break across the specimen. A number of more specialized tools are frequently useful, but usually they can be kept in the laboratory for further work.

Heavier tools such as railroad picks and miner's ("drift") picks and light sledge hammers are needed when a large amount of rock must be broken in hunting for fossils. The paleontological or "Marsh" pick has one end flattened for splitting the layers of sediments. It is similar to, although smaller than, a railroad pick. The infantry or trench pick is less expensive and usually just as handy.

Smaller tools in addition to the geologist's hammer and punches consist of various shapes and sizes of "scratchers", both curved and straight. They can be made from shoemakers' awls and are used for working away the rock that surrounds the specimen. Whisk brooms or large paint brushes are used for brushing away debris and dirt. Trowels and pocket knives are sometimes useful, as are buckets and scoops for removal of earth.

Common camping equipment should usually be carried in the car, as fossil hunting takes one well off the main highways. The author always carries a shovel, axe, and block and tackle, besides large canteens, tin cans, or water bags which are necessary in a dry country. A small box of canned and dried food and crackers can be kept in the car for emergencies.

How are fragile fossils cared for in the field?

If the specimen is soft or fragile, it must be treated before removal. After it is cleaned, pure white shellac is most commonly used to coat and preserve the surface. The shellac must be diluted from 1/2 to 2/3 with alcohol so that it does not form a thick coating. A convenient method of carrying the shellac is in a mayonnaise jar, the cover of which is pierced so that the brush handle can be stuck through the hole and held there by a string or rubber band wrapped around it. In this way the brush cannot dry and the shellac is kept clean. Some prefer glue to shellac, which has a drying effect. Others believe that glue should never be used for coating a specimen, as it is hard to remove and is gummy.

When the specimen is cleaned and ready, it is prepared for transportation to the home laboratory. Lupher (39) has found that tin cans are most useful in carrying small fragile fossils. The specimens can be wrapped in tissue paper and placed loosely in tin cans, and can then be moved with safety even when mixed in a box with large rock specimens. Wet newspaper or tissue wrapped around fragile shells is a very effective protection, because the paper is soft when wet and dries to form a remarkably strong paper shell around the specimen.

If the fossil is very large and cannot be lifted from the ground in one piece, it is then "jacketed", a process which is described under the chapter on treatment of bones.

A screen can be used to separate and recover the shells occurring in soft sediments (loose sands or gravels). A few rigid boxes and lumber and nails for crating large specimens should also be carried along.

How is the fossil recorded?

It is better to leave a fossil in the rock than to collect it without a careful and detailed account of the locality in which it is found. Museums and scientific collectors cannot use specimens whose exact location of origin is not known, since the fossil is practically worthless without this information. The main value of a fossil lies in its ability to "date" the geologic formation in which it occurs and to tell what the conditions around it were at the time when it was buried. Many otherwise rare fossils collected by persons who did not record the localities from which they came now have little or no scientific value.

The collector should carry a small notebook with him at all times (some prefer small filing cards that can be carried in a box). In this notebook is recorded all essential information about the specimen, its locality (and locality number), geologic formation, type of rock and rock structures.. The locality number should be written upon the fossil itself with India ink and pen carried in the field for that purpose. This recording must be done in the field at the time of collection, as it is a well known fact that one seldom describes a locality completely enough even when on the spot, and a description written up after one gets home is apt to be useless. Each sample should be numbered and the number entered in the notebook opposite the description, preferably on separate pages or cards.

The following points should be noted:

Locality and specimen number: If a large number of fossils are taken from one place, a locality number is sufficient. One system used gives information for the number "V 39 16", as meaning that the fossil is a vertebrate (V), collected in 1939, at locality number 16.

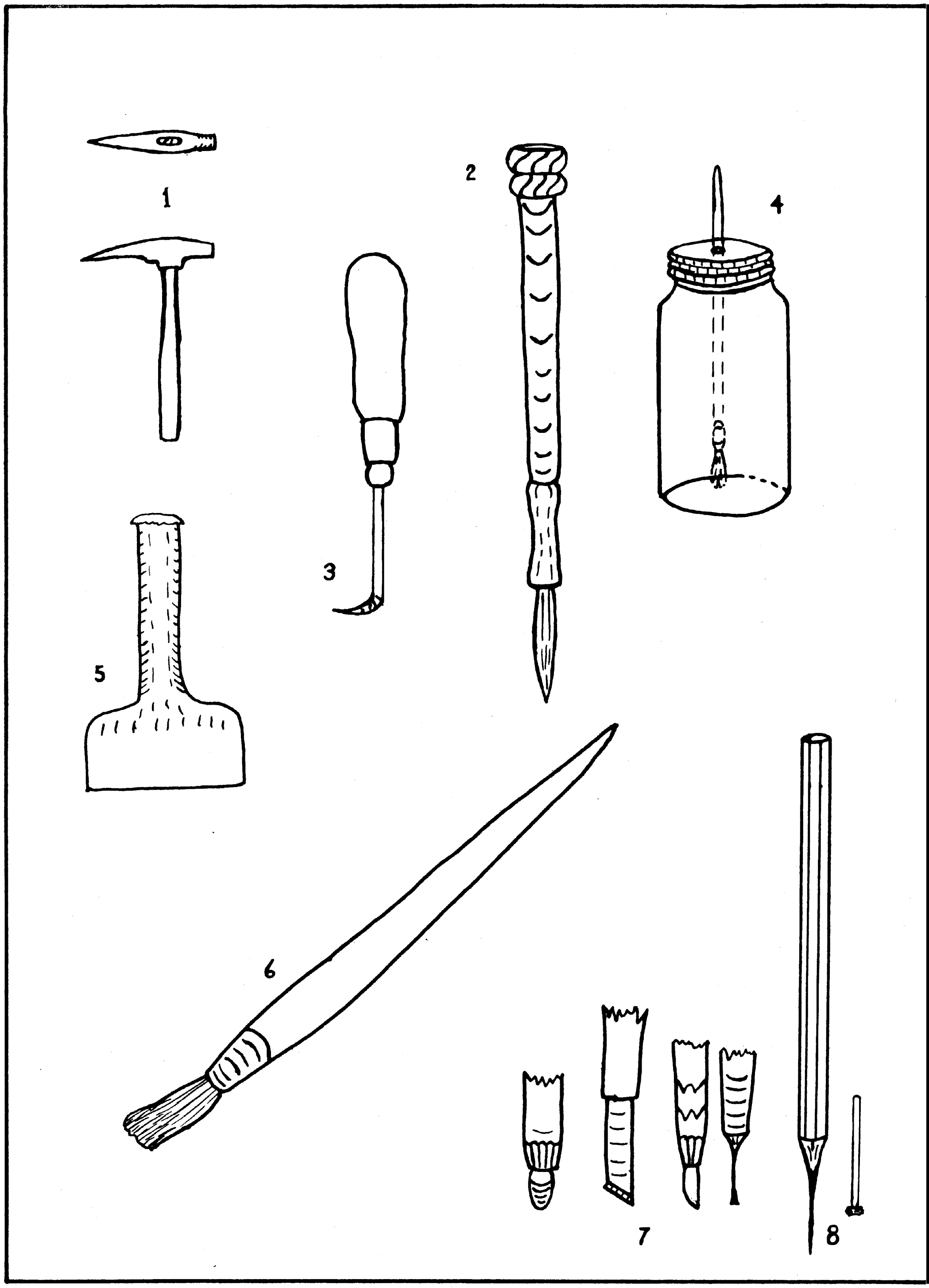

Plate 1. 1, geologist's pick; 2, "Chinese" pick; 3, awl; 4, shellac bottle; 5, paleontologist's chisel; 6, camel's hair brush; 7, scratchers; 8, needle made from dentist's burr.

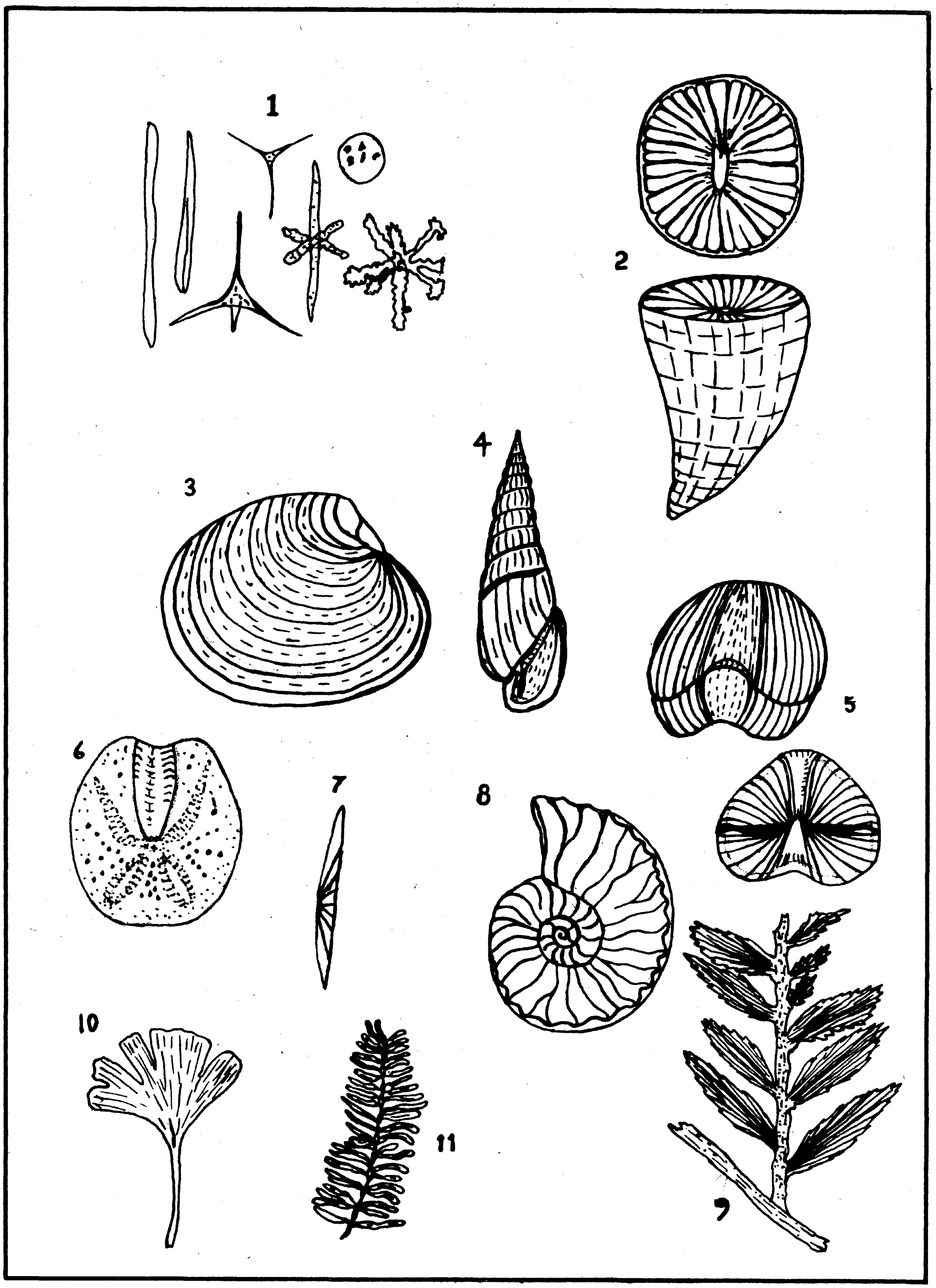

Plate 2. 1, sponge spicules (much enlarged); 2, solitary coral; 3, clam; 4, snail; 5, brachiopod; 6, sea urchin; 7, sand dollar; 8, ammonite, 9, cycad; 10, gingko; 11, sequoia.

Location of specimen: The exact position of the fossil in the excavation and its location with relation to the various layers of sediments should be noted ("ten feet below the top of the central sandstone layer" or "18 inches above the basal conglomerate"). A photograph of the digging is very convenient, and the exact location of the specimens can be marked upon it later with India ink. Next best, a sketch can be made of the locality. The location of the digging should be described according to the land survey, if possible (section, township and range), and it should be further described as to elevation and any natural landmarks such as creeks, roads, peaks, towns, or other points of general knowledge. In other words, be sure that a total stranger to the region could take your description and go directly to the locality.

The rock formation and the structures within it should be described. If the formation has a name and its age is known, this should be given. The thickness of the formation, and the distance of the specimen from its top or bottom, or the distance from some prominent marker bed are pertinent data. If there are characteristic structures such as unconformities, faults, folds, or crossbedding apparent, these should be described.

The name of the collector and the date at collection should always be noted.

CHAPTER III

SHELLFISH AND OTHER SPINELESS CREATURES.

What are "invertebrates"?

"Invertebrates", or creatures lacking a backbone, have contributed more, perhaps, to the arrangement of the geologic time table than all other types, due to their relative abundance in the ocean and along the shores and thus in the sedimentary rocks of the earth. The number of different forms and kinds of invertebrates runs into the tens and even hundreds of thousands, and the types vary rapidly, both in time and over the earth. They occur in tremendous variety, and the familiar forms of those which furnish easily preserved hard parts are listed below:

One-celled animals (see Chapter VI)
Sponges and corals.
Sea Urchins and sand dollars
Bryozoans (moss-like animals)
Bivalves: clams, oysters, mussels, brachiopods, etc.
Snails
Nautilas, squid, octopus, ammonites (extinct)
Crabs, lobsters, shrimp, scorpions, insects, spiders
trilobites (extinct)

These types can be studied in the texts given in the bibliography.

How are shells collected?

Shells occurring in loose sediments, such as sand or gravel, can be removed easily with a screen or large sieve. All broken pieces should be carefully collected and fitted together. They can sometimes be cemented together in the field after cleaning with a toothbrush or stiff paint brush, but this is usually done in the laboratory. They are packed in soft paper, cotton, or wet newspaper, and put in small individual boxes, tin cans, or in larger boxes with individual compartments. If a large amount of material is collected from loose sediments, it may be packed in boxes or sacks in the sand or sediment in which it occurs.

When the shell has decayed and left only a mold, it is sometimes possible to paint the inside surface with oil so that the mold can be filled with plaster of paris, and the rock broken away to leave a plaster cast of the specimen. A mold of the inside of a shell is of less value than one of the outside in identifying the species.

Chalky or crumbly shells can sometimes be preserved by uncovering one side and painting with shellac or Bakelite varnish. The other side is then uncovered and painted.

Heavy tools are needed to break out fossils in hard rocks, and then it is often a very slow chipping and scraping job to then completely release the specimen. Sometimes it is easier to break out the fossil and take a plaster cast of the mold than to save the fossil itself. In hard shales and slates one can only split the rock and save the pieces that show fossil imprints on the split surfaces. Both sides of an impression should be saved.

Fossils will usually weather and stand out from the surface of exposed limestone, while in freshly-broken fragments they are very hard to recognize.

CHAPTER IV.

BONES - FROM MOUSE TO MAMMOTH.

What are vertebrates?

The great group of animals with backbones, known as vertebrates, are less common and numerous than the invertebrates or animals without backbones, but they have great variety of size and kind. The more important divisions of this great "phylum" are:

Fishes: sharks, lung fish, garfish, true bony fish.
Amphibians: water dogs, frogs, toads, extinct stegocephalians.
Reptiles: lizards, snakes, turtles, crocodiles, and the extinct dinosaurs, flying and swimming reptiles.

Birds.

Mammals: which include 11 orders, the most important of which are:
- Marsupials: kangaroo and other Australian types.
- Bats.
- Edentates: ground sloths, glyptodonts.
- Carnivores: dogs, cats, weasels, bears, seals, extinct creodonts.
- Rodents: rats, mice, rabbits, squirrels, beaver, etc.
- Hoofed mammals which have 1, 3 or 5 toes; horse, rhinoceros
- Hoofed mammals which have 2 or 4 toes: sheep, cow, pig, deer, camel, elephant and mammoth; also extinct Amblypods, Condylarths, and titanotheres.

Whales and dolphins.

Primates: monkeys, apes, man.

How are vertebrate fossils found?

In Oregon vertebrates are most frequently found in the beds of volcanic ash or tuff which make up several formations, especially in the eastern part of the state. When covered with lava or rimrock, these beds often form cliffs, as in the canyon of the John Day below Dayville. The collector must actually "prospect" around the base of these exposures, looking the slopes over carefully for chips and pieces of bone. When one is found, he tries to follow it up the slope down which it came, and to discover its source if possible. The fossil from which it was derived may be found sticking out of the solid rock, or it may have been mostly worn away.

How are bones collected?

The petrified bones and teeth of vertebrates require a great deal more care in their removal from the surrounding rock than do fish skeletons, which can be split out like leaves from the fine sediments in which they lie, or than the shells of the simpler types of animal.

Bones or teeth found loose upon the surface can only be labeled and packed away. Sometimes it is possible to fit several fragments together to make a more or less complete piece.

Bones found in place in the rock may be much more valuable, and greater care must be taken. Unless the collector has had some experience it is usually wisest to cover up the locality and wait until a professional paleontologist can work out the fossil. Improper treatment may ruin a valuable specimen.

If there is more than one bone or fragment of bone in the rock, care must be taken to mark and keep them in their original relation to each other, as the reconstruction of the animal will depend upon how the bones were arranged in the rock.

The fossil bone or collection of bones is first carefully uncovered on one side. A mallet or hammer and punch and scrapers are used to cut away the rock, while the surface of the fossil is kept brushed off. Whenever there is any doubt as to whether a particular piece is rock or bone (and this is often the case) it is left in place and later worked out in the laboratory. Plenty of rock should be left on the fossil now, as it will act as a support during transportation and protect the bone surface. The surrounding rock or "matrix" is slowly chipped or scraped away without exposing any more of the bone than necessary, until the fossil stands out from the rest of the rock.

Soft and crumbly surfaces are painted with one or more coats of dilute shellac or Bakelite varnish. Shellac cannot be used if the specimen is wet and cannot be dried out. One method that is satisfactory in this case is the use of a thick coating of beeswax. The specimen is now broken clear of the rock, care being taken that it stands out far enough from the surface so that none of the fossil is left. It is wrapped in wet newspapers and placed in tin cans or tied firmly in burlap or sacking, and packed for transportation.

In rare cases the specimen is so large that it cannot be removed from the rock in one piece without breaking, so the process of "jacketing" is employed. When the exposed upper surface of the fossil has been cleaned and shellacked, and the surrounding rock cut away so that the specimen rests on a pillar of rock, it is covered with strips of wet newspapers or sheeting to prevent the plaster of paris from sticking, and the "jacketing" is begun. Burlap bags are opened and cut into long strips about three inches wide (or less for smaller specimens), and soaked in water. Plaster of paris (preferably "gauging grade" of "slow-set" variety) is poured into a pan of water until it appears above the surface, and mixed quickly. The strips are dipped into this mixture, wrung out, and laid across the fossil block in overlapping layers from one end to the other, so that the ends hang down on either side. When the entire upper surface is covered, one strip is tied completely around the base to hold the free ends of the others in place when the block is broken free from the pillar.

After drying (overnight if possible) the specimen is then completely undercut and turned over. The excess rock is trimmed away to within a few inches of the bone. The surface of the fossil, if soft, is soaked with shellac, and the bottom side is then stripped and jacketed in the same way as the top. The whole specimen when dry may be crated or tied to sticks or boards for transportation. Excelsior, dipped in the plaster of paris mixture, can be used for making contacts between the crate and the specimen, so that it will rest solidly and not jar. This is also sometimes used to fill up the hollows in irregularly shaped specimens and strengthen them.

Other cements, such as flour and water paste, can be used, but the "jackets" are hard to remove later.

Whenever the specimen is collected in more than one piece, be sure that all the parts are present and labeled so that they can later be fitted together. A missing segment may make restoration difficult.

CHAPTER V.

LEAVES AND OTHER PARTS OF PLANTS.

Where are plant fossils found?

Imprints of leaves are not infrequently found in deposits of fine clay or volcanic ash, laid down in pools or lake beds. Often these imprints are so well preserved that even the finest details of the veination can be seen. In eastern Oregon they are found in ash, clay, shale, and in diatomite; in western Oregon in clays, coal, shale, and fine sediments.

Silicified wood is to be found in a number of places, especially in eastern Oregon. It requires no particular care in collection, but can be improved for museum display and identification by cutting across the grain and polishing the surface. Opalized specimens form beautiful exhibits and in thin layers their transparency makes them highly attractive.

Trees that have been buried by lava flows may leave molds of their outer surface. These are true fossils, but only rarely can they be collected and brought to the museum. In some cases a plaster cast can be made, but they are seldom of diagnostic value.

Diatoms are microscopic plants and are noted in Chapter VI.

How are plant fossils collected?

The paleontologist's pick consists of a hammer with one square face and the other end elongated into a flat chisel-shaped point for splitting the rock layers apart. A still more useful implement is a wide or shovel-bladed chisel. When the surfaces upon which the leaves lie have been exposed, the edges of the pieces can often be trimmed and squared up with a dull knife, so as to make a neat specimen.

Leaf impressions are very delicate, and since they are best preserved in soft rocks they must be carefully handled. Authorities differ in regard to the shellacking of leaf surfaces. Even a thin coating is said by some to obscure the finer details of the leaf structure. Others believe that when the shellac is applied carefully to the leaf imprint and not to the surrounding rock, it brings out the structures and makes a more attractive display specimen, as well as preserving the surface. The rock fragments should be carefully packed in soft paper so they cannot rub against each other. They are stored in shallow trays, never piled on top of each other.

When leaves are found in wet clays, it is sometimes necessary to shellac the entire specimen, or else the piece will crumble as it dries.

Leaves are of especial interest as they enable the collector to reconstruct past climates and land conditions. The presence of redwoods in eastern Oregon during the Miocene, for instance, indicates that the climate at that time was moist and warm; whereas at the present time it is colder and drier. (Chaney, 38). Nuts, cones, and berries are rarely found, but the collector should be on the lookout for them.

CHAPTER VI

MICROSCOPIC ANIMALS AND PLANTS.

What are microfossils?

Fossils whose small size necessitates the use of considerable magnification in their study are called microfossils. Usually those less than one-half inch in diameter will come under this category.

Microfossils are extensively used by oil companies for the age determination of the oil-bearing shales and nearby formations. The most important and widespread group of microfossils is the Foraminifera, a group of minute organisms with calcareous shells in a tremendous variety of shapes. "Forams" are frequently abundant in fine sediments, and are greatly differentiated and alter rapidly throughout the different formations. They are so small that they can be collected from well-drill cores, and the formations in the well can thus be identified and mapped.

Microfossils other than foraminifera are small molluscs with calcareous shells, radiolaria, and spicules from the siliceous skeletons of sponges; ostracods, which are small chitinous-shelled, free-swimming arthropods; and conodonts, supposed to be worm-jaws. Diatoms are minute single-celled plants with siliceous frameworks.

How are microfossils collected?

The difficulties involved in removing microfossils from hard sediments are considerable and the technique is difficult. For the amateur it is usually sufficient to inspect carefully the softer sediments for such remains, and when signs of organisms are seen (such as minute seed-like pods, whorls, spheres, spicules, etc.,) to collect the sample in the type of envelope used for ore samples or seeds. This envelope has a metal clasp across the top, the ends of which are folded over after the top has been rolled down. The locality number can be written upon the envelope.

How are microfossils prepared?

The first step in the preparation of specimens for study in the laboratory is the drying of the rock, either naturally at room temperature, or in an evaporating dish over a flame. The rock is then broken so that the fossils can be separated from the matrix; the fragments should not be larger than 1/8 to 1/2 inch in diameter. This may be done with a hammer and piece of steel or with a mortar and pestle, but care should be taken not to grind the sample and crush the minute shells.

After the sample is crushed, further treatment depends upon the type of the material and its composition. Some material needs no further treatment. Usually, however, it must be moistened or even boiled in water to disintegrate it thoroughly and release the microfossils. The breakdown is hastened by stirring; an egg-beater is effective since it does not crush the shells.

Other treatments involving the use of various acids, alkalis, and machinery are too detailed to mention here. They are discussed in Camp and Hanna (37).

After thorough disintegration is effected, the material is screened. The screen is shaken gently with a horizontal motion, while a small jet of water is played upon it to help the fines pass through. Most foraminifera will collect upon 20 to 100 mesh screens. Screens must be carefully cleaned after use to avoid contamination.

After screening, the sample is ready for drying and mounting. It is dried upon an evaporating dish in an oven or over a flame, and then placed in a black background tray, under a magnifying glass.

Although the binocular microscope is preferred for the work of sorting and identifying the specimens from the sample, it is also possible to use a simple biologic microscope; and a small field microscope is sufficient for the study of the larger foraminifera, although diatoms require higher magnification.

A thin layer of the specimen is spread out on the small black-bottomed tray (made to fit on the microscope stage, or at a level with it) which is often ruled with white lines so that the worker can view separate portions in order without repeating. The individual shells are then picked up with the end of a slightly moistened brush, dissecting needle, or other sharp instrument..

The shell is then mounted on a microscope slide made from a piece of cardboard for a base, another cardboard punched with half-inch holes for the central layer, and a top cover of glass, heavy celluloid, or photographic film. The three portions should be mounted together so that the top can be removed. The bottom layer should be black. The ingenuity of the collector can be exercised in devising attractive and convenient slides. A number of types are suggested by Camp and Hanna (37).

A minute drop of a dilute solution of gum tragacanth, gum arabic, or glycerine is placed in the bottom of the "cell" or hole in the middle cardboard of the slide. The foram shell is then transferred with the pointed brush or other sharp tool to the bottom of the cell and glued down. With one shell in each opening, or cell, the slide is ready for study or filing.

Even if the specimens cannot be immediately identified, a collection of all the various types of shell (foraminifera in this case) can be made, together with a rough estimate of the relative members present of each type. Then the collection when fully identified will be of considerable scientific value.

CHAPTER VII

THE HOME LABORATORY AND MUSEUM.

A common fault of the amateur is to try to clean the fossil too closely in the field. The delicate work should be left until one is back at home or in the laboratory, especially as the rock left around the specimen helps support and preserve it during transportation. A great deal of the interest and instruction in fossil hunting lies in the careful preparation of the specimens for study and display; and this work should be done not on the field trip where time is usually a factor, but in the collector's laboratory where a variety of tools, sufficient light, a convenient work table, and above all, leisure time, are available.

What tools are used in preparation of fossils?

Tools used for digging away the rocky matrix from the fossil are, in order of delicacy of work, slender punches and small hammers or wooden mallets, scratchers and scrapers (old dental tools), and needles mounted in wooden handles. Paint brushes, tooth brushes, wire brushes, and whisk brooms are used for cleaning the surfaces. Old Victrola needles, mounted in small chucks or in wood are good for fine work. Old dental burrs are of better steel and can be ground down to a point. Woodcarving outfits contain several tools which make convenient scrapers. Steel wool, sand and emery paper, and wire brushes are used for smoothing the matrix around a specimen, and can sometimes be used on the specimen itself if it is especially hard.

A comfortable work bench with a stool and good lighting are essential for good work. A desk lamp with moveable arm is very convenient.

How are the fossils prepared for display?

After the wrappings have been removed, the fossils are checked to see that they still retain their identifying number. The various pieces of material are placed with numbered slips in shallow pasteboard trays of various sizes. These can be kept in large drawers until ready for cleaning and putting together.

When reconstruction is started, it is best to try to fit the various pieces together before the matrix is removed, unless the specimen is very large. This is done by cleaning the surfaces to be fitted with water and a toothbrush, and then applying water glass, cellulose acetate, or even thin plaster of paris. Large pieces can be reinforced by drilling small holes and inserting stiff pieces of wire or small dowels. Authorities differ on the type of cement to use. Lupher recommends LePage's Glue as being much better than cellulose cement or shellac, while Camp and Hanna prefer the latter, as glue is said to deteriorate with time.

The cellulose cement can be purchased as "Dupont cement" and is a clear white. If water glass (egg preservative) is mixed with 20 to 30 percent talc, it forms a white cream that is a powerful cement.

After drying, the specimen may be waterproofed with a thin coat of shellac, although Lupher (39) says that unpetrified bones are rendered rather brittle and dry by shellac. He recommends the use of boiled linseed oil, the oil soaking into the specimens readily and forming a tough, durable, strengthening material.

Large blocks of material are placed on the "sand table", a wide shallow box partly filled with sand, and sometimes set upon a rotating stool for convenience. The specimen is partly imbedded in the loose sand, which gives the material a firm support but allows its position to be easily altered. Sand bags are used to hold smaller specimens while they are being prepared. One can adjust the fossil in a pocket on the top of the canvas bag of sand and then pound it vigorously from various angles and still it remains secure.

One side of the plaster cast is removed, the matrix on that side carefully and slowly chipped and scraped and cleaned off, and the surface shellacked or painted with boiled linseed oil. This side is then covered with damp newspapers and a new plaster cap put on to protect it before the specimen is turned over and the other side prepared.

When both sides have been finished, it can be decided which will be uppermost in the display; or whether the entire fossil can be mounted on a firm base. If the bones are too fragile for upright mounting, the base may be one of the plaster caps which has been squared, smoothed, sanded, and painted a pleasing color. It will supply the close fitting firm support necessary.

The technique varies greatly with the type of material, but in all cases care must be taken not to injure the fossil itself. The X-ray has even been used as a guide when specimens are particularly difficult to separate from their matrix. The process is often a slow and painstaking one, but a well prepared and mounted specimen will repay much time and labor. The detailed discussion of methods is not the purpose of this bulletin, and the reader is referred to Camp and Hanna (37).

The arrangement of the specimens on shelves or in cases can follow the order of life types (all shells together, all wood together, etc.), but more frequently all specimens from one locality are kept together. This latter arrangement gives a better idea of the various types of life in existence at that particular place at the time when the sediments and fossils were laid down.

When the fossils are stored or placed on display, they should be accompanied by a small card (3x5 filing card is a handy size) which gives the various data concerning the specimen. The cards should give the common name and the technical name of the fossil (if that can be determined), the locality from which it came (with the number which is on the specimen), the formation and its age, and finally the name of the collector and date of collection. Sample labels might read as follows:

Locality No. U.O.135
Catalogue No. 56

Name: Sea Snail (Epitonium Condoni Dall)

Locality: U.O. no.135. Smith Quarry, near eastern city limits of Eugene, Oregon.

Formation: Eugene formation (Oligocene).

Collector: H. G. Schenck, June 20, 1920.

Locality No. P-29-1
Catalogue No. 992

Name: Redwood (Sequoia langsdorfii).

Locality: No.1, S.$\frac{1}{2}$ of sec.25, T.8S., R.41 E., northeast of Virtue Flat, Baker Quadrangle, Oregon.

Formation: Diatomaceous interbed with basalt correlated with Columbia River Basalt formation. (Miocene)

Collector: R. W. Brown, July, 1929.

Locality No.1-30-1
Catalogue No.15411

Name: Clam (Pecten operculiformis Gabb)

Locality: Lot 1, Sandstone, Logan cut, near quarter corner between secs.9 and 10, T.40 S., R.8 W., 3 miles south of Takilma, Oregon.

Formation: Horsetown (?) formation (Cretaceous)

Collector: P. J. Shenon, August, 1930.

APPENDIX "A"

DONT'S FOR DIGGERS.

Don't forget to record the exact locality on the spot, so that a complete stranger could take your description and go right to it. A fossil without a location is practically worthless.

Don't forget to ink the locality number on your specimens in the field. It is easy to label them on the spot, but hard to remember which is which when you get back home.

Don't dig just for the fun of getting fossils out. Get only enough for your own collection, and leave some for the other fellow.

If the fossil is a large vertebrate, don't try to take it out unless you have the proper equipment and experience. Cover it up again and get in touch with an expert.

Don't try to clean the specimen too closely in the field or you may lose it. The last cleaning and preparation is a delicate job and should be done in the laboratory.

Don't stint the wrapping and packing materials. Better to have the fossil too thoroughly wrapped than to have it broken or crumbled in transit.

APPENDIX "B"

AUTHORITIES IN WESTERN PALEONTOLOGY.

Invertebrates:

B. L. Clark, University of California, Berkeley.
R. L. Lupher, Washington State College, Pullman.
S. W. Muller, Stanford University.
E. L. Packard, Oregon State College, Corvallis.
H. G. Schenck, Stanford University.
H. A. Wheeler, Mackay School of Mines, Reno.
C. E. Weaver, University of Washington, Seattle.

Vertebrates:

C. L. Camp, University of California, Berkeley.
Chester Stock, California Institute of Technology, Pasadena
C. J. Hesse, University of California, Berkeley
R. A. Stirton, University of California, Berkeley
V. L. Vanderhoof, University of California, Berkeley.

Plants:

R. W. Chaney, University of California, Berkeley.
Ethel Sanborn, Oregon State College, Corvallis.

Microfossils:

Hubert G. Schenck, Stanford University, California.
G. D. Hanna, California Academy of Sciences, San Francisco.
R. M. Kleinpell, Union Oil Company of California.
J. A. Cushman, Boston, Massachusetts.

APPENDIX "C"

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APPENDIX "D"

SOME FOSSIL LOCALITIES IN OREGON

(Compiled from chart by Robin Drew and James Draper, under direction of Warren D. Smith, University of Oregon).

Locality:	Age	Characteristic Fossils
Baker County:		
Big Creek S.of Medical Springs	Permian	Productus, Spirifer
Martin's Bridge on Eagle Creek	Triassic	Halobia, Terebratula
Homestead	Permian	Spirifer, Productus, Tetracorals
Near Keating	Miocene	Sequoia,Salix,Acer,Quercus,Prunus
Rye Valley	Pleistocene	Elephant
Benton Valley:		
Blodgett Valley	Mid-Oligocene	Aturia
Clackamas County:		
Gladstone	Pleistocene	Horse
Oregon City	"	Elephant
Canby	"	"
Wilsonville	"	"
Clatsop County:		
Astoria	Oligocene	Acila,Tellina,Solen,Yoldia,Pecten
	Miocene	Pecten
Fossil Creek 3 m. from Grays River	Oligocene	Tellina
5 m. E. of Necanicum	Oligocene	Concretions with conifer cones
Astoria	Oligocene	Seal
Columbia County:		
Pittsburg Landing	Oligocene	Acila,Tellina,Solen,Yoldia,Pecten
10 m. N. of Scappoose	Mid-Oligocene	Aturia
West Creek 2 m.SW. of Clatskanie	Mid Oligocene	Aturia
West of Vernonia on Nehalem river	Oligocene	Tellina
Keasy on Rock creek	Eocene	Venericardium, Turitella
Coos County:		
Coaledo	Eocene	Venericardium, Turitella
Cape Arago	Eocene	Turitella
Fossil Point	Miocene	Pecten
1.25 m. E.of Myrtle Point	Pliocene	Mastodon
Between Empire and South Slough	Miocene	Sea Lion
Coaledo	Eocene	Magnolia, Potamogetton

APPENDIX "D" (continued)

Locality:	Age	Characteristic Fossils:
Crook County:		
Southeast of Suplee	Jurassic	Cephalopoda, Brachiopoda
"	Triassic	"
Grindstone creek	Carboniferous	Brachiopoda
Brink's Ranch 2 m. E. of Prineville	Mid Miocene	Oak, Madrona, Gingko.
Ream's Ranch 10 m. E. of Prineville		" " "
Riverside Ranch 18 m. E. of Prineville	Upper Oligocene	Plants
Gray's Ranch 11 m. E. of Post		Redwood and associated flora
Logan Butte	Oligocene	Creodonts, carnivoras, rhinos.
Prineville	Pleistocene	Elephant
Douglas County:		
Starr's Ranch near Oakland	Oligocene	Turitella, Natica, Venus
Near mouth of Little River	Eocene	Turitella, Cardita, Venericardia
Basket Point on Umpqua River	Eocene	Turitella, Cardita, Venericardia
Nickel Mtn. & Buck Pk.	Jurassic	Cephalopoda
Mouth of Rattlesnake Cr. into Cow Creek	Jurassic	Aucella
Riddle	Jurassic	Cephalopoda and Brachiopoda
Cow Creek W. of Riddle	Cretaceous	Pecten, Trigonia
Buck Mountain	Cretaceous	Aucella
On R.R. 25 m. SW of Roseburg	Jurassic	Ferns, Equisetum
On S.Umpwua river and Cow creek	Cretaceous	Gingko
Comstock	Eocene	Auralia, Sycamore, Poplar
Roseburg	Pleistocene	Mylodon
Gilliam County:		
3.5 m. S. of Lone Rock	Upper Oligocene	Sequoia, Juglans, Salix
Olex	Pleistocene	Elephant
Grant County:		
Cant's Ranch 6 m. W. of Dayville		
Van Horn's ranch 6 m. E. of Dayville	Upper Miocene	Oak, Madrona, Salix, Acer, Prunus
Site 12 m. E. of Dayville	Mid Miocene	Oak, Madrona, Gingko
White Hills E. of Dayville	Mid Miocene	" " "
1 m. S.E. of Tipton	Mid Miocene	" "
Austin	Mid Miocene	" "
Upper John Day river fossil beds, both above Dayville and below	Oligocene	Creodonts, carnivores, and rhinos, early horses and camels

APPENDIX "D" (continued)

Locality:	Age:	Characteristic Fossils:
Harney County:		
Red Butte N. of Burns	Jurassic	Pecten, Pholadomya
Beaver Creek branch of Silvies river	Jurassic	Pecten, Pholadomya
Trout creek SE of Fields	Mid Miocene	Oak, Madrona, Douglas Fir cones
Jackson County:		
O'Shea creek 1.5 m. S.W. of Phoenix	Jurassic	Aucella
Doe and Thompson Creeks	Jurassic	Aucella
Thompson Creek	Cretaceous	Trigonia
Elk River NE of Trail	Cretaceous	Trigonia
Griffin Creek 2 m. E. of Jacksonville	Cretaceous	Exogyra
4 m. S. of Ashland	Cretaceous	Trigonia
"	Miocene	Oak, Madrona
Sam's creek	Cretaceous	Populus, Pinus, Sequoia
Talent	Pleistocene	Horse
Rogue River	Pleistocene	Mastodon
Jefferson County:		
Vanora Grade on Warm Springs Road	Pliocene	Flora
Road Crossing at Cherry Creek	Eocene	Equisetum, Juglans
Josephine County:		
Logan Cut N. of Waldo	Cretaceous	Pecten, Pleuromya, Meekia
Lake County:		
49 Camp Extension into Oregon	Mid Miocene	Oak, Madrona
Fossil Lake	Pleistocene	Birds, Rodents, Horses, Mylodon,
Paisley	Pleistocene	Camel, Bison
Goose Lake	Pleistocene	Bison
Lane County:		
Eugene, Smith's Quarry	Oligocene	Solen, Spisula, Agasoma, Mulinia
Goshen	"	Oak, Smilax, Walnut
Jasper	"	" " "
Rujada	"	" " "
Springfield	"	" " "
Underpass N. of Goshen	"	" " "
Springfield	"	Shark remains
Eugene	Pleistocene	Mylodon, Horse, Bison
Coburg	"	Elephant

APPENDIX "D" (continued)

Locality:	Age:	Characteristic Fossils:
Lincoln County:		
Yaquina	Oligocene	Acila,Cardium,Fusinus,Thracia
Waldport	"	" " " "
Newport	Miocene	Sea Lion, Whale, Sea Cow.
Linn County:		
Albany	Oligocene	Acila
Scio		Fern
Brownsville	Oligocene	Flora
Harrisburg	Pleistocene	Elephant
Albany	"	"
Lebanon	"	"
Tangent	"	"
Malheur County:		
Willow Ranch N.of Vale	Mid Miocene	Oak,Madrona
Rockville	Mid Miocene	Sycamore,Poplar
Willow Creek	Pliocene	Fresh water fish
Harper	Pliocene	Antelope
Rome	Pliocene	Antelope
Marion County:		
Santiam River above Mehama	Oligocene	Solen,Spisula
Salem	"	" "
St.Paul	Pleistocene	Elephant
Multnomah County:		
Eagle Creek	Oligocene	Sequoia,Juglans,Salix
Buck Creek	Pleistocene	Sequoia,Oak,Willow,Walnut
Portland	"	Camel, Bison
Polk County:		
Bethel Hill	Mid Oligocene	Aturia
Holmes Gap near McCoy	Oligocene	Acila
Dalles	Eocene	Lithothamnium limestone
Tillamook County:		
Tillamook	Oligocene	Acila
Umatilla County:		
Pilot Rock	Eocene	Redwood and associated flora
Cold Springs	Pleistocene	Camel
Milton	Pleistocene	Elephant
Umatilla	"	
Wallowa County:		
W. of Wallowa Lake	Jurassic	Halobia,Cephalopoda
B.C. Basin	Triassic	Cephalopoda
Joseph	Pleistocene	Bison

APPENDIX "D" (continued)

Locality:	Age:	Characteristic Fossils:
Wasco County:		
Cove Creek	Upper Eocene	Redwood and associated flora
Dugout Gulch	Upper Oligocene	Sequoia, Juglans, Salix
Clarno's Ferry	"	" " "
The Dalles	Pliocene	Sequoia, Populus, Salix
"	"	Camel, Horse
Washington County:		
Tunnel near Buxton	Oligocene	Acila
Scroggin's Canyon, Gaston	"	Tivela
Tualatin R. near Dilley	"	Solen, Spisula
SW of Forest Grove	"	" "
Wheeler County:		
Antone	Cretaceous	Trigonia
Bridge Creek	Upper Eocene	Redwood and associated flora
½ m. NE of Fossil	"	"
3 m. above Clarno Ferry	Eocene	Equisetum, Auralia
Yamhill County:		
Wapato Lake	Oligocene	Solen, Spisula
Newburg	Pleistocene	Elephant, Horse
Dayton	"	Horse, Elephant
Dundee	"	Horse

APPENDIX E.

TIME AND LIFE DIVISIONS OF THE GEOLOGIC PAST

Major Divisions	Periods	Epochs	Dominant Life	Advances of Life	Where found in Oregon
Cenozoic 4%	Quaternary 1%	Recent	Age of Man	Rise of civilization	
		Pleistocene or Glacial		Dawn of reason, art, industry, Extinction of great mammals	Throughout state
	Tertiary 3%	Pliocene	Age of Mammals and Flowering Plants	Man-ape changing into man	Eastern Oregon; along coast
		Miocene		Culmination of mammals and flowering plants	" "
		Oligocene		Rise of higher mammals, primates, and modern birds	John Day and Willamette valleys
		Eocene		Vanishing of archaic mammals	Central Oregon, Coast Rge.
Mesozoic 11%	Cretaceous		Age of Reptiles and Mediaeval Fishes	Rise of archaic mammals, extinction of dinosaurs	Central and southwestern Oregon
	Jurassic			Rise of flowering plants, extreme specialization of reptiles	Central, southwestern and northeastern Oregon
	Triassic			Rise of toothed birds and flying reptiles. Rise of dinosaurs. reptilian mammals. ammonites	Central, southwestern and northeastern Oregon
Paleozoic 30%	Permian		Age of Amphibians and Ancient Fishes	Rise of land vertebrates, modern insects & ammonites	Baker and Wallowa counties
	Carboniferous			Rise of primitive reptiles, insects, ancient sharks, crinoid maximum	Baker and Wallowa counties
	Devonian		Age of Fishes	First land floras. First evidence of land animals (footprint)	Southwestern Oregon
	Silurian			Rise of lung-fishes and scorpions	None known
	Ordovician		Age of Invertebrates	First colonial life (corals)	None known
	Cambrian			First marine faunas. Rise and dominance of hard-shelled Trilobites	None known
Proterozoic 25%	Algonkian		Age of Primitive Invertebrates	Fossils scarce and primitive	None known
Archeozoic 30%	Archean		Age of Larval Life	Fossils problematic	None known