UNIVERSITY OF MISSOURI STUDIES

EDITED BY
W. G. BROWN
Professor of Chemistry

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I

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PREFACE

About two thirds of this study has been published at different times in various German scientific periodicals, chiefly in the Zeitschrift für Psychologie und Physiologie der Sinnesorgane. The author has long hesitated to present in book form the results of his labor in this remote corner of scientific investigation because the interest in these problems seems to be neither intense nor general. This lack of interest on the part of the scientific public, however, is not due to the unimportance of the subject, but rather to a wide-spread conviction that all the problems pertaining to it were solved half a century ago and that therefore nothing problematic is left. For years during which — since his student days — these problems have been in the mind of the writer, he has belonged to an exceedingly small minority of scientific men, who have not permitted themselves to become captives of this conviction. But since this minority is gradually increasing in number, and since professional friends have encouraged the writer he has decided to lay before the public the results of his investigations in a continuous exposition of his theory as far as it goes at present. It is natural that he has preferred to do this in the English language, since nearly all his previous publications concerning it are in German.

The author does not pretend to present in this book a complete, perfect, and final solution of the problem concerning the mechanics of the inner ear. His farthest reaching hopes will be fulfilled if he succeeds in impressing upon the reader's mind the fact that there are here still problems left for solution and in giving these problems such a clear and definite formulation that the interest of others will be turned towards them. There is little hope for a final solution of these problems except by the co-operation of many investigators. The contents of this book are arranged from a pedagogical rather than from a logical point of view. The author does not intend to present a systematic representation of his own ideas for comparison with the ideas of others, but rather a series of lectures as he would deliver them before a class of college students, not presupposing any knowledge or any interest but what a somewhat advanced college student might be expected to possess. A reader who should prefer to make himself acquainted with the contents of this book from another point of view, will be able to do this by the aid of the index added.

The author has attempted to omit as much as possible everything of a polemic nature. His criticism of the views of other investigators may be found in his previous publications. In this book he does not propose to record the views of other scientists, but the conclusions which he has reached himself after more than a decade of thought concerning these problems. For the reader who might be interested in the development of the author's thought concerning these problems, he has added at the end of the book a list of those publications of his own which are directly concerned with the problems here presented.

The author hopes that this booklet will help to break down the barrier of dogmatism which has too long stood in the way of progress in this field of scientific inquiry, and which is still far from being a thing of the past. It is truly dogmatism to profess that the application of so simple a theorem as that of Fourier can do justice to an attempt at comprehending the mechanical processes underlying the wonderfully complicated and unfortunately only superficially known phenomena of audition.

THE MECHANICS OF THE INNER EAR

Everyone knows that the part of our body which in ordinary life we call the ear and which anatomists call the pinna, is not the organ of hearing but a mere appendage to the organ. Its chief utility consists in the fact that it aids us in distinguishing sounds coming from a source in front of us from sounds in our rear. We know how much more difficult it is to understand the words of a speaker behind us than the words of one who stands before us. We can reverse this condition by forming of our hands leaves similar to the external ears, but naturally larger and placing them opposite the ears, that is in front of the opening, the auditory passage. Then, sounds from the rear can enter the passage and reach the tympanum with a much greater force than sounds coming from the front. Animals, being able to move their external ears, can use them, of course, to greater advantage than human beings.

The external ear

The organ of hearing—in the narrower sense of the word—that is, the anatomical structure within which the ends of the auditory nerve fibres receive their peripheral excitations, is to be found stretched out along the central line of a tube which is very narrow relative to its length. This tube is called by the anatomists the cochlea, because it is not built in the form of a straight line, but coiled up like the tube of a snail shell. The advantage of its being coiled up in this way is obviously not to be sought in its mechanic—or rather hydrodynamic—function. At least, no

The tube containing the sense organ is long and narrow

one, to the writer's knowledge, has ever expressed himself as inclined to look for it there. For its hydrodynamic function it is clearly of no great importance whether the tube is curved or straight, and we shall speak of it in the following for the most part as if it were straight, in order to simplify the discussion. The real advantage of this shape of the tube is doubtless a mere anatomical one, it being possible thus to find a better place for it in the base of the skull.

The contents of the tube, a fluid, is incompressible

We must, in order to understand the function of this tube, be aware of the fact that it is filled with a watery fluid, lymph, and that its walls consist of hard unyielding bone. Now, when we go through the literature of the subject, we often see writers speak of waves in the fluid which are said to pass along the tube as air waves move in a tube filled with air. Views of this kind cannot, of course, contribute towards an understanding of the process of stimulation of the peripheral nerve ends. They are not rational considerations of the facts before us, but theoretical dreams, forgetting the physical conditions of the case. Let us regard the velocity of the sound in such a fluid as that of the inner ear as about fourteen hundred meters, let us remember that the whole length of the tube is only a couple of centimeters, let us understand, then, that even with rather high tones of short wave lengths—beyond the musical range—the total length of the tube is only a small part of the spatial length of the waves said to travel up and down the tube; and we shall admit at once that to speak of tone waves travelling in the lymph up and down the tube is like speaking of a horse race which is to take place within a dog kennel. We have to follow the custom of the physicists who in such cases neglect the compressibility and elasticity of the small volume of fluid altogether. We must, therefore, regard the fluid in the cochlea as being of identical density throughout at any given time, that is practically, as unelastic, incompressible.

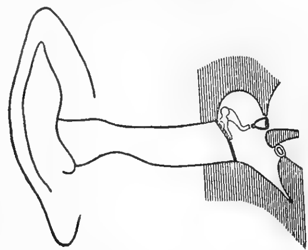


Fig. 1. The external and the middle ear

The tube has two windows to communicate with the middle ear

The walls of the tube consist of hard, unyielding bone, except in two places where the bone is broken through and the openings closed by flexible membranes. These two places are commonly called the oval and the round windows. (The fact that the tube communicates with the semicircular canals and the other parts of the labyrinth can here be neglected, since all these communicating cavities are also enclosed in bone, not possessing any windows.) On the other side of these windows there is the air of the middle ear. Let us now consider at once what could happen to the fluid in the tube if rhythmical changes of pressure in the external air (a "tone") caused, through the tympanum, like changes (of condensation and rarefaction) in the air of the middle ear. Let us at present, however, consider this under the imaginary assumption of no chain of ossicles existing in the middle ear. What was said about waves in the fluid of the tube holds good to some extent also for the air in the middle ear. That which occurs there is the same as that which occurs, say, in a bicycle pump, that is, an alternate condensation and rarefaction of all the particles of air almost simultaneously. This condensation and rarefaction always acts in the same sense (positive or negative) on both windows of the tube. According to the laws of hydrodynamics no motion in the fluid of the tube can result from the difference in size of the two windows. It is hardly comprehensible, therefore, why we find in literature lengthy discussions of the question whether it is the round or the oval window through which "the tone waves" enter the inner ear. They do not enter through either window since they do not occur in the middle ear, the volume of this cavity being too small to contain whole tone waves. Only after complete destruction of the tympanum would the question as to the manner in which an air wave strikes the two windows attain practical importance. Under normal conditions we must regard all the air particles in the middle ear as being, at any time, of identical density, and, thus, as unable to produce any movement in the inner ear.

Disturbances within the tube are caused by motion of the stirrup

If there were no ossicles, the fluid in the tube would remain practically motionless. But to the membrane of the oval window is attached the plate of the stirrup which has a somewhat rigid connection with the tympanum. The result is that every movement of the tympanum is accompanied by a movement of the stirrup in the same (positive or negative) direction. Whenever the tympanum moves inwards, the air in the middle ear is, of course, somewhat condensed. But this condensation or rarefaction has no relevant influence on the fluid in the tube, as before mentioned. The alternate condensation and rarefaction of the air in the middle ear, resulting from like processes in the external auditory passage, is an unavoidable, but functionally negligible by-product of the mechanical process in question, bearing no direct relation to the function of the tube. It is the movement of the stirrup which causes the disturbances in the fluid of the tube which we have soon to study in detail. And this motion of the stirrup is made possible only through the mediation of solid bodies, the auditory ossicles.

The auditory ossicles are a system of levers

The bony connection between the stirrup and the tympanum would serve its purpose of causing movements in the fluid of the tube whatever might be the special structure of this connecting link. As a matter of fact, it is arranged in such a particular manner that it acts as a lever (or system of levers), the large arm, so to speak, being attached to the tympanum, the small arm to the stirrup. This effect, however, is produced in different animals in different ways. In birds, for example, (Fig. 2) there is no chain of three little bones, but only a single bone, a rod bearing an oval plate. The leverage of this simple connection is explained by the fact that the tympanum and the window plate are not in parallel planes. The far

Fig. 2. Schematic representation of the leverage in birds

more complicated connection by means of three links of a chain of bones in most of the mammals has been theoretically studied by various investigators and found to result in a similar, but probably more delicately adjustable leverage than the simpler arrangement in birds. The advantage of the leverage is easily understood. To cause a fluid to move along a narrow tube requires a considerable force because of the friction resulting from the narrowness of the passage. The extent of movement, on the other hand, may be of any minuteness, the nerve ends certainly being sensitive to the very slightest curving of their tufts of hairs of which we shall have to speak again. It is of advantage, therefore, to gain force at the expense of magnitude of displacement.

Why would not one window be sufficient?

Someone might here raise the question: Why are there two windows when only one of them has a solid connection with the tympanum? The answer to this question is very simple. If there were not a second window, the stirrup could not move at all. Imagine a bottle filled with water up to the stopper and the stopper fitting the neck most accurately. Would it be possible to drive the stopper farther in? The water being incompressible, it would not be possible for a moderate force to drive a perfectly fitting stopper in any more than to pull it out. The second window, closed by a flexible membrane, is therefore necessary if the movements of the stirrup and of the fluid in the tube are to take place. If it were not for movements of the fluid, the round window would be superfluous. It is, however, not an essential condition that the second window should open on the middle ear and not perhaps directly on the external air space; for instance, on the external auditory passage, or anywhere on the skull. But it is an essential condition that the one window containing the stirrup plate open on a drum and that the plate be rigidly connected with the external membrane of this drum. Thus every condensation or rarefaction of the air outside the drum must result through movements of the tympanum in like condensations or rarefactions inside the drum; the movements of the tympanum must result in movements of the stirrup, and consequently in movements of the fluid in the tube. If the tympanum is destroyed to such an extent that the middle ear can no longer act even imperfectly as a drum, movements of the fluid in the tube must be difficult to produce. The organ is then deprived of its normal manner of functioning—a defect which does not necessarily involve total deafness, yet certainly a great impairment of the sense of hearing.

We naturally do not wonder at the fact that the round window is arranged in the simplest way possible, that is, opening on the middle ear not far from the oval window.

Let us now attempt to determine what movements would occur in the tube, caused by movements of the stirrup, if this tube were a perfectly plain tube, containing nothing whatever but an incompressible fluid. It is a decided advantage to study first a case as simple as can be imagined. We are sure that, thus, the elementary foundations of our thought will be clear and not confused by the influence of a complexity of conditions and a sum of powerful prejudices which almost inevitably ac-

The movement of the fluid in a plain tube

Fig. 3. Movement of fluid in a plain tube

company a complexity of conditions. Let us try to keep clear of such influences. In figure 3 we see the anatomical facts of our imaginary case diagrammatically represented: a long and narrow tube, two windows at one end, one of these windows containing the stirrup, the other end of the tube closed.

The question is this: What will happen to the particles of fluid in the tube when the stirrup moves slightly inwards or outwards? This is a problem which can be answered either on the basis of our general knowledge of similar processes or by means of a special experiment. Let us first try the former way. When the stirrup is pushed inwards and the round window outwards, the liquid near the windows must certainly move in the direction indicated by the arrows in the figure. Of course, the direction of the movement would be the opposite if the movement of the stirrup changes its sign and pulls instead of pushes. But what would happen in the fluid at the other end of the tube? At **x** or even at **y**? The answer to the question is simple: Nothing would happen. No movement of any kind could possibly occur there, since there is no sufficient cause why any movement should occur. The friction of the fluid against the walls of the tube, which is quite considerable in a narrow tube, must prevent any spreading of the disturbance beyond a very near limit. That is, whenever the stirrup moves back and forth, those particles of the fluid which are in the nearest path leading from the oval to the round window must move accordingly. All the rest of the fluid remains motionless.

A simple experiment

In order to demonstrate the facts just mentioned to those finding difficulty in understanding that from the general laws of hydromechanics nothing else could result in the case in question but what we have just described, we may perform the following experiment. A box containing white clay in a plastic condition has two circular openings on one side, not far from each other, as shown by figure 4 in cross-section. We now press, by means of a piston, into one of the openings, A, a small quantity of colored clay, then a small quantity of white clay, and again colored clay until the latter becomes visible on the outside of the box at the other opening, B. In our figure we see at **a** and **b** the colored clay pressed in first. The part protruding beyond the outside of the box is cut away. At **c** we see the white clay pressed in afterwards, and at f the advance guard, so to speak, of the colored clay pressed in last. What has happened within the box is obviously this. The colored clay pressed in first, collects inside the box near A in the direction of B. A corresponding amount of the white clay with

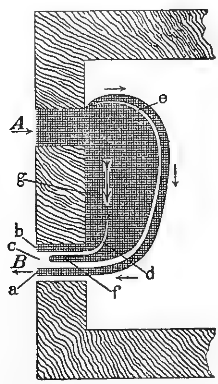


Fig. 4. An experiment with plastic clay

which the box was filled has been pushed out through the opening B. The white clay pressed in next forces up the colored clay somewhat as a mass of glass is blown up in a glass factory to form a bottle. This white clay is forced up in turn by the succeeding colored clay, the "bottle" of colored clay increasing its dimensions at the same time. During this whole time and afterwards the total mass moves in the direction of B. However, the particles of clay to the left, nearer the openings, move much more quickly than those farther to the right. This is seen from the fact that the left wall **d** of the white "bottle" has been separated entirely from the opening A and is just getting ready to disappear altogether through the opening B, whereas the right wall **e** is merely beginning to sever its connection with A. We have here a simple experimental proof for the statement of the preceding paragraph that friction prevents the spreading of the motion beyond narrow limits, causing it to occur as near the two openings as possible. Although the experiment in this form does not show it, the reader hardly doubts that somewhat farther to the right, say six inches from the openings, no motion whatsoever has occurred during the whole time. The quickest motion, of course, is in this particular case not found at the extreme left, at **g**, but about a fourth of an inch to the right, since the friction at **g** is too great. Without entering into a detailed study of the hydrodynamic problem which confronts us here, in which friction against the walls, internal friction in the fluid, and the momentum of the fluid play their roles, let it be sufficient to say here that the motion is practically limited to the portion of the tube near the windows in accordance with the general law of nature that whatever occurs, occurs with the least possible expenditure of energy. Some clay is pressed in at A. The same quantity has to pass out at B. This can be made possible by many kinds of displacement of the particles within the box. But only one form of displacement becomes actual, the one that requires the smallest amount of work to be done by the piston at A. And this form of displacement consists in the displacement being confined to the neighborhood of the openings.

The effect of a rigid partition within the tube

Let us now consider another imaginary case which will contribute towards a better understanding of the processes actually occurring in the ear. Suppose a part of the tube, near the windows, to be divided by an inflexible partition, as shown in figure 5. It is self-evident that in this case every movement of the stirrup would cause the particles of fluid in the upper and lower division of the tube to move in the directions of the arrows, parallel to the partition; and the particles at **y**, at the end of the partition, to move up or down. But the fluid farther on in the undivided tube would remain motionless, as in the former case, since there is no sufficient cause why it should move. If the partition extended farther, the only change resulting would be a diminution of the length of that part of the tube where the fluid remains permanently motionless. If the partition extended to **x** (Fig. 5), leaving only a small opening of communication between the upper and lower division, all the fluid within the tube would have to move whenever the stirrup moves. If the partition extended throughout the tube, leaving no communication whatever between the two divisions, no movement of the fluid could then take place, of course; but no piston-like movement of the stirrup could then take place either.

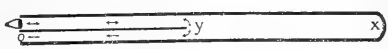


Fig. 5. A rigid partition in the tube

The effect of a flexible, but inelastic partition within the tube

Let us now imagine a third case. Suppose a partition to divide the tube lengthwise into two divisions, leaving, however, a small opening of communication between the divisions at **x**. Suppose further this partition to be neither perfectly rigid like a wall of hard bone nor as readily yielding and in turn contracting as a thin rubber membrane, but to be of the physical nature of a soft leather strap somewhat loosely stretched out between the opposite sides of the tube to which it is assumed to be well attached. To have something definite in mind, let the reader think, for comparison of its function, of a leathcr-seated chair. If you press from below, the seat yields and bulges upwards; but soon it stops in spite of your effort. If now you sit down on the chair, the seat bulges downwards; but again, it soon stops—how could it otherwise be used for the support of your weight? But what is particularly important to note here, is the fact that the leather seat, after it has bulged either way, may continue to remain thus until some external force acts upon it again from the other side. Now let us consider the movements which would occur in the fluid of a tube, divided into two divisions by a partition of the nature just described. If the partition could yield indefinitely, the case would obviously be practically the same as the first one we studied—without any partition. That is, the fluid would move near the two windows and the part of the partition suspended between moving masses of fluid would move with the fluid. Farther on where the fluid remains motionless the partition would remain motionless too. But we made the assumption that the partition, like the seat of a leather-seated chair, can move only within certain narrow limits up and down. Now, the result of this condition will be this. When the stirrup begins moving inwards, the part of the partition next to the windows must follow the movement of the fluid and move downwards. But soon it has reached its lower limit. Consequently it acts now as an unyielding partition, the effect of which we studied in our second case above. The fluid just above and below this temporarily unyielding part can now move only horizontally, but the particles of fluid next to the end of this now motionless piece move down and push the underlying piece of the partition down until it has reached its lower limit. And so, gradually, further and further pieces of the partition come

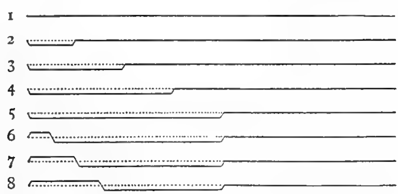


Fig. 6. The partition moves within an upper and a lower limit

down until the stirrup stops moving inwards. Figure 6 shows a number of successive stages of the position of the partition during this process. The vertical scale in this representation is, of course, enormously exaggerated relative to the horizontal scale. But at once after stopping, the stirrup begins to move in the opposite direction. At once the particles of fluid next to the windows (not those which have moved down last) move upwards and take the corresponding part of the partition with them until it has reached its upper limit. Now the following parts come up, and so on in exactly the same way as before, except that we have now an upward instead of a downward movement, — until the stirrup stops moving in this direction. Let us remember by all means, because a mistake made here in our comprehension of the process would result in serious errors later, that the bulging of the partition, whether up or down, begins inevitably as near the two windows as possible, and that further pieces can bulge in either direction only under the condition that all the pieces nearer the windows have already reached their limit in that same direction.

A safety valve

We made at the beginning of the last paragraph the assumption that there was a small opening between the two divisions at the extreme end of the tube. Let us see what purpose such an opening could serve. What would be the result of an extraordinarily large movement of the stirrup, so large that the whole length of the partition would reach its—upper or lower—limit of position before the stirrup ceased to move in the same direction? The result would be either an enforced stop of the movement of the stirrup or, if the external force acting on the tympanum and stirrup was too violent, a bursting of the partition. The latter disastrous result, however, can to a considerable extent be guarded against by the opening in question. As soon as the total length of the partition has bulged the fluid will begin to flow through this opening from one division of the tube into the other, until the stirrup stops moving in the same direction. Such an opening therefore can serve as a kind of safety valve for the protection of the partition.

The anatomy and physiology of the inner ear

After having studied the hydromechanical function of several imaginary tubes with divers interior equipments, let us now turn to a careful survey of the facts which the anatomists have discovered for us concerning the structure of the inner ear. Figure 7 shows us in a cross-section all the important details which have been found there by the anatomists. Hard bone pro-

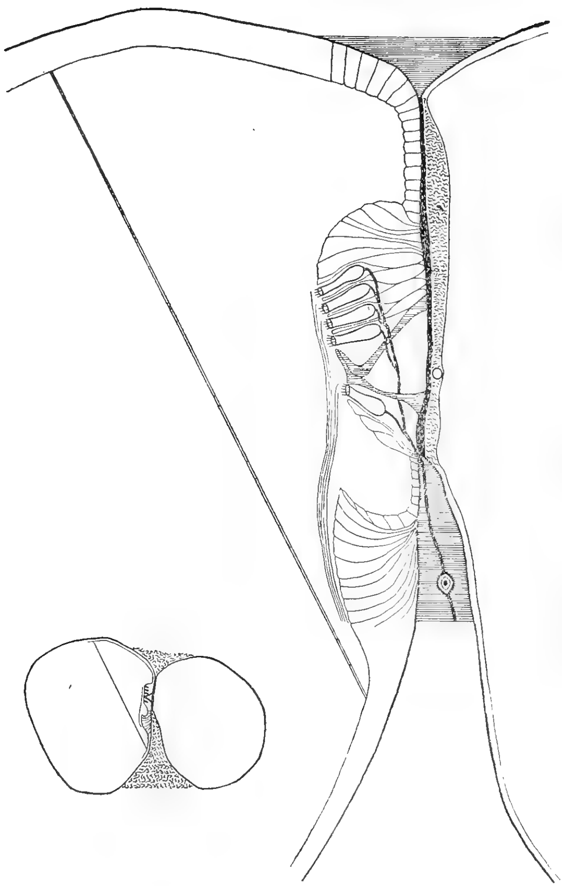


Fig. 7. To the left above is shown a section through the tube, with its two divisions and the partition. Below is shown a more magnified section of the partition alone

trudes from diametrically opposite sides of the bony wall of the tube, on the left side more than on the right. But the bone does not protrude far enough to actually cut off the lower part of the tube from the upper. While, therefore, we do not find a hard, inflexible partition, we find indeed some kind of a partition since the space between the bony protrusions is filled with a delicate structure which we shall have to study somewhat in detail. This structure, which we shall always refer to hereafter as "the partition" in the inner ear, is customarily spoken of under the name of its discoverer as the organ of Corti. The lower part of this partition has been shown to be a membrane, generally called the basilar membrane. This is obviously the strongest part of the partition, capable more than any of the other elements of structure to resist a pressure of the fluid above or below. But we must not think that this membrane is the main part of the partition considering its volume. It is rather small in bulk compared with the rest. Above the membrane we see a triangular structure, something like two pillars which have fallen towards each other. This structure is usually called the rods of Corti. Its mechanical significance becomes at once clear to us when we see at its sides the delicate end organs of the auditory nerve fibres. These end organs would obviously be crushed by the push of the fluid which occurs now from above, now from below, as we have seen, if they were not braced by this arch. No better protection could be devised than this triangular structure which effectually preserves the natural form of the soft tissues as the skeleton does in the total animal body, without interfering with a slight bending or compression of the tissues of the partition. On the upper side of the partition, opposite the basilar membrane, we notice another membrane, but much more delicate in structure, easily torn to pieces when sections are made for the miscroscope. This membrane touches the tufts of hairs which are the extreme peripheral parts of the sensory organs. This membrane, however, is firmly attached to the left side of the partition only. Its right end is free or seems to be almost free. The kind of action exerted by this membrane upon the hair tufts can only be guessed. The real connections between, and the physical properties of, these tissues are not well enough known. We may perhaps make this action a little clearer by assuming that the upper membrane, when the partition bulges upwards, pulls the hairs slightly, and that a bulging of the partition downwards means merely a relief from this pull. It is hardly worth while, however, to enter into details of a function which cannot be more than hypothetical since there are no data upon which to base any more definite theory. But there is little doubt, that the points between the tufts of hairs and the membrane in question are to be regarded as in the strictest sense the periphery of the sensory apparatus of hearing. And we shall scarcely make a grave mistake in assuming that a double bulging, back and forth in the vertical direction, of the partition causes a single shock in all those nerve fibres whose termini are located in this part of the partition, and that somewhere in the neurons a new process, perhaps a kind of chemical process, is set up if more than one of such shocks are received in quick succession, that the special character of this new process is dependent on the frequency with which these shocks follow each other, and that thus we perceive a definite tone, occupying—according to the frequency of shocks received—a definite point in the total series of sensations of hearing.

The physical properties of the partition as a whole

In the preceding paragraph we studied briefly the anatomical elements of the partition in their mutual relations. We now have to get a definite idea of the physical properties of the partition as a whole in its relation to the surrounding fluid. These properties depend, of course, on the properties of its elements. The partition as a whole can certainly not be regarded as perfectly rigid and unyielding to pressure. It consists of tissues too soft to be unyielding. On the other hand, we cannot possibly assume that under the influence of pressure the partition could bulge to any large extent, for this would be disastrous to the delicate end organs of the nerve fibres. We could hardly make a mistake, then, in assuming that the partition can yield, but only within very narrow limits up as well as down, even if we did not know anything about the physical properties of the anatomical elements. We know, however, that the basilar membrane is a comparatively tough structure, probably capable of considerable resistance. We are justified, then, in our conviction that the whole partition bulges in response to pressure but resists such pressure as soon as a certain rather narrow limit of displacement is reached.

Here, however, arises another question of the greatest importance, which, unfortunately, cannot be answered with anything approaching accuracy. This is the question as to the elasticity of the partition. Of course, all the elasticity the partition can possibly have must be the elasticity of the basilar membrane. The basilar membrane is the only one of the anatomical elements of the partition which might have a tendency to restore spontaneously the whole partition to its original position after the pressure causing the displacement has ceased and before any pressure in the opposite direction has had time to act towards this result.

Is the basilar membrane elastic?

There is only one way of deciding for our present purpose the question as to the elasticity of the basilar membrane. We must recall our knowledge of the elastic properties of similar membranous tissues which are found in divers parts of the human body and elsewhere in the organic world. Now, we know that there are plenty of membranes in the body which, when stretched within certain limits, show a tendency to return to the original shape. But they never remain in a stretched condition, that is, under tension, for any length of time. Indeed, they would become permanently lengthened if they remained thus. This is the consequence of a universal biological law. We may, for instance, bend a sapling and expect it to straighten itself as soon as we let it go, because of the elasticity of the stretched tissues of the convex side and the compressed tissues of the concave side. But if we tie it in this bent position to another tree and return after a year and cut the tie, we find that it has adjusted itself to the position we gave it. This biological fact does away at once with certain theories found quite frequently in physical and other textbooks, which speak of the basilar membrane as consisting of a great number of stretched strings, comparable to the strings in a piano. These theories assert, after having introduced, in opposition to the laws of biology, the idea of a permanent, constant tension of the basilar membrane, that these different strings—as in a piano—are under different tension and differently weighted and that they serve accordingly as resonators, responding sympathetically to the various sounds of the external world. However pretty this theory of "the piano in the ear" may appear, authors who expect their readers to accept it as the truth should first of all try to convince them of the possibility of living animal tissues retaining their tension for any length of time instead of adjusting themselves to the permanent stretching and thus losing their tension, as all living tissues do. We shall not, of course, entertain for a moment this idea of the basilar membrane being under constant tension, since our aim is not unreality, but reality. We need not, therefore, discuss any further the assumption of the presence of resonators in the inner ear, which falls with the above rejected, preposterous assumption of a permanent tension. That the membrane is capable of resistance, as it probably is, means something very different from the assertion that it is under constant tension, which is biologically impossible.

The actual question before us is evidently the question as to the elasticity of the partition as a whole. Now, we have seen that the only element of it which, according to its structure, may be regarded as elastic, is the basilar membrane. This membrane, however, we have found to be quite a small part of the bulk of the partition. If the partition is displaced by an external force and, this force having ceased, is caused to return to its original place by the tension which the basilar membrane has just suffered, such a spontaneous return movement must be greatly retarded by the bulk of inelastic tissues of the partition which the membranous part of it has to drag or shove along with itself. A spontaneous return of the partition to its normal position must be therefore very slow when compared with the velocity of a displacement caused by a rather powerful external influence from the stirrup. Let us, then, keep in mind that with respect to the elastic properties of the partition there are only two alternatives: Either the basilar membrane is practically inelastic; then the partition as a whole is inelastic and cannot spontaneously return to its original position after having been displaced. Or the basilar membrane is elastic; then the par-

Is the partition as a whole elastic?

tition can spontaneously return after having been displaced, but with a velocity that is only very small compared with the velocity of its displacement. Of the two alternatives the latter seems to be the more probable.

Protection of the surfaces of the partition from the friction of the fluid

We saw on a previous page, in our second imaginary case of a partition, that the fluid moves along the unyielding partition, causing friction on the surfaces of the partition. The same friction must be suffered by any part of the real partition as soon as it has reached its upper or lower limit and as long as the stirrup continues to move in the same direction, pushing the fluid on over the initial parts of the partition. If we had to design an apparatus to function thus, would we not see that the surfaces of the partition were sufficiently protected so that the rush of the fluid over them could not injure them? It is interesting to raise this question of protection with respect to the actual partition in the tube. If we look above at figure 7, representing a cross-section of the partition, we notice that the lower surface of the partition is well protected from injury by friction of the fluid by a part of its own structure, the tough basilar membrane. The upper surface, however, with its delicate sensory cells would be exposed to injuries by friction were it not for the membrane of Reissner which we see stretching across the upper division of the tube. The space between this membrane and the partition does not communicate with the rest of the upper division or with the lower division. It would therefore be really more nearly correct, in speaking of a partition dividing the tube into two divisions which communicate through an opening at the extreme end, to call the total body between the membrane of Reissner and the basilar membrane the partition. No movements perpendicular to the plane of the drawing can occur in the fluid below the Reissner membrane. The fluid here can only move up and down, pushing or pulling the organ of Corti into its limit of displacement. No friction of the kind above referred to, which might do injury to the delicate tissues of the organ of Corti, can therefore take place, and the problem of protection from friction is thus solved. We shall, however, in order to make our language as simple as possible, restrict the term partition to the organ of Corti, neglecting the membrane of Reissner, since this membrane, aside from the important protection which it offers to the tissues below, does not seem to possess any function whatever.

The safety valve

We saw on a previous page that an imaginary partition which is able to yield to the pressure of the fluid only within certain limits would be exposed to the danger of breaking whenever an extraordinarily powerful external force tended to cause a movement of the stirrup which would displace more fluid than the yielding partition could make room for, and that this danger might be avoided or at least greatly lessened by an opening of communication between the two divisions at the end of the tube. It is interesting to learn from the researches of the anatomists that such an opening—a safety valve, as we may call it—actually exists at the extremity of the tube of the cochlea.

We may now, after making ourselves familiar with the structural elements of the inner ear and their physical properties, enter into a discussion of the actual function of the organ.

Stimulations of the brain resulting from a given rhythmical movement of the stirrup

We have thus far taken into consideration only a single movement of the stirrup, in either direction. We must now study the result of a rhythmical movement of the stirrup, back and forth, a number of times during a certain length of time. In order to have a definite case before our mind we will suppose the stirrup to move back and forth in such a way that it will describe a sine curve on a board moving parallel to the plane of the paper. In figure 8 is represented a single period of such a curve in a horizontal position. It is not necessary, however, to imagine this definite curve. What we shall have to say will apply equally to any simple periodic movement, whether of the form of a sinusoid or of a combination of straight lines or of any other

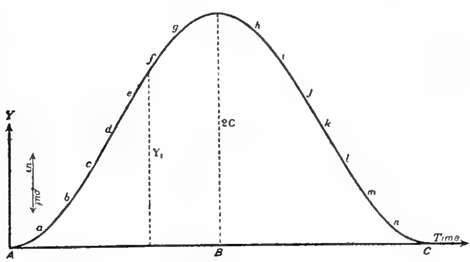


Fig. 8. A curve representing stirrup movement

curve connecting each maximum with the preceding and the following minimum. The question arises then by what means —computation, simple description in words, or otherwise—we can obtain a clear and sufficiently detailed view of the movements of the partition. What we want to know is the form of motion for each point of the partition, and the temporal relations existing between all the several movements. Only thus can we obtain a definite view concerning the nervous stimulations received by the brain as the result of a given rhythmical movement of the stirrup. In order to find the movements of the partition in every detail we might try computation since this is the method which yields, although not always the clearest, yet in general the most accurate results.

Our chief task, then, would be, stated again as definitely as possible, to find out for each point of the partition which moves at all the exact time which elapses from a jerk down to a jerk up and from a jerk up to a jerk down. Figure 9 may help us to understand the conditions of computing the time interval in question.

Computation of the form of motion of the partition

Let us call x the distance of any point of the partition from the point of x_0 nearest the windows. The length of the part of the partition which moves in response to the motion of the stirrup depends, of course, on the amplitude of the movement of the stirrup. This length alone is represented in the figure. What is farther to the right remains motionless. The dotted lines above and below represent the upper and lower limit of each moving point of

Fig. 9. The partition in the tube and its limits of movement

the partition. In our curve, figure 8, the minimum, at A, represents the position of the stirrup most to the left, the maximum, at the time B, the position of the stirrup most to the right. The horizontal line represents, of course, the time. To the position of the stirrup at A corresponds the position of the partition (in figure 9) in its upper limit; to the position of the stirrup at B the position of the partition in its lower limit. Let us now find out when any arbitrary point x_1 is jerked up and when it is jerked down, measuring the time from A. It is obvious that the amount of fluid for which room is made by the piece of the partition from x_0 *to* x_1 moving from its upper to its lower limit is equal to the amount of fluid displaced by the stirrup moving inwards through the distance measured by y. (For convenience we place the zero point of the system of coordinates in a minimum point of the curve.) It would be very easy, therefore, to find the equation of interdependence of x and y, if the following conditions were fulfilled:

Four assumptions provisionally made; not as hypotheses, but for the sake of a gradual comprehension

1. If the quantity of fluid displaced were proportional to the horizontal movement of the stirrup.

2. If the partition were perfectly inelastic; that is, not offering any resistance to a displacement until either of the limits is reached, and then offering absolute resistance.

3. If the distance between the upper and lower limits were the same at any point of the partition.

4. If the width of the partition at any point near the windows were the same as at any point far away from them.

Attempt at computation continued

Let us temporarily regard these conditions as fulfilled. If they are fulfilled, x is proportional to y. That is, a unit of movement of the stirrup always pushes down (or raises, as the case may be) a unit of the partition lengthwise. Or, expressed in a formula:

$$\text{(I)} \qquad y = Cx$$

where C is a constant dependent on the physical properties of the organ.

The equation of the curve in figure 8 is:

(II) $$y = c(1 - \cos 2\pi nt);$$

that is, while t changes from zero to $\frac{1}{n}$, y changes from zero through c, $2c$, and again c, back to zero. We now substitute Cx for y:

$$c\ (1 - \cos 2\pi nt) = Cx, \text{ consequently:}$$

(III) $$\cos 2\pi nt = 1 - \frac{C}{c}x$$

This formula permits us to calculate t, that is, the exact time when any point of the partition is jerked down. But it holds good only for the time from A to B, that is, while the stirrup moves in one direction. As soon as the stirrup reverses its movement a new formula has to be applied, since the movement of the partition is of a kind which is mathematically called a discontinuous function. The moment when the stirrup reverses its movement and the farthest point of the partition has been jerked down, the function jumps, so to speak, from this point to the beginning of the partition and the first point, nearest the windows, is jerked up. The formula to be used from B to C is to be derived by substituting $(2c - y)$ for y in (I), since x would now be proportional to $(2c - y)$. We then have the following new equations:

(IV) $$2c - y = Cx.$$

(II) $$y = c\ (1 - \cos 2\pi nt), \text{ consequently:}$$

(V) $$\cos 2\pi nt = \frac{C}{c}x - 1.$$

This formula is valid from B to C, that is for values of t varying from $\frac{1}{2n}$ to $\frac{1}{n}$, while the partition is being jerked upwards. We notice that the only difference between the right side of (III) and the right side of (V) is the sign, For the same x we obtain the same absolute value of $\cos 2\pi nt$, but in the one case it is positive, in the other negative. Now, it is easy to see what this means for the time interval between a downward and an upward jerk of any point of the partition.

Remembering that (III) is valid for jerking down, (V) for jerking up, we notice that the arc of $\cos 2\pi nt$ runs through the first and second quadrant while the partition is being jerked down, through the third and fourth quadrant while the partition is being jerked up. Therefore, since we found that the time of jerking down of a definite point x_1 and the time of jerking up of the same point are subject to the condition that $\cos 2\pi nt$ yields the same absolute value, but differing in sign, the time of jerking up must be found in a quadrant opposite to the quadrant wherein the time of jerking down occurred, never in an adjoining quadrant; that is, if the former time is to be found in the arc $2\pi nt$, the latter must be found in the arc $2\pi n(t + \frac{1}{2n})$, since the addition of $\frac{1}{2n}$ to t means the addition of two quadrants. The difference of time, therefore, is always $\frac{1}{2n}$. In other words, the time interval from a jerk down to a jerk up and from a jerk up to a jerk down of any definite point is with this particular curve always the same, being exactly one half of the whole period. We have thus found by computation the exact movement of the partition in case the movement of the stirrup is of the form of a sinusoid.

Summary of the foregoing discussion

We have seen then that, provided a certain set of conditions (our four provisional assumptions) is fulfilled, and provided the movement of the stirrup is of the form of a simple sine (or cosine, as this means the same) curve, computation of the movement of the partition is possible. But computation is neither particularly clear—at least those who are not professional mathematicians will think so—nor is it universally applicable, but only in a few cases of stirrup movement, the above, the case of straight lines connecting the maxima and minima, and a very small number of others.

To prove that computation is not universally applicable let the movement of the stirrup be represented by the function

$$y = c(2 - \cos 2\pi mt - \cos 2\pi nt)$$

Computation abandoned

and let m be equal to 4 and n equal to 5 (the simple case of a major third, musically speaking). Even in a case like this, by no means far fetched, rather the contrary, computation is impossible since it would involve, as the mathematical reader may easily convince himself, the solution of an equation of the fifth degree in order to find the mutually corresponding values of y and t for the maxima and minima of the curve. Without these values for the maxima and minima, which are the points of discontinuity of the function representing the movement of the partition, we could not proceed at all. It is out of the question, therefore, to expect that computation pure and simple, even under the four assumptions provisionally made, will ever give us a satisfactory comprehension of the function of the inner ear. We must look for other means in order to obtain our end, an insight into the details of movement of the partition.

Let us, then, try to represent the movement of the partition in the above case as well as in others graphically. I

Graphic methods of determining the exact movement of the partition

shall offer to the reader two methods of graphic representation. The first of these is more accurate in some respects than the second, but a little more difficult of application.

The vertical axis of our system of coordinates in figure 10 may represent the succession of points of the partition, be-

First graphic method

ginning from next to the windows. The horizontal axis may represent the time. I must warn the reader against thinking that the figures resulting on the paper are pictures of something that exists in the ear or elsewhere. The figures are not pictures of existing things but merely symbols of a function, that is, of the time when any point of the partition is jerked up or down. The construction of the figure is based on the following considerations. Let us mark on the paper the points indicating the time when any given point of the partition is jerked. When we shall have marked a sufficient number of such points, we shall draw a curve through them. But how do we find the points? The movement of the stirrup is represented in figure 8. When the stirrup has its extreme position to the left (according to Fig.

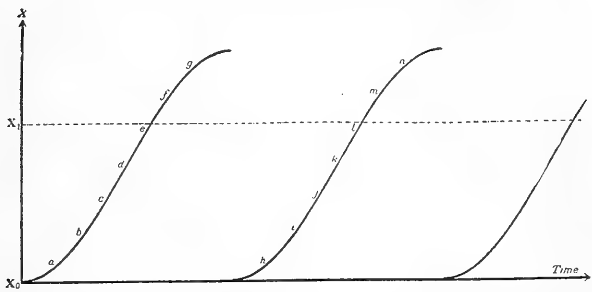


Fig. 10. Graph of the times when each point of the partition is jerked down (curves of odd numbers) and up (curves of even numbers). Compare figure 8

9) and just begins to move inwards, we mark the time as zero and the point of the partition which is jerked down also as zero, since the point which is jerked is the point nearest the windows. In figure 10 we find this point near *a*. As the time advances (Fig. 8) the stirrup moves farther and farther inwards, with gradually increasing and later again decreasing velocity. A further point, say *b*, in figure 10 must be located somewhat to the right of *a* and above *a*, since a more distant point of the partition is represented by a higher position of the mark in our system of coordinates, and the

fact that it is jerked later is represented by a position farther to the right. Now, since the velocity of the stirrup increases as shown by figure 8, the following marks have to be placed higher than proportionate to their advance to the right. That is, points marked off by equal steps on the partition are now jerked successively in briefer time intervals than before. Later approaching the time B in figure 8, the stirrup moves again more slowly, and the marks in figure 10 advance therefore more rapidly towards the right, as seen in *f* and *g*. If we now draw a complete curve through the marks *a, b, c, d, e, f, g,* we convince ourselves readily that the new curve is the same curve as the one in figure 8 from A to B. Of course, if we have not chosen the same vertical and horizontal scales in both figures, the new curve must appear more or less steep than the old one. But the selection of a scale for a graphic representation is entirely a matter of convenience. Choosing identical scales, we simply have to transplant the first half of the curve in figure 8 from A to B into the new figure.

But now the stirrup begins to move in the opposite direction, causing the partition to be jerked upwards gradually. The point of the partition nearest the windows is jerked up first, the others later in regular order. Now, it can be easily seen where we have to place the further marks in our new figure, namely *h, i, j, k, l, m, n.* We find them, or rather immediately the complete curve of which they are points, by simply turning the second half (B to C) of the curve in figure 8 upside down, without, however, making any change between right and left. In this way we go on, simply transplanting the parts of the stirrup curve, leaving the rising ones in the same position, but turning the falling parts upside down.

If we now desire to find out for any point of the partition, for example, for x_1, the exact time when it is jerked down and when it is jerked up, all we have to do is to pass on from this point (Fig. 10) to the right (along the dotted line), since this direction, according to definition, represents the time. Our first crossing of a curve (in *e*) means a jerk down; the next crossing (in *l*) a jerk up; and so forth. That is, the odd crossings mean each a jerk down, the even crossings each a jerk up. The time intervals can then be measured with a rule. We find in this special case that the intervals are all equal. We have thus graphically represented the exact movement of the partition in a case where the movement of the stirrup is of the form of a sinusoid. The same graphic representation is applicable to any given curve, however complicated it may appear. This method has universal validity. We shall soon convince ourselves of its importance for the analysis of a complicated curve.

What movement of the stirrup produces the sensation of a single tone (free from overtones)?

We can easily learn from the graphic representation before us that under the assumptions provisionally made the stimulation of each nerve ending can hardly be influenced by the form of the stirrup curve, that is, whether this curve is a sinusoid, or made up of straight lines connecting the maxima and minima, or of any other shape, provided the maxima and minima remain unaltered. Let us suppose that each "down" means a shock to the nerve end and that the "ups" are indifferent as to nervous excitation. We see immediately (Fig. 10) that the time interval between two shocks at any point of the partition must be exactly the same, since each down curve would be exactly like any other down curve, whatever the shape of the up curve. (This result would be the same if the "ups" meant excitation of the nerve end and the "downs" were indifferent.) That is, the particular shape of the curve representing the movement of the stirrup, has no significance for the question whether a single tone will be heard or not. If all the down curves are identical, a single tone only is audible. I remind the reader, however, that we are deriving this conclusion on the basis of our provisional assumptions, and further, that we are speaking here of movements of the stirrup, not of rhythmical pressure changes of the air in the external ear or of movements of a tuning fork or any other vibrating body. In discussing later the effect of the latter conditions upon the stirrup, we shall see that their form is not necessarily identical with the form of the stirrup movement.

The physiological condition of tone intensity

As yet, we have studied only very simple movements of the stirrup. Before we take up the problem of how the inner ear analyzes more complicated movements of the stirrup, we ought to remember that we have not yet discussed the physiological condition of tone intensity. We have spoken only of the frequency with which shocks are received by the nerve ends. But the frequency of the shocks determines only the attributes of pitch and quality, not the attribute of intensity of a tone sensation. Let us look to another sense organ, the olfactory organ, for a suggestion. On what physiological condition does the intensity of an odor depend? Although we have no definite knowledge here any more than in the sense of hearing, we have reason to believe that the intensity of an odor depends, or may depend, on two conditions: 1. The number of nerve ends stimulated; and 2. the concentration of the substance which stimulates each of these nerve ends. Accepting this suggestion we have to see what conditions might determine tone intensity. Only these two can come up for consideration, so far as I can see: 1. The number of nerve ends which receive shocks in a definite frequency; and 2. the suddenness, the impetuosity with which each nerve end is shaken when the point of the partition in which it is located is jerked down. Now, the second of these two conditions is theoretically almost beyond our reach. We cannot, in the present state of our knowledge, obtain a very clear idea of differences in the suddenness with which the nerve ends might be shaken in different cases. It will be best, therefore, to omit this factor in the discussion of intensity altogether, or at least for the present, rather than burden our theory with arbitrary hypotheses the usefulness of which is no more probable than their uselessness. At present we shall limit our discussion to the first condition, the number of those nerve ends which are stimulated with equal frequency.

A difficulty in the theoretical determination of tone intensity. Fifth provisional assumption

It is clear that the number of nerve ends stimulated depends in some way on the length of that part of the partition which is jerked up and down in a certain frequency. But here we are confronted by this difficulty. We do not know whether the nerve fibres are equally distributed along the partition. It might be the case that on a certain length of the partition near the windows a greater number of nerve ends were found than on an equal length farther away from the windows; or the reverse. In our present state of knowledge this difficulty cannot be overcome. In order to go on with our theory, we have to make an assumption. We shall make, of course, the simplest, the least arbitrary assumption. We assume, provisionally, that equal parts of the partition lengthwise contain equal numbers of nerve ends. If it should be found that the theory agrees with the facts of auditory observation more closely under another assumption, we would have to substitute this for the one now made. Of course a definite answer given to the problem by the anatomists would be more satisfactory.

We can measure the length of that part of the partition which is jerked up and down, only by the aid of our knowledge (if we have any) of the movement of the stirrup. Now, the reader will recall among our provisional assumptions the one that the width of the partition at any point near the windows is the same as at any point far away from them. But the anatomists tell us that this assumption is incorrect; that the partition is about twelve (or more) times as wide at the end as near the windows. Nevertheless we shall provisionally make the assumption of proportionality between any length of the partition being jerked up and down and the extent of the movement of the stirrup which causes the movement of this piece of the partition, in order to understand first a simpler, though imaginary, case and to proceed gradually to a comprehension of the actual, rather complicated function of the partition. Let us be aware, however, that, having thus simplified the actual conditions, we cannot expect to find a perfect, but only an approximate harmony between the results of a theoretical analysis and the direct observations of an actual sound analysis by the ear. We may find, indeed, with respect to tone intensity, rather serious disagreements between the facts and the theory. But these disagreements will disappear as soon as the theory takes account of what, for simplicity's sake, we provisionally neglect.

Another difficulty in the theoretical determination of tone intensity

Making the two provisional assumptions just mentioned, we can theoretically measure the intensity of a tone sensation by the total length of that part of the partition the nerve ends of which are excited with one definite frequency. In our graphic representation (Fig. 10) the intensity can then be measured by the vertical distance between the horizontal coordinate and the top of the curves which represent the down and up jerks.

Tone intensity in our graphic representation

We discussed above the result of a simple back and forth movement of the stirrup. Let us now do the same with a more complicated movement. Figure 11 represents the new stirrup movement which we are going to study. This curve is approximately the one represented by the equation

Analysis of the combination 2 and 3

$$y = (1 - \cos 2\pi 2t) + (1 - \cos 2\pi 3t);$$

which justifies us in saying that it represents physically the sum of two tones of the vibration ratio 2 : 3. Let us apply

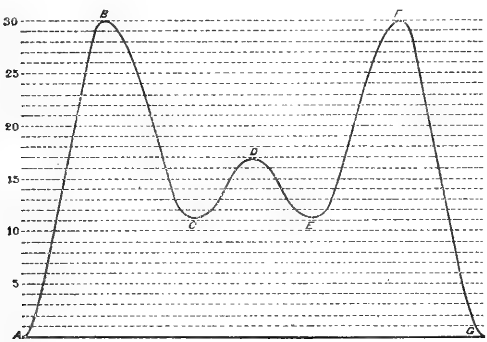


Fig. 11. The combination 2 and 3. First characteristic phase

the same graphic method to this case. We have first to transplant the part of the curve from the first minimum to the following maximum, A to B, into figure 12. Now, when the stirrup reverses its motion, the parts of the partition near the windows begin to be jerked up. Therefore, the curve from the maximum B to the next minimum C has to be turned upside down and then transplanted. The following part of the curve, from C to D, must be transplanted in its original upright position, but placed on the horizontal coordinate of the new figure, whatever its elevation in the original curve may be, since every reversal of the movement of the stirrup causes at once a movement of the parts of the partition next to the windows and only later a movement of the following parts. So we continue transplanting each section of the curve, alternately upright and upside down. This figure (Fig. 12)

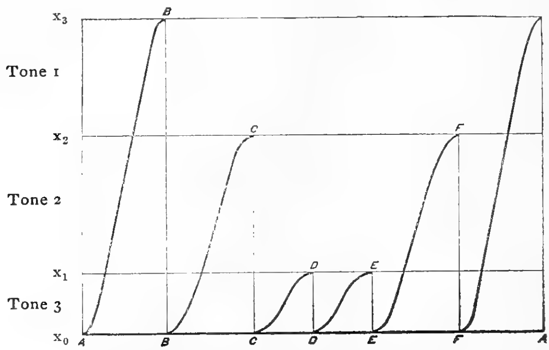


Figure 12. The combination 2 and 3. First characteristic phase. (A is identical with G.) Compare figure 11

is to be interpreted in the same way as figure 10. The distances from x_0 to x_1, x_1 to x_2, and x_2 to x_3 represent three pieces of the partition, x_0 being next to the windows. During the unit of time, which is here the period from A to G, all the nerve ends located between x_0 and x_1 receive, as is easily seen, three shocks, counting the number of shocks received by the number of downs (or ups, since this distinction between the physiologically effective and ineffective direction of jerking is arbitrary, for want of better knowledge as to the manner of excitation of the nerve ends). All the nerve ends between x_1 and x_2 receive, as the figure shows, counting from left to right, two shocks in the unit of time. And all the nerve ends between x_2 and x_3 receive one shock. The nerve ends located farther towards the apex of the cochlea do not receive any stimulation and do not, therefore, concern us. How many tones should we expect then to hear in this case? The answer is as easy as simple: Three different tones, since shocks of three different frequencies are received by the several nerve ends. And the musical relationship, the pitch, as we say, of these tones is determined by the relative frequencies found, which are 3 and 2 and 1. The relative intensity of these tones is to be measured, in accordance with our remarks in the preceding paragraph, by the relative lengths $x_0 x_1$, $x_1 x_2$, and $x_2 x_3$.

Two important facts: Sound analysis and production of subjective difference tones

A movement of the stirrup, not probably exactly like, but similar to the one just discussed could be produced by sounding simultaneously with approximately equal intensities two tuning forks representing the ratio of vibration rates 3:2. It is well known that we hear in such a case three different tones, 3 and 2, which we may call "objective" or primary tones, and 1, which we may call a "subjective" or difference tone. Some further facts concerning such subjective or difference tones will be mentioned subsequently for those readers who are not familiar with the conditions under which they make their appearance. The appropriateness of calling the subjective tones in question "difference tones" will then become apparent. The fact that our theory of the function of the inner ear and actual observation in this case agree so nicely, is highly satisfactory to us and ought to encourage us to proceed further in applying the theory to other special cases of movements of the stirrup. Let us keep in mind that our theory thus far has explained in a special case two most fundamental observations: 1. That our organ of hearing is capable of analyzing a compound acoustic process; and 2. that it has the power of producing on its own account subjective tones which no study of mere external conditions could ever have revealed to us as a natural consequence of the physical processes we call tones.

A problem for future solution

We saw in the preceding paragraph that all the nerve ends between x_0 and x_1 received three shocks in the unit of time. A measurement of the distances in the figure, however, shows that the time intervals between these three shocks, although approximately the same, are not exactly alike (and, moreover, there are differences in this respect between the several nerve ends all of which receive three stimulations). Now, it is probable that the particular nervous excitation set up in each ganglion cell by these three stimulations of its terminal fibre and thence carried farther to the brain, may be just the same in either case, whether the shocks are received in an exactly regular rhythm or in a slightly irregular succession. It will be one of the problems of the future to decide what is the limit of irregularity which must not be overstepped if the sensation produced is to be the same as that of a regular series of shocks of the same frequency. At present we have hardly any certain data upon which to found a decision. We must leave this problem open for the present. It would be well, however, to remember that the above graphic representation of the movement of the partition—for simplicity's sake—is based on a number of assumptions, and that the actual movement of the partition is doubtless somewhat different from the one which is here under discussion, and which contains probably only the essential features of the actual movement, not all its minor details. It is entirely possible, under these circumstances, that the irregularity in question is in reality much less considerable than it appears to us now, and what seems to be an important problem, may turn out to be no problem at all. The reason we have for believing that the actual irregularity might be less than the one found here, is that in the graphic representation we have assumed a movement made up of absolutely sudden, unprepared jerks, with intervals of perfect rest between them. The real movement is probably a more gradual change from rest to motion and back to rest; and the result of this might very well be an equalization of the time intervals preceding the shocks received by the nerve ends. This, however, is not offered as a solution of the problem, but merely as a suggestion for the future investigator of this subject.

Second method of graphic representation of the movement of the partition

Let us try another method of graphically representing the movement of the partition under the provisional assumptions made. This method has a certain disadvantage as compared with the method used above, in being less accurate with regard to the time intervals, but, on the other hand, the advantage of a greater simplicity for the constructor as well as for the reader. The extension of the partition from the windows towards the apex of the cochlea is here represented, not—as before—by the vertical, but by the horizontal extension of the figure, from left to right. Figure 13 shows the method as applied to the same curve (Fig. 11) which we have just discussed. The first thing we have to do is to draw in the given curve (Fig. 11) at equal distances so many lines parallel to the horizontal coordinate that each of the maxima and minima can be regarded as lying on one of these parallels. If this is not easily done, then any arbitrary number of parallels may be drawn. But the drawing as well as the interpretation of the new figure requires a little more attention in this case, because we have to consider fractions. In this figure there are thirty equidistant lines drawn parallel to the horizontal coordinate. A greater accuracy than this would be entirely out of place, since our representation in any case is merely an approximate representation of the actual movement of the partition. These horizontal parallels are auxiliary lines, serving the purpose of a measuring scale. The second thing we have to do is to draw a second, independent, system of auxiliary lines enclosing a corresponding number of spaces. These lines are the thirty-one vertical parallels in figure 13. The horizontal lines here indicate for the times A, B, C, and so forth, the positions of the different points of the partition at the upper or lower limit of movement. The vertical

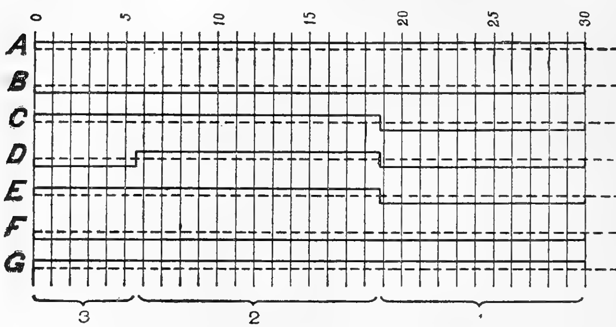


Fig. 13. Successive positions of the partition. The combination 2 and 3. First characteristic phase. Compare figure 11

auxiliaries serve the purpose of cutting off the partition a number of equal sections corresponding to the number of parts into which we divided the total amplitude of the given curve representing the movement of the stirrup. To the right of these sections which move are to be imagined the parts of the partition nearer the apex which do not move at all in this special case and which do not, for this reason, concern us here. At the time A, all the moving parts of the partition are at their upper limits, since the stirrup has at this time its extreme outward position. From A to B, the stirrup moves through thirty units inwards, pushing down successively all the thirty sections of the initial part of the partition. We find, therefore, in figure 13 at B all the thirty sections at their lower limits. From B to C, the stirrup makes an outward movement through nineteen spaces. The result is an upward movement of an equal number of sections of the partition. We find, therefore, at C the first nineteen sections of the partition at their upper limits. All the following parts of the partition remain exactly in the positions at which they were at the time B, since—according to the assumptions under which we are working—no force whatsover has acted upon them. That is, the sections twenty to thirty are still at the lower limits, and the further parts of the partition in their normal positions. From C to D the stirrup moves inward through six spaces, as seen in figure 11. It causes therefore the first six sections of the partition to be jerked down. In this position we find them in figure 13 at D. All the rest of the partition remains exactly as it was at C. That is, the next thirteen sections are still at the upper limits and the following eleven still at the lower limits where we found them at B. From D to E, the stirrup makes an outward movement through six spaces, causing an equal number of the initial sections of the partition to be jerked up. We therefore find in the figure at E the first nineteen sections of the partition at the upper limits, the following eleven at the lower limits. From E to F, the stirrup moves inward again through nineteen spaces, causing nineteen sections of the partition to be jerked down. We find, therefore, in the figure at F all the thirty moving sections of the partition at the lower limits. From F to G, the stirrup moves outward through thirty spaces, as seen in figure 11. This causes thirty sections of the partition to be jerked up. So we find in figure 13 at G the whole initial piece of the partition which moves and therefore alone concerns us, at the upper limit. The stirrup has now reached the very position from which it started at A; and the partition has the same position which it had then. We have thus graphically represented the characteristic positions through which the partition passes during a complete period of the movement in question.

The graphic representation, of course, is only a means to an end. We have to read off from this representation how many shocks are received during the period by the nerve ends on each section of the partition. This is easily done. Let us again, for want of definite knowledge, make the assumption that a jerk down of the partition means a stimulation of the nerve ends, and that a jerk up is irrelevant. We then simply have to go down in the figure from the top to the bottom and count the number of times each section is jerked down. The first section is down at B, up again at C, down for a second time at D, up again at E, down for a third time at F, and up again at G. The nerve ends on this section, therefore, receive three shocks during the period. We find the same number of stimulations on the following five sections. Let us now inspect the seventh section. It is down at B, up at C and still up at D and E. It is down for a second time at F and up again at G. That is, the nerve ends on this section receive two shocks during the period. The same is true for the following twelve sections. Let us now look at the twentieth section of the partition. It is down at B, still down at C, D, E, and F; up again at G. That is, the nerve ends here receive only one shock during the period. The same holds for the following ten sections. We see, then, that three tones must be simultaneously heard, which we may call, according to the relative frequency of stimulation, the tones 3, 2, and 1. The relative intensities of these tones may be regarded—under the provisional assumption of a uniform distribution of nerve ends lengthwise over the partition—as six,

How to read off the tones heard and their intensities

thirteen, and eleven, according to the number of sections which receive the greater or smaller number of shocks.

Difference of phase. Characteristic curves of a tone combination

Let us now apply the second graphic method to another given movement of the stirrup, which will make clear to us another interesting property of the ear with respect to the manner in which this organ analyzes an objective sound. The curve of the stirrup (Fig. 14) is made up of two component curves, very similar to the curves composing the last curve discussed. That is, each of the two components is approximately a sinusoid, one of a period equal to two thirds of the other's period, both of approximately the same amplitude. The resultant curve is constructed here as before by measuring and adding together the ordinate values of the components in the drawing. The difference between the present case and the last case discussed is a difference of phase. If the reader should not know what this means, it can be easily understood by the aid of figure 14. We find there two sinusoids, one with two and one with three maxima within the same period, which accordingly may be called curve two and curve three. Now imagine curve two moved slightly to the right until the minima at the extreme right and also the minima at the extreme left coincide. We then have exactly the case discussed above; that is, the addition of the two curves would result in a compound curve as represented by figure 11. The curves of figure 11 and of figure 14 may be called the characteristic curves of the ratio 2 : 3, because they are the two extreme forms between which the compound curve changes as the result of a change of phase, that is, of a lateral movement of curve two, while curve three remains stationary. Let us convince ourselves here that there are no more than two characteristic compound curves. If we move curve two again slightly to the right, the same distance as before, that is, one twelfth of the period, we obtain a compound curve as shown in figure 16, which is exactly like figure 14 when read from the right to the left. And if we change the phase again in the same manner, that is, move curve two again one-twelfth of the period to the right, we obtain a compound curve as shown in figure 18, which is exactly like figure 11 only turned upside down. We shall demonstrate in the succeeding paragraphs that it is entirely irrelevant with respect

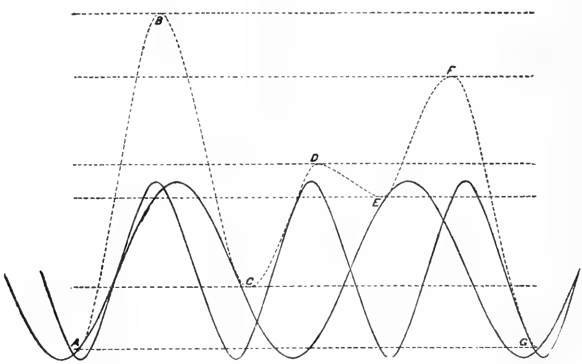


Fig. 14. The combination 2 and 3. Second characteristic phase

to our theory whether we read a curve from the left or from the right, in its first position or turned upside down. We shall demonstrate thus that there are indeed only two compound curves, no more, which are characteristic of a combination of two sinusoids. This is an important fact because it makes much simpler and easier our task of comprehending the function of the inner ear.

Let us apply, then, the second graphic method to this second characteristic curve of the combination 2 and 3. We locate, in figure 14, the horizontal coordinate so that the absolute minima of the compound curve are to be found thereon. We then draw a number of equidistant lines, say thirty, parallel to the horizontal coordinate. To avoid making the figure obscure I have indicated of these parallels only those which pass approximately through the maxima and minima of the curve. We further draw a system of thirty-one equidistant vertical parallels enclosing a series of thirty equal spaces which represent succeeding pieces of the partition. In this system of auxiliaries we represent the positions of the partition at the time A, B, C, and so forth. At A in figure 15 we find all the moving sections of the partition at their upper limits, since the stirrup has at this time, as figure 14 shows, the most outward position, the external air pressure and accordingly the density of the air in the middle ear being lowest. At B we find all the thirty initial sections of the partition down,

Theory applied to second characteristic curve of combination 2 and 3

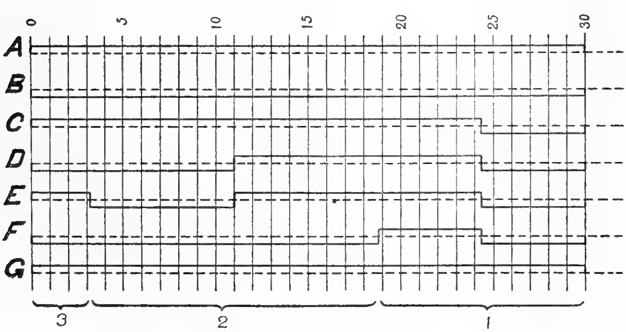


Fig. 15. Compare figure 14

since from A to B the stirrup has moved through thirty units of space inwards. At C we find the twenty-four initial sections raised again since the stirrup has moved outward through twenty-four spaces. At D the eleven initial sections of the partition are at their lower limits since from C to D the stirrup has moved through eleven spaces in an inward direction. From D to E the stirrup moves outwards through three spaces. Accordingly we find at E the first three sections of the partition raised to their upper limits. From E to F the stirrup moves inwards through eleven spaces. Accordingly eleven sections of the partition must be pushed down to their lower limits. We find the first three down at F. The following sections up to the twelfth were already down at E. In order to represent eleven sections of the partition as just pushed down we have to place at F the twelfth and the following, including the nineteenth, sections of the partition at their lower limits. Then the first three and the latter eight make up the total number of eleven sections pushed down. From F to G the stirrup moves outwards through twenty-four spaces. Accordingly all sections of the partition are raised to their upper limits except those from the nineteenth to the twenty-fifth which were already at their upper limits at F and therefore simply stay there. So we find the partition at the time G in exactly the same position in which it was at A; and we must find it again in the same position since now another period of stirrup movement begins, exactly like the period just discussed. We now have to read off the tones heard and their intensities in the same manner as we did this before. The result is that we must expect to hear the three tones 3, 2, and 1 in the relative intensities three, sixteen, and eleven.

Comparing our analysis of the curve in figure 14 with the former result obtained from figure 11, we observe that in spite of the remarkable difference of appearance of these curves to the eye, the tones which we expect to hear are the same. This is, of course, of the greatest importance in musical practice. Imagine the unsurmountable difficulties if the director of an orchestra were responsible for the phase in which the several tones produced by the members of the orchestra acted upon the auditory organs of each hearer in the concert hall. But, as it is, each hearer perceives the same tones whatever the phases of the objective processes in the air. Now those who believe in the existence of a system of strings like "a piano in the ear," have laid much stress on this fact of the practical irrelevance of phase, and some have even gone so far as to say that it compels us to assume sympathetic resonance to be the mechanical power of the auditory organ. I need not persuade the reader, however, that such a compulsion does not exist. Some have gone still farther and asserted that phase difference has never and under no circumstances any influence whatsoever upon the auditory perception. Their theory of the mechanics of the inner ear may lead to such a consequence, to an absolute irrelevance of phase. Experiment, however, has not yet proved that phase difference of the sinusoidal components of stirrup movement has never any influence of any kind upon the perception. Our theory has shown us the practical irrelevance of phase differences and, at the same time, left a possibility for slight influences of this kind upon the perception, resulting in a change of the relative intensities of the several tones heard. The intensities of the three tones for one phase we found to be six, thirteen, and eleven; for the other phase three, sixteen, and eleven. That is to say, we would hear in the second case the same tones, but their relative

Practical irrelevance of phase

intensities would not be exactly the same as those in the first case. That is, difference of phase may be irrelevant, but it need not be so. Let us recall, however, that our representation is only a rather remote approximation to the actual movements of the partition, so that actually the influence of phase upon the perception may be other than it here appears to be. What is important is our insight into the possibility of a slight influence of this kind.

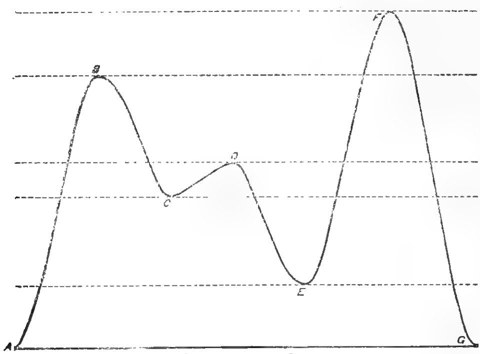


Fig. 16. Compare figure 14

Theoretic irrelevance of the sign of the coordinates

I promised to demonstrate that the application of our theory yields the same result if we read the curve of stirrup movement from the right to the left, or turn it upside down. The former case is illustrated by figure 16, which is exactly like figure 14 when read from the right to the left. Figure 17 shows the successive positions of the partition. At B the twenty-four initial sections are down. At C the first eleven of them are up again. At D three are down again. From D to E the stirrup moves through eleven units of space outwards.

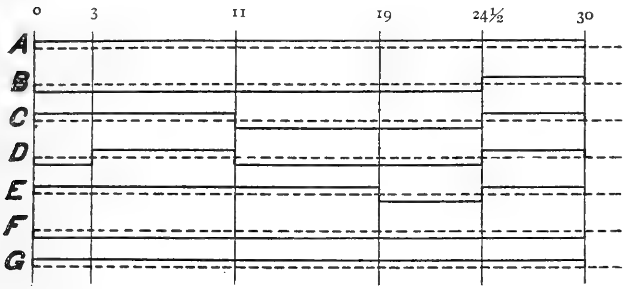


Fig. 17. Compare figure 16

Therefore at E the first nineteen sections are up, eight of them being up already at D. From E to F the stirrup moves in-

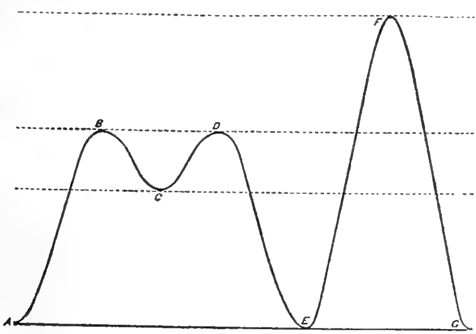


Fig. 18. Compare figure 11

wards through a little more than twenty-four units of space. Therefore at F thirty sections are down, five of them being down already at E. At G (equal to A) all the thirty sections are up again. The tones to be heard, which the reader after all the previous practice in this task can easily read off, are 3, 2, and 1 with the relative intensities three, sixteen, and eleven.

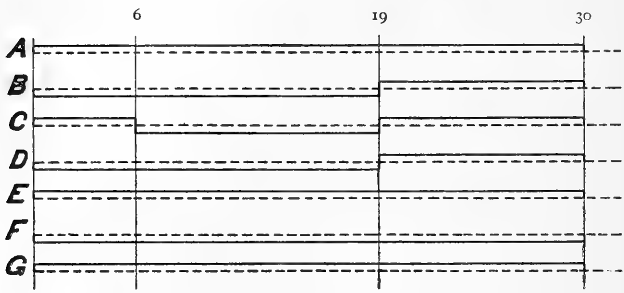


Fig. 19. Compare figure 18

As expected, this result agrees perfectly with our analysis of the curve in figure 14.

Let us now demonstrate that turning the curve upside down has no influence on the theoretic result. Figure 18 is exactly like figure 11, only turned upside down. In figure 19 we see

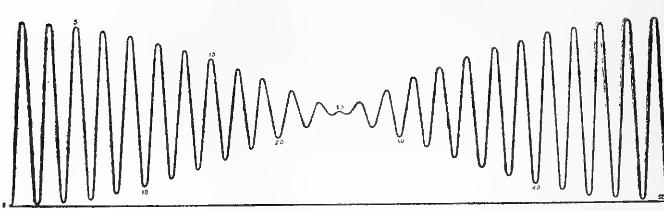


Fig. 20. The combination 24 and 25

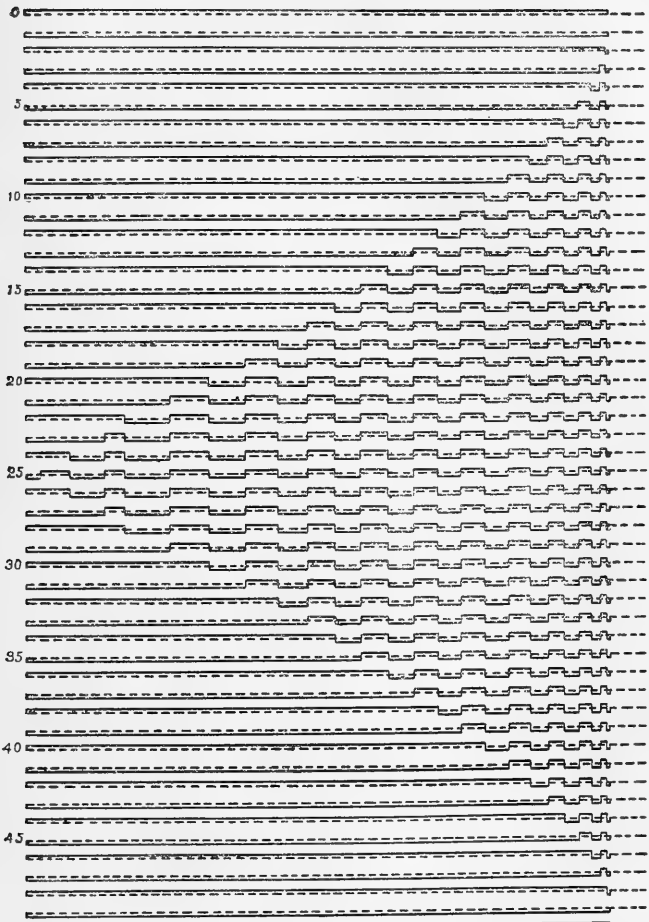


Fig. 21. The combination 24 and 25. Compare figure 20

the successive positions of the partition corresponding to this curve. The interpretation of the figure is so simple that the reader will easily read off, without any aid, what tones are to be heard; namely the tones 3, 2, and 1 with the relative intensities six, thirteen, and eleven. This is exactly the same result as that of our analysis of the curve in figure 11.

The interval studied above is in musical terminology that of a fifth. Let us now study an interval which is even smaller than a semitone. The compound curve in figure 20 is made up of twenty-four vibrations originating from one source and twenty-five from another. Figure 21 shows the successive positions of the partition corresponding thereto. The initial section of the partition moves up and down twenty-five times during the period. We may, therefore, conclude that the nerve ends located here will transmit to the brain a process resulting in the sensation of the tone 25. In order to discuss this matter with more accuracy, I have not relied only upon the draftsman's skill in constructing the compound curve, but computed the ordinate values of some of the maxima and minima. Such a computation is exceedingly tiresome work, since for each pair of values in the table it is necessary to compute twenty or more values in order to select from them what appears as the maximum or minimum. But the accuracy of this method can be carried to any decimal desired. We learn from the table of these values that the relative intensity (when determined in the same way as above) of the tone 25 would be nine (that is, 200—191).

The tone combination 24 and 25

INTERVAL 24:25, EQUAL AMPLITUDES

	Abscissa	Ordinate	Abscissa Difference	Point	Ordinate Difference
Min.	0	0	73	0	400
Max.	73	400	73	1	400
Min.	147	2	74	2	388
—	—	—	—	—	—
Max.	1540	246	—	21	—
Min.	1620	167	80	22	79
Max.	1685	221	65	23	54
Min.	1755	191	70	24	30
Max.	1800	200	45	25	9
Min.	1845	191	45	26	9
Max.	1915	221	70	27	30
Min.	1980	167	65	28	54
Max.	2060	246	80	29	79
—	—	—	—	—	—
Min.	3453	2	—	48	—
Max.	3527	400	74	49	388
Min.	3600	0	73	50	400

Do we hear the tone 25?

If we regard—quite arbitrarily—the time from one stimulation to the next as measurable by the abscissa differences of the succeeding maxima, we observe that this difference is about one hundred and forty-seven at the beginning of the period, that it decreases very slowly and is about one hundred and forty-five at the maximum twenty-three, about one hundred and fifteen at the maximum twenty-five, the same at the maximum twenty-seven, and that it increases gradually till the end of the period. One twenty-fifth of the whole period is one hundred and forty-four. This is the average abscissa difference, on which the pitch of the tone heard depends, since the abscissa difference is inversely proportional to the frequency of stimulation. But the actual abscissa differences, as we have just seen, deviate from the average, particularly in the middle of the period. Now, some one might prefer to conclude that we ought not to hear the tone 25 all the time, but at first a tone somewhat lower than this, gradually rising slightly and falling again in pitch towards the end of the period. Whether we should draw this conclusion I will not attempt to decide. Neither do I care to express a definite opinion as to what we actually hear. Let the reader who wants to know this find it out by an experiment of his own. What I must point out, however, is the fact that the time interval between two maxima is not necessarily the time between two stimulations. In a provisional way, the interval between two maxima or between two minima or between two points of inflection or between two points of any other name and definition may be used thus, but let us always remember that this is only a provisional, an artificially simplified method, which can scarcely yield more than a rough approximation of what actually happens.

Do we hear the tone 24?

Another section of the partition moves up and down twenty-four times during the period. The length of this section, which determines the relative intensity of the tone heard, is derived from the table as being twenty-one (221 — 200). If we look at the time interval between the successive maxima, we find this to be at the beginning of the period one hundred and forty-seven, to decrease gradually to one hundred and forty-five at the maximum twenty-three, to be two hundred and thirty from maximum twenty-three to maximum twenty-seven (maximum twenty-five has disappeared, as seen in figure 21), and to fall again to one hundred and forty-five. Here again, I will not attempt to decide what we ought to expect theoretically, because we have no right to deduce anything definite from a theory in a direction in which this theory is as yet professedly indefinite, in which it obviously lacks as yet all details, owing to the deficiency of the requisite experimental data. I can only repeat here what I said in the preceding paragraph.

No indiscriminate counting of stimuli allowed

Before we continue this attempt at an interpretation of figure 21, let us consider an imaginary case the application of which to our figure will soon make itself clear. Imagine that during half a second a nerve end receives in regular intervals fifty stimulations, but during the following half-second no stimulations at all; then again for half a second fifty stimulations in regular intervals, and again for half a second none; and so on. What could we hear in such a case, but a tone for half a second, nothing for half a second, a tone again for half a second, nothing again for half a second, and so on. And what tone would it be? Plainly the tone which we ordinarily call 100, because the frequency with which fifty stimuli are received in half a second is the same as that with which one hundred are received in one second. I need not waste any effort in trying to prove what is self evident, namely that it would be absurd to count in a case like this simply the number of stimuli during any whole second and to expect, these being fifty, that we should hear the tone 50. And yet this way of counting has been actually proposed. But this proposition may well be ignored.

What beats do we hear?

Now let us return to the interpretation of figure 21. The third section of the partition, the length of which is twenty-four (191 — 167), receives stimulations in approximately equal intervals until about the miximum twenty-three when there is no stimulus at all until about the maximum twenty-nine. With the rough approximation here possible we may say that there is no stimulus during about one-tenth of the period. From our discussion in the preceding paragraph it follows that during about nine-tenths of the period we should hear a tone and during one-tenth of the period we should hear nothing so far as the nerve ends of this section are concerned. The pitch of the tone we must expect to lie between the tones 24 and 25, acording to the probable frequency with which the stimulations are received during that part of the period during which they are received.

The "mean" tone

It is plain that the fourth, fifth and following sections of the partition must move up and down very much the same as the third section does, with this difference only, that for each further section the pause when no stimulations at all are received becomes longer and longer. The total sensation, then, which is derived from the sum of the nerve ends of the third and the following sections must be a tone of a certain intensity at a certain time when all these sections mediate the sensation, but becoming weaker and weaker as one after another of the sections stops moving until for a moment it ceases altogether, then appearing again and increasing up to its former intensity. And so on again and again. That is to say, we hear this tone "beating." And since its pitch lies probably somewhere between 24 and 25, between the "primary" tones (perhaps its pitch is not quite constant but may vary slightly during each period), I propose to call it the "mean tone" (German: Zwischenton). The question whether we hear such a mean tone I do not care to answer here, this discussion being devoted to theory, not to experimental research. Let the reader who desires make observations of this kind himself.

The difference tone

The farthest section of the partition set in motion by this movement of the stirrup moves up and down only once during the period. The nerve ends located here receive one shock during each period and convey therefore the sensation of the tone 1, the difference tone of this case. The intensity of the difference tone, corresponding to the length of this section of the partition, is two.

It is not impossible, however, it is even probable, also that a few of the sections just preceding this last convey the sensation of this difference tone, instead of that of the mean tone. The last section which may convey the sensation of the mean tone moves only twice up and down during the period, in quick succession. This double movement is followed by a long pause during which no movement occurs. Now, experimental research of recent years has proved that two shocks received by the auditory nerve ends may be sufficient to give the sensation of the tone corresponding to the frequency with which the two shocks are received—but only within the middle region of the tonal series. Towards either end of this series four, six, and even more shocks are found to be necessary for the sensation of the tone corresponding to the frequency of the shocks. What, then, will be the consequence of choosing the tones 24 and 25 somewhat higher? The section of the partition which makes the two up and down movements in quick succession can no longer convey the sensation of a short mean tone. If there is only one period of movement, no sensation at all will then result. But if many periods succeed, it is much more likely that the double movement of the partition section will have the effect of a single shock than no effect at all; and the repetition of this shock in each succeeding period must result in the sensation of the tone 1, the difference tone.

If the tones 24 and 25 are chosen still higher, it becomes improbable that even three shocks received by the nerve ends in quick succession between two long pauses can give the sensation of a short mean tone. In this case it is highly probable also that the second section before the last conveys the sensation of the difference tone. And so a few more of those more distant sections may convey the sensation of the difference tone instead of the mean tone.

If the difference tone results exclusively from the function of the nerve ends located on the last moving section of the partition, its relative intensity is two, according to the above table. But if the difference tone results from the function of the nerve ends of further sections, its relative intensity must be higher and the maximum intensity of the mean tone correspondingly lower. That is, the phenomenon of a beating mean tone must be the less pronounced the more audible the difference tone; and the difference tone of a small interval like the one in question must be the more audible the higher the pair of primary tones in the tonal series.

Summarizing now our interpretations of figure 21, we must say that so far as the meager data reach from which we can draw theoretical conclusions, the following seems likely to be the total impression (listening with one ear, having the other ear plugged): 1. A tone 25 of the constant, but comparatively weak intensity nine; 2. a tone 24 of the constant, but comparatively weak intensity twenty-one; 3. a mean tone (perhaps slightly varying in pitch during each period) of an intensity which varies once during each period from zero to a definite maximum intensity and back to zero. This maximum intensity may be (under the most favorable conditions) as high as (relatively) three hundred and sixty-eight, but must be much less if the primary tones are above the middle region of the tonal series. Its being less means that the "beats" are less pronounced; 4. a difference tone the relative intensity of which may be (under the most unfavorable conditions) as low as two. Its intensity, however, may be greatly increased, at the expense of the maximum intensity of the beating mean tone, in case the pitch of the primary tones is raised.

The combination 24 and 25; summary

Before we take up the theoretical discussion of further tone combinations, the reader ought to obtain some information concerning the difference tones which we hear in addition to the "objective" tones in the several combinations. To give such information of this kind as is indispensable, I shall state here the laws of these phenomena in as clear and comprehensible a manner as possible. These laws given below do not pretend to tell all the difference tones which we might possibly hear in every possible combination of objective tones. Neither do they tell the relative intensities of the difference tones, although this is a matter of no small importance. Laws of difference tones of this scientific perfection are as yet not known and may never be known. The laws below merely tell those difference tones which one is most likely to hear in those combinations which correspond to relatively simple ratios of the vibration rates and are therefore (musically and otherwise) particularly interesting. These laws are the following four:

Laws of difference tones

In case the ratio of the vibration rates does not differ much from 1:1, let us say 11:12, or 9911:9989, a single difference tone is audible, whose pitch corresponds to the pitch of a tuning fork the vibration rate of which is equal to the difference of the vibration rates of our case. In addition to the difference tone, however, beats are usually clearly audible, and a mean tone may be audible too which lies between the two primary tones. If the interval is quite small, this mean tone is usually more pronounced than either of the primary tones, particularly when we hear with one ear only, having the other ear plugged. The beats just mentioned seem to be the fluctuations of the intensity of the mean tone rather than of the primary tones, if we use one ear only.

First law of difference tones

A second class of ratios which is of particular interest, is that of the ratios whose numbers differ by one. In each of these cases the difference tone 1 is audible, but often quite a number of additional difference tones can be perceived. If the numbers of the ratio are rather small, as in the case of 5:4, all the tones from the highest, that is, 5, down to 1 are without any great difficulty noticeable. As we study ratios of increasing numbers, the tones following directly upon 1 (in a rising direction) seem to have a tendency to drop out. And if we go on in the same

Second law of difference tones

Objective tones	Difference tones easily audible
2, 1	–
3, 2	1
4, 3	2, 1
5, 4	3, 2, 1
6, 5	4, 3, ?, 1
7, 6	5, 4, ?, 1
8, 7	6, 5, ?, 1
9, 8	7, 6, 5, ?, 1
10, 9	?, 1

way, we soon find only one difference tone left, the tone 1. We have then simply reached a case in which the difference tone is determined by the first law above. The accompanying table represents this class of ratios with their difference tones.

A third class of ratios are the ratios made up of comparatively small numbers, representing intervals less than an

Third law of difference tones

octave. In these cases three difference tones are often easily noticeable, one corresponding to the direct difference of the vibration rates $(h - l)$; one corresponding to the difference between the latter number $(h - l)$ and the vibration rate l of the lower primary tone, that is, $(2l - h)$; and one corresponding to the difference between the just mentioned differences $(h - l)$ and $(2l - h)$, that is $(2h - 3l)$. It is to be noticed, however, that a difference tone is rarely audible which corresponds to a difference larger than the subtrahend; for example, the primary tones 9 and 5 produce the difference tones 4 and 1, but not $3 = 4 - 1$, or at least not an easily noticeable tone 3, three being larger than one. The following table contains a few examples of this class:

Objective tones	Difference tones easily audible
8, 5	3, 2, 1
5, 3	2, 1
9, 5	4, 1
7, 4	3, 1
11, 7	4, 3, 1

The fourth class are the ratios made up of comparatively small numbers, representing intervals larger than an octave.

Fourth law of difference tones

The first fact to be noticed here is the lack of an easily observable difference tone corresponding to the direct difference of the two vibration rates. Such a tone, if audible, would lie between the primary tones. As a rule, only one difference tone is easily noticeable in these cases, which can be found according to the following rule: Find the smallest difference between the larger number of the ratio and any multiple of the smaller number. The table contains a few instances of this class:

Objective tones	Difference tones easily audible
11, 4	$1=3\times4-11$
12, 5	$2=12-2\times5$
9, 4	$1=9-2\times4$
11, 3	$1=4\times3-11$
5, 2	$1=5-2\times2$
8, 3	$1=3\times3-8$

The use of such laws

Let me repeat that the above rules do not pretend to represent scientific laws in the strict sense of the word. They are stated here chiefly for a practical purpose. If the reader who is unfamiliar with difference tones will use the above "laws" as directions for observation and obtain a first hand knowledge of the phenomena of difference tones, he will be more interested in the theoretical discussions which are to follow, and able to decide for himself in what directions the mechanical theory is yet most undeveloped and most wanting in details.

The combination 4 and 9

Let us apply our theory now to the combination of two sinusoids of the relative periods nine and four, that is, of the relative frequencies 4 and 9. The compound curve, representing the function

$$f(x) = 1.99 + \sin 4x + \sin 9x$$

is shown in figure 22. The period is made to begin and to end with the lowest ordinate value of the function, zero, because this has certain technical advantages.

It is, of course, in a periodical function, entirely irrelevant for the mechanical theory what point we regard as the beginning of the period. The accompanying table contains the pairs of corresponding coordinate values of all the maxima and minima of the curve. These values are found by computing a large number of pairs of values and selecting from them

INTERVAL 4:9, EQUAL AMPLITUDES

	Ordinate	Abscissa	Ordinate		Ordinate Difference
Max.	+ 169	119	368	P	338
Min.	— 16	318	183	Q	185
Max.	+ 75	471	274	R	91
Min.	— 199	696	0	A	274
Max.	+ 110	929	309	B	309
Min.	— 2	1094	197	C	112
Max.	+ 142	1275	341	D	144
Min.	— 189	1512	10	E	331
Max.	+ 42	1724	241	F	231
Min	— 42	1876	157	G	84
Max.	+ 189	2088	388	H	231
Min.	— 142	2325	57	I	331
Max.	+ 2	2506	201	J	144
Min.	— 110	2671	89	K	112
Max.	+ 199	2904	398	L	309
Min.	— 75	3129	124	M	274
Max.	+ 16	3282	215	N	91
Min.	— 169	3481	30	O	185
Max.	+ 169	3719	368	P	338

those which have the highest and lowest ordinate values. This computation is a very slow process, but has no limit of accuracy. Figure 23 shows the positions of the partition belonging to the maxima and minima of figure 22. We see that at A the initial forty sections of the partition are in their upper positions. At B, the first thirty-one of them are at their lower limits. At C, the stirrup has caused eleven sections to assume their upper limits. From C to D, the stirrup moves inwards through fourteen units of space, pushing down the eleven sections which were up at C, leaving the following twenty unmoved since they are down already, and pushing down three more, so that now the first thirty-four

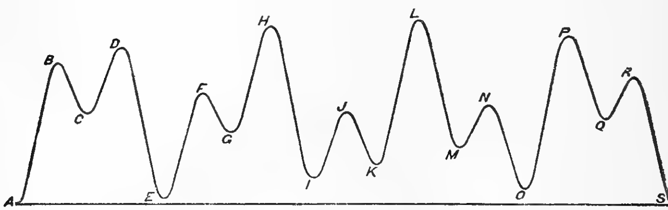


Fig. 22. The combination 4 and 9

sections of the partition are down, six further sections are up, and all the following ones are in their normal positions. From D to E the stirrup makes an outward movement through thirty-three units of space, moving up the first thirty-three sections of the partition. From E to F, the stirrup moves inwards through twenty-three units of space; and so on. At S, we find the partition in the same position as at A, our starting point; then, a new period begins.

Do we hear 9?

Let us now try to interpret the figure. We can easily see that the first eight sections move down and up again nine times during the period. This would mean that the nerve ends located on this section convey to our mind the sensation of the tone 9 of the relative intensity eight. The ninth section of the partition moves down and up only eight times during the period; but after our discussion about the omission of stimuli it is clear that we should not be justified in concluding that we must hear the tone 8. This tone would be audible only if the frequency with which the stimuli occur on the ninth section was less than the frequency on the first eight sections. However, there is no reason why we should regard the fre-

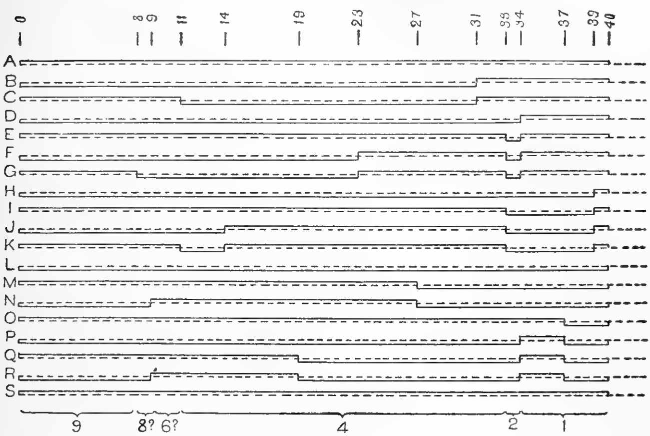


Fig. 23. The combination 4 and 9. Compare figure 22

quency as different. It seems most probable, then, that the nerve ends of the ninth section convey to us the sensation of the tone 9, but with a short pause (or possibly, because of the after-sensation, a diminution of intensity only) at the moment about G, when no stimulation takes place. Our total impression of the tone 9 is, of course, the sum of the sensations conveyed by all the nine initial sections. This means that the tone intensity perceived would, on the whole, be nine; but that for one moment in each period this intensity of the tone might suddenly be slightly decreased. It does not seem improbable—so far as our theoretical data permit us to draw a conclusion—that such a sudden, but weak decrease in intensity might become noticeable as a kind of just perceptible "beat." I leave it to the reader to decide experimentally whether the tone 9 in this combination appears slightly "rough" or perfectly "smooth."

Do we hear 6?

The tenth and eleventh sections of the partition move down and up six times during the period. But we must remember here from our previous discussion that—in order to conclude as to the tones to be heard—no indiscriminate counting is permissible. Mere counting of stimuli would indicate the tone heard only in case it seems probable that these stimuli occur in equal or approximately equal intervals. Now, a survey of figure 23 does not make it appear probable that the stimuli on the two sections in question occur in even approximately equal intervals. The partition moves down at F and remains in the lower position until it moves up at I. It moves down at J and immediately, at K, up again. Down at L and up at M. In this upper position it remains until P, when it moves down. At Q it is up again, to stay in the upper position until B, when it moves down. At C it is up again. At D it moves down, at E up, and at F down again. Are we justified in concluding that the nerve ends located on these two sections of the partition must convey to our mind the sensation of the tone 6 of the intensity two; or any other definite sensation? I do not know how to answer this question. If we knew the time intervals between the successive stimuli exactly, we might attempt to decide whether one or the other sensation would be more or less probable in this case. But we know that figure 23 is only an approximate, not an exact representation of the actual movement of the partition. It is a certain comfort in this dilemma that the practical importance of a decision in this case is rather small, for the reason that, whatever sensation these two sections might produce, it would be a sensation of the relative intensity two only, a rather weak sensation compared with the tones which appear theoretically certain.

Do we hear 4?

The twelfth, thirteenth, and fourteenth sections of the partition move down at B, a second time at F, a third time at J, and a fourth time at P. These sections, therefore, move down and up four times during the period in approximately equal intervals. The five following sections of the partition move down at B, a second time at F, a third time at L, and a fourth time at P. These sections, therefore, move down and up four times during the period in approximately equal intervals. The four sections from the twentieth to the twenty-third move down at B, a second time at F, a third time at L, and a fourth time at P. These sections, therefore, move down and up four times during the period in approximately equal intervals. The following four sections move down at B, a second time at H, a third time at L, and a fourth time at P; that is, four times during the period in approximately equal intervals. The four sections from the twenty-eighth to the thirty-first move down at B, a second time at H, a third time at L, and a fourth time at P; again, four times during the period in approximately equal intervals. The thirty-second and thirty-third sections move down at D, a second time at H, a third time at L, and a fourth time at P. These sections, therefore, move down and up four times during the period in approximately equal intervals. It follows that according to our theory we must expect to hear the tone 4 of a relative intensity twenty-two, since it is produced by all the sections from the twelfth to the thirty-third.

The thirty-fourth section of the partition moves down at D, and up again at O; down at P, and up again at S. That is, the nerve ends of this section receive two stimuli during the period. We may expect to hear, therefore, the tone 2 of the relative intensity one. The three following sections of the partition move down at H and up again at O. The nerve ends on these sections receive, therefore, one stimulus during the period. The next two sections move down at H and up again at S. The nerve ends here receive one stimulus during the period. The fortieth section moves down at L and up again at S. The nerve ends here receive one stimulus during the period. We must hear, then, the tone 1 of the relative intensity six. The tones 2 (weak) and 1 (strong) are the only difference tones in this case which we can derive from our theory with some degree of certainty.

Do we hear any difference tones?

Summarizing now the results derived from our representation of the movements of the partition in the case of the ratio 4:9, we find that we must expect to hear the tones 9, 4, 2 and 1, with the relative intensities nine, twenty-two, one and six; leaving out of discussion the doubtful sensation of the intensity two which may be conveyed to our mind by the tenth and eleventh sections. Now, it is quite natural to ask the question whether we hear these tones with just these relative intensities. Unfortunately, no exact answer to this question is possible, because this matter, owing to technical difficulties and other circumstances, has never been experimentally subjected to accurate measurement. It is known, however—what also appears in the above statement of our results—that in a combination of two tones the higher one loses in intensity, compared with the lower one. Yet it is doubtful if this loss in intensity is so great as the number nine indicates, compared

The relative intensities compared

with twenty-two. The present writer at least is inclined to doubt this. He believes that the theory, representing only an approximation to what actually happens in the organ of hearing, exaggerates the degree of this loss of intensity on the part of the higher tone. He is also inclined to believe that the theory exaggerates the relative intensity of the difference tone 1, which was found to be six. In reality, this tone seems to be somewhat weaker than is indicated by this number.

The third and fourth provisional assumptions recalled

Let us remember, now, the provisional assumptions which we made in order to render the graphic representation of the movement of the partition as simple as possible. We may raise this question: Is not, perhaps, the above disagreement between theory and experimental observation a result of one or more of these provisional assumptions? I shall demonstrate that this is indeed the case. Or, more exactly, I shall demonstrate that, if we omit one of these assumptions and take into account in its stead the actual anatomical conditions so far as these are known, we change the results of the theory in such a direction as to diminish the exaggerated loss of intensity of the higher primary tone and also the exaggerated intensity of the difference tone.

The partition is narrower near the windows

The partition was provisionally assumed to be of equal width all along the tube. As a matter of fact, its width near the windows is only one-twelfth or one-tenth (measurements differ somewhat) of what it is at the far end of the tube. And further, it is to be noted that the width of the partition does not increase uniformly along the tube, like the area between the dotted lines of figure 24, but that it increases first rather rapidly, later more slowly, like the area between the curved lines. The figure, however, does not represent the true relation between the width and the length of the partition. The partition as a whole is much narrower in comparison to its length than appears in the figure. Let us try, then, to get a clear conception of the functional significance of these facts. It is of no particular importance, in this connection, whether the measurements upon

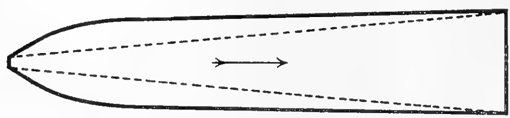


Fig. 24. Shape of the partition

which the following considerations are based are more or less incorrect, as they probably are; for our intention is merely to get an idea of the general direction in which the actual shape of the partition changes the results of a theory having provisionally assumed that the partition is everywhere of equal width.

A unit of stirrup movement equals a unit of displaced fluid

When the partition yields in either direction, up or down, its former place is taken by the fluid of the tube. Let us call the quantity of fluid which has taken positions formerly occupied by the partition "the displaced fluid." Now, it is plain that the quantity of displaced fluid must always be approximately proportional to the distance through which the stirrup has moved since its last reversal of movement. If the partition were equally wide everywhere, then any section of equal length, far from or near the windows, would make room, in moving from one limit to the other, to the same quantity of displaced fluid as any other section. And then, plainly, the length of that part of the partition which is caused to move from one limit to the other would always be proportional to that part of the stirrup movement which caused it to move.

This is the effect of our provisional assumption. But if the partition tapers as it does, a unit of displaced fluid (corresponding to a unit of stirrup movement) is made room for by sections of the partition of very unequal length according as the displaced fluid unit is located nearer or farther from the windows. Where the partition is narrow, a longer section would have to move in order to make room for a unit of displaced fluid. Where the partition is wider, a shorter section would make room for the same quantity of fluid.

The computation of a table

Since, then, tone intensity depends on the length of the partition section which is jerked up and down, and since this length is not proportional to the given value of the stirrup movement, it is useful to have a table showing the partition lengths corresponding to various stirrup movements in order to get a clear idea of the influence of the tapering of the partition upon the relative tone intensities. To simplify the computation of such a table, it is well to restrict it to a short distance from the windows, so that we

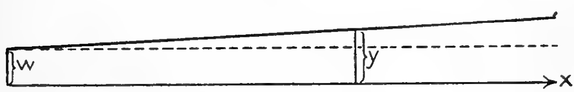


Fig. 25. The partition widens

may approximately assume the partition to increase uniformly in width within this distance. Let us call w the smallest width of the partition, near the windows; let us assume that a distance from the windows equal to $50w$ the width of the partition is $6w$, and let us assume a uniform increase of width. Let us call y the width at any point of the partition and x the distance of this point from the beginning near the windows. We then know (Fig. 25) that the ratio $\frac{y-w}{x}$ is equal to the ratio of $\frac{6w-w}{50w}$

$$\frac{y-w}{x}=\frac{6w-w}{50w}=\frac{1}{10}$$

$$y=w+\frac{x}{10}=\frac{10w+x}{10}$$

The area described by a cross-section of the partition

The area described by the cross-section of the partition in being jerked from one limit to the other may be called a at the point where the width of the partition is smallest, α at any arbitrary point of the partition. These areas, let us assume, are geometrically similar. This assumption possesses a higher degree of probability than what would follow for the areas from the third provisional assumption made above for the sake of simplicity. It then follows that the ratio of the areas is equal to the ratio of the squares of the widths of the partition at the same points.

$$\frac{\alpha}{a}=\frac{y^2}{w^2}$$

$$\alpha=\frac{a\,y^2}{w^2}$$

For y we substitute its value found above and have then the equation:

$$\alpha=\frac{a(10w+x)^2}{10^2w^2}$$

The left side of this equation is a measure of the area described by the cross-section of the partition at the point x, in being jerked from one limit to the other. The right side of the equation contains the variable x, the distance of any point of the partition from its beginning near the windows, and the two constants a and w. The former of these constants is the area described by the initial point of the partition in moving from one limit to the other, of whatever form this area may actually be found to be. The latter is the width of the partition at the initial point.

The mathematical reader immediately sees that that quantity F of displaced fluid for which room is made by a movement of any given section of the partition is determined by the following equation, which can be easily integrated.

The quantity of fluid for which room is made

$$F=\int_{x_1}^{x_2} a dx$$

In order to integrate this equation we have to express a as a function of x. This has been done above under the temporary assumption of a uniform increase of width. The result is stated in the equation just preceding the last. We then have

$$F=\int_{x_1}^{x_2} \frac{a}{100w^2}(10w+x)^2 dx=$$

$$=\frac{a}{300w^2}\left[(10w+x_2)^3-(10w+x_1)^3\right],$$

where x_2 is the farther, x_1 the nearer of the two points enclosing whatever section of the partition is in question.

If the section in question is an initial section of the partition, then x_1 is equal to zero, and the quantity of displaced fluid is

$$F=\frac{a}{300w^2}\left[(10w+x_2)^3-(10w)^3\right].$$

Let us regard the partition as consisting of sections each of the length of w. We can find, then, the quantities of displaced fluid for which room is made by the first section, the first two, the first three, the first four, and so forth, sections by making x_2 successively equal to w, to $2w$, to $3w$, to $4w$, and so forth. If $x = nw$, we have

$$F = \frac{a}{300w^2}\left[(10w+nw)^3-(10w)^3\right]=$$
$$=\frac{a\,w}{300}\left[(10+n)^3 - 10^3\right].$$

Let us arbitrarily regard $\frac{a\,w}{300}$ as the unit of displaced fluid. We could then easily compute a table which contains the number of fluid units displaced by the number n of partition units. If the number of partition units is, for example, three, the quantity of displaced fluid is $(13^3—10^3)$ units and so on.

Two tables possible

More useful, however, is a table which progresses in a regular series of units of fluid and tells us—in decimals—the lengths of the initial sections which make room for these quantities of fluid; for our representation of the movement of the partition tells us the quantities of displaced fluid, and the corresponding section lengths are to be found in order to obtain a more correct idea of the relative tone intensities. In order to compute such a table it is advantageous to use a larger fluid unit than the above. Let us determine the total quantity of fluid for which room is made by the partition section from $x = 0$ to $x = 50w$, that is, the whole part of the partition near the windows for which we have assumed a uniform tapering or change of width; and let us—arbitrarily—regard one-fiftieth of this quantity as the fluid unit.

$$F = \frac{a\,w}{300}\left[(10+50)^3 - 10^3\right]=$$
$$=\frac{215000\,a\,w}{300}$$

The fluid unit, defined as one-fiftieth of the above quantity, is therefore

$$\frac{4300\,a\,w}{300}$$

Any number m of such fluid units is then

$$\frac{4300\,a\,w\,m}{300}$$

We derived above the following equation between fluid quantities and partition lengths

$$F = \frac{a}{300\,w^2}\left[(10w + x_2)^3 - (10w)^3\right]$$

In this equation we have to substitute for F the above expression of fluid quantity and then to solve the equation for x_2.

$$\frac{4300\,a\,w\,m}{300} = \frac{a}{300w^2}\left[(10w + x_2)^3 - (10w)^3\right]$$

$$(10w + x_2)^3 = 10^3 w^3 + 4300 w^3 m$$

$$10w + x_2 = w\sqrt[3]{1000 + 4300m}$$

$$x_2 = (\sqrt[3]{1000 + 4300m} - 10)w$$

The following table contains the corresponding values of m and x_2, measured in the unit of length w.

The use of the table

Let us see, now, how we must use the table of fluid quantities and partition lengths. We recall that any unit of stirrup movement causes the displacement of a unit of fluid. What we have called above "the relative intensities of the tones heard" refers directly to relative numbers of units of stirrup movement; indirectly also to relative numbers of units of displaced fluid, since it is highly probable that the quantity of displaced fluid is approximately proportional to the extent of a stirrup movement. What we want

TABLE OF THE RELATIONS BETWEEN FLUID DISPLACEMENT AND PARTITION LENGTH

m	x	m	x	m	x	m	x	m	x
1	7.43	11	26.42	21	35.03	31	41.22	41	46.18
2	11.25	12	27.47	22	35.73	32	41.75	42	46.62
3	14.04	13	28.46	23	36.40	33	42.28	43	47.07
4	16.30	14	29.41	24	37.05	34	42.80	44	47.50
5	18.23	15	30.31	25	37.70	35	43.31	45	47.94
6	19.92	16	31.17	26	38.32	36	43.81	46	48.36
7	21.45	17	32.00	27	38.92	37	44.30	47	48.78
8	22.83	18	32.80	28	39.51	38	44.78	48	49.19
9	24.11	19	33.57	29	40.10	39	45.26	49	49.60
10	25.30	20	34.31	30	40.65	40	45.72	50	50.00

to know now, is the length of the several sections of the partition of which—in the last case of tone combination, 4 and 9—the first or initial one moves up and down nine times and produces the tone 9, the second produces no definite tone with certainty, the third produces the tone 4, the fourth the tone 2, and the fifth the tone 1.

The fluid quantity for the tone 9 is measured, as we found above, by the relative number nine. Now, let us, for example, assume that this means an equal number of fluid units in our table. We then read off the corresponding partition length as being 24.11 units. The fluid quantity for the uncertain tone was measured as two units. But now, we cannot simply read off from the table the number of partition units corresponding to two; for the partition section making

TONE INTENSITIES IN THE COMBINATION 4 AND 9

Tones	Uniform width	Tapering
9	22.5%	52.7%
Uncertain	5.0%	5.0%
4	55.0%	34.8%
2	2.5%	1.1%
1	15.0%	6.4%

room for these two fluid units is not an initial section. We must read off, therefore, the value corresponding to eleven fluid units (26.42) and subtract from this the value corresponding to nine fluid units (24.11). We thus see that the length of the partition section about the tone of which we could not come to a decision is 2.31 units. The fluid quantity for the tone 4 was measured as twenty-two. But here again we cannot simply read off the length of the partition section producing this tone, because this section is not an initial section. We must read off the values for $9+2+22=33$ and for $9+2=11$ and subtract the latter from the former. These values are 42.28 and 26.42. The length of that section of the partition which moves up and down four times is therefore 15.86 units. The intensity of the tone 2 is one fluid unit. The length of the partition section corresponding to this fluid unit is 42.80—42.28=.52. The fluid quantity for the tone 1 is six fluid units. We have to read off from the table the values corresponding to 9+2+22+1+6=40 and to 9+2+22+1=34 fluid units. These values are 45.72 and 42.80. The length of that section of the partition which produces the tone 1 is therefore 2.92 units of the partition.

The relative intensities of the tones 9, 4, 2, and 1

The relative intensities of the four tones 9, 4, 2, and 1, would then be, not as nine to twenty-two to one to six, but as 24.1 to 15.9 to .5 to 2.9; and the tone about which we could not reach a definite conclusion would have the relative intensity 2.3 instead of two. For the sake of better comparison let us express the relative intensities in percentages. The table shows in one column the tone intensities in case we regard the partition as of uniform width and in another column the intensities in case we regard the partition as tapering and possessing those properties upon which the present computation is based.

This result not final

We must not, of course, regard the result found in the second column of intensities as any more final than that in the first column. We have assumed that the initial section of the partition tapers uniformly so that, the initial width being w, its width is $6w$ at a distance of $50w$. But we do not know that it tapers just this way. We have further assumed that the areas described by cross-sections of the partition in moving from one limit of position to the other, are geometrically similar. But we do not know whether they are or not. We have further assumed that the total movement of the partition in this case extends just to the distance of $45.72w$.

But this is an arbitrary assumption, and the results of the table, as is shown farther below, would look different if the total movement did not extend just so far, but farther or less far. We must not, then, regard this result as final, but simply observe if it tends to change the relative intensities in such a direction as might correct the intensities which seemed somewhat objectionable. Now, we objected, first, to the fact that the higher of the primary tones had such a slight intensity compared with the lower one, 22.5 per cent compared with 55.0 per cent. Now we see that taking into account the tapering of the partition raises the intensity of the tone 9 to 52.7 per cent and lowers that of the tone 4 to 34.8 per cent. As stated before, these particular figures must not be regarded as a final result. It is irrelevant that now the lower tone is weaker than the higher. What is important is the fact that the influence in question is in the direction in which it must be in order to correct the objectionable features of the former computation. A further result of this influence is the reduction of the former intensity of the difference tone 1, which we regarded as rather high, from 15.0 per cent to 6.4 per cent—again a change in the desired direction.

The relative intensities not independent of the absolute intensity of the compound sound

We can obtain here a more special insight in addition to the general insight into the fact that tapering of the partition tends to increase the intensities of the tones produced by the initial sections, to decrease the intensities of the tones produced by more distant sections of the partition. More especially, we shall observe that the amount of this increasing or decreasing influence varies according as the total length of the partition section set in motion varies, that is, as the total intensity of the compound sound heard varies. Imagine, for example, three tones, which we call A, B, and C, being produced by successive sections of the partition. Imagine further that the quantity of displaced fluid for the tone A is 20 per cent of the total amount of fluid displaced by the compound sound wave, that the quantity for B is 50 per cent, and the quantity for C 30 per cent. This is a percentage which might easily be found in an actual case. The pitch of the tones A, B, and C is irrelevant. The table below contains all the values which are of interest to us, for two cases. In the first case the actual fluid quantities are two, five, and three, by assumption; in the second case they are ten, twenty-five, and fifteen. That is, the stirrup movement in the second case is of the same form, but exactly five times as large as in the first.

Quantities of displaced fluid			Length of sections (absolute values)				Length of sections (percentages)		
A	B	C	A	B	C	Σ	A	B	C
2	5	3	11.3	10.2	3.8	25.3	44.7%	40.3%	15.0%
10	25	15	25.3	18.0	6.7	50.0	50.6%	36.0%	13.4%

The table shows that the tone intensities do not increase proportionally to the increase in the amplitude of stirrup movement. The amplitude in the second case is five times that of the first case; but the total intensity (Σ) of the audible sound in the second case is less than twice that of the first case (50.0 compared with 25.3). The table shows further that the intensity of the tone A is in the first case 44.7 per cent, in the second case 50.6 per cent. That is the increase in the intensity of the whole sound is favorable to the relative intensity of the tone produced by the initial section of the partition. The percentage intensity of this tone, A, is increased at the cost of the tones B and C, the percentages of both of which are diminished.

Thus far we have studied the effect upon the relative tone intensities of initial and more distant sections which would result from a uniform increase in width of the partition as compared with a uniform width. But we know that the partition does not increase uniformly, but rapidly at first, near the windows, and more slowly the farther we go from the windows (Fig. 24). To understand the theoretical result of this manner of increase, it is not necessary to compute a new table. It is plain that, if a more distant section increases less than we assumed in computing the preceding table, showing the corresponding values of m and x, this would cause a longer piece of this distant part of the partition to move in order to make room for a certain quantity of displaced fluid. That is, the decrease in the broadening of the partition would counteract the effect last discussed. We saw in the preceding paragraph that an increase in the intensity of the whole sound does not leave the relative intensities of the partial tones unaltered, but favors the intensities of the tones on the initial sections, reduces those on the distant sections. But now, if we increase the intensity of the whole sound, we throw the tones of the more distant sections on still more distant sections, that is, on sections where the broadening of the partition is much less than that assumed in the table. Consequently, the tones of distant sections cannot lose in percentage as much as a derivation from the table would indicate, but might even gain somewhat in percentage of intensity through an increase of the total intensity of the sound.

Increase in width of partition not uniform

The need of a more accurate and detailed anatomical knowledge

The preceding paragraphs must impress us with the perplexity of our situation. We want to comprehend the facts of audition as depending on the structure and function of the sense organ. But every endeavor to enter into the details of the function of the organ is thwarted by the poverty and inaccuracy of our anatomical knowledge. We cannot obtain a definite idea of the intensities of the various physiological processes resulting from a compound aerial wave unless we know exactly the manner of increase in width of the partition. It is not sufficient to know that it increases first rapidly, then slowly. We need a very exact measurement of the width of succeeding cross-sections of the partition and of the distance of each of them from the beginning of the partition near the windows.

The need of a more accurate observation of the psychological facts of hearing

On the other hand, we need also a much more detailed and accurate comparison of the relative intensities of the components of stronger and weaker compound sounds, based on psychological experimentation and observation. Thus far, practically nothing in this regard is known with exactness. It is to be hoped that, in spite of the extraordinary technical difficulties and the costliness of the apparatus required for such investigations, an accurate knowledge of these psychological facts will be obtained. We need this knowledge because some of the constants contained in the mechanical theory may never become directly measurable, for example, the elastic properties of the partition, and, therefore, will have to be inferred from their psychological consequences.

Two important consequences of the partition's shape. Sensitiveness of the ear

Two consequences of the particular shape of the partition which we have just discussed in as much detail as anatomical knowledge permits should be emphasized. The first of these is of the greatest biological significance. It is certainly important for the animal to be very sensitive to sound, that is, to be able to hear sounds which are very weak and cause only a minute movement of the stirrup. Now, the initial part of the partition being exceedingly narrow, even the minutest quantity of fluid displaced by the stirrup must spread considerably lengthwise over the partition and thus stimulate quite a number of nerve ends. But it would not be advantageous to have the partition equally narrow all along. In that case comparatively weak objective sounds would cause the whole partition to move up and down and the displaced fluid for which no room can be made by the partition, to flow back and forth through the "safety valve." Strong objective sounds would then make the same impression upon the animal as sounds of medium physical intensity. This disadvantage is overcome by the partition's tapering, by its being narrow at the beginning, but wide farther on, so that even sounds of considerable strength do not involve the whole partition. But again, there would be a disadvantage if the partition's width increased uniformly; for then the relative intensities of simultaneous tones—as we have seen—would not be even approximately independent of the absolute intensity of the total sound. This disadvantage might be avoided by the width increasing first rapidly, then more and more slowly. If it is thus avoided, either partially or totally, we do not exactly know because of lack of exact anatomical data.

The second of the consequences to be emphasized is probably of little biological significance, but possibly of some importance to the student observing difference tones in a psychological laboratory. It is quite possible that, as a result of the tapering not being uniform but decreasing as the windows are left behind, the relative intensity of difference tones, which are obviously produced by the more distant sections of the partition, is somewhat greater when the absolute intensity of the whole sound is rather great. If this is so, it would be advisable to use for the observation of difference tones fairly strong primary tones rather than weak ones. Whether this conclusion is borne out by experience, I must leave to the reader to decide.

Conditions more or less favorable to the observation of difference tones

The above discussion of tone intensities naturally leads us to take up the theoretical aspects of the fact frequently observed by experimenters that in a combination of a lower and a higher tone the latter is sometimes entirely inaudible, provided, of course, that it is physically much weaker than the former. The reverse, however, that is, the disappearance of a physically weak low tone when sounded together with a strong higher tone, has hardly been observed. The phenomenon in question can, perhaps, be most easily observed with such ratios at 1 : 2, 2 : 3, or 1 : 3. Let us study, then, one of these ratios, say 1 : 2, from the theoretical point of view.

The disappearance of a higher tone

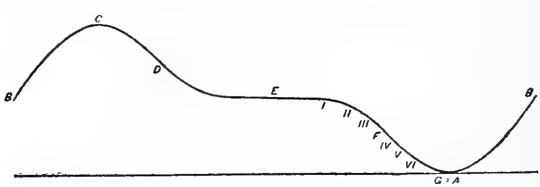


Fig. 26. The combination 1 and 2, unequal amplitudes

Let us combine two sinusoids according to the following equation:

$$f(x) = 2\sin x + \sin 2x.$$

The combination 1 and 2, when 2 is comparatively weak

That is, the amplitude of the sinusoid of the shorter period is one-half of the amplitude of the sinusoid of the longer period. Figure 26 shows the curve representing the stirrup movement, and the accompanying table shows the exact numerical values of those points of the curve which, as we shall see, are of particular importance to us, that is, the maxima and minima, and the points of inflection. These values are easily found in this particular case. To find the maxima and minima, we have to set the first derivative of the above function equal to zero and solve the equation for x; for the maxima and minima are those points where the tangential angle or differential coefficient is zero.

$$f'(x) = 2\cos x + 2\cos 2x = 0.$$

To find the points of inflection, we have to set the second derivative equal to zero and solve the equation for x; for the points of inflection are those points of the curve where the tangential angle neither increases nor decreases.

$$f''(x) = -2\sin x - 4\sin 2x = 0.$$

The purely arithmetical work I do not care to perform here. The table shows its results. It is plain that, if we represent the successive positions of the partition according to the same rules as formerly employed, we find that only one tone can become audible, the tone 1. The tone 2 has disappeared because its addition does not increase the number of the maxima and minima of the compound curve (Fig. 26), but merely influences its shape. However interesting this insight may be into the fact that a weak higher tone added to a strong lower tone may be entirely inaudible, the present theoretic result is not quite satisfactory. It is somewhat unsatisfactory because it seems improbable that the higher octave should become inaudible as soon as its amplitude is decreased to one-half of the amplitude of the lower tone. It seems, judging from experimental experience, that the higher octave must be weakened by far more, in order to become entirely inaudible. Now, to correct the above theoretic result, we cannot make use of the previous considerations concerning the influence of the tapering of the partition. As long as there is an initial section, however short, jerked down and up twice during the period, the result of tapering may be the lengthening of this section and a corresponding increase of the relative intensity of the higher tone. But when there is no initial section at all which moves twice, no tapering of the partition can create one. Let us, therefore, recall the other provisional assumptions.

INTERVAL 1 : 2, AMPLITUDES 2 : 1

	Ordinate	Abscissa	Ordinate		Ordinate Difference
Inf.	0	0	2598	B	2598
Max.	+ 2598	600	5196	C	2598
Inf.	+ 1125	1045	3723	D	1473
Inf.	0	1800	2598	E	1125
Inf.	— 1125	2555	1473	F	1125
Min.	— 2598	3000	0	G = A	1473
Inf.	0	3600	2598	B	1473

The second provisional assumption recalled

The second of our provisional assumptions is that the partition is perfectly inelastic, that is, not offering any resistance to a displacement until either of the limits is reached, and then offering absolute resistance. Now, does our anatomical knowledge warrant such an assumption? The most striking fact derived from an anatomical study of the organ is the absence of any solid body which might serve to interfere suddenly, abruptly, with a yielding movement of the partition in either direction. Even the analogy with the leather seat of a chair is hardly admissible if we mean thereby a flabby, wrinkled piece of leather. The analogy probably holds good only if we imagine the leather in such a condition as we find it in a new, unused chair, occupying a perfect plane, being practically free, however, from any stresses as long as no weight is resting upon it, yielding to a certain extent if a certain weight is placed upon it, but not yielding in proportion to the weight if the weight is increased. It is probably in a similar manner that the partition resists pressure. What determines the limit of yielding must be the partition's own elasticity. But let us always remember that there is no elastic force—no stress—in the partition while in its normal position, that its elastic force is the result of a displacement in either direction, that this elastic force increases much more rapidly than the displacement, and that therefore a constant increase of pressure on any point of the partition does not cause a constant movement of this point, but a movement first rapid, then quickly decreasing in velocity. Figure 27 is a graphic representation of such a function under the arbitrary assumption—which, perhaps, may be regarded as a rough approximation to the actual conditions—that the elastic force of the partition increases proportionally to the tangent of its displacement. The abscissæ represent the increasing pressure, the ordinates the corresponding displacements of the partition. We notice, then, that there is a practical limit of yielding, that an increase of pressure beyond a certain point is practically ineffective, does not cause any further displacement to speak of.

There can be no doubt that the assumption of a relation existing between the displacement of the partition and the pressure, similar to the relation between an angle and its tangent—however rough the approximation to the facts—is

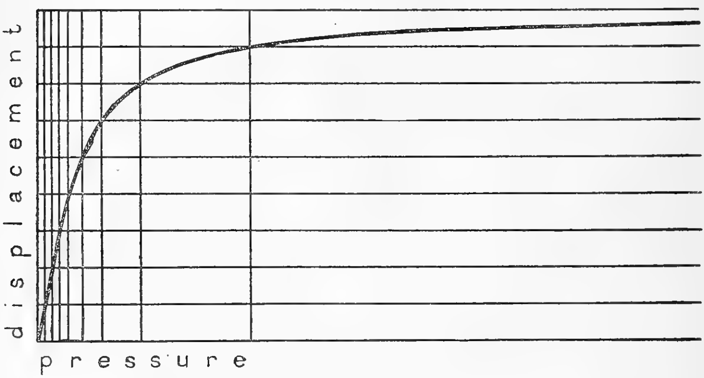


Fig. 27. The probable relation between pressure and displacement of the partition

much better adapted to the anatomical facts than the second provisional assumption. Of course, the second provisional assumption simplifies greatly the graphic representation of the successive positions of the partition, but at the cost of all accuracy. Wherever the approximation thus possible is sufficient for our purposes, we shall, of course, continue to work under that simpler assumption. But let us now apply the latter assumption to our problem of representing the successive positions of the partition which correspond to the stirrup movement of the curve in figure 26. Let us disregard, however, the varying width of the partition, in order to avoid too much complication. We shall again assume the partition to be of uniform width, without, however, forgetting the fact that this is an arbitrary simplification of the conditions.

The significance of a point of inflection

Imagine that the whole partition is in its normal position, free of any stress, and that the stirrup begins an outward movement of the form of the curve from E to G in figure 26. We see from the curve that the stirrup moves at first very slowly, then gradually more and more quickly until at F, the point of inflection, it moves with the greatest velocity. Now, a simple consideration will make it plain to us that the pressure acting upon the initial part of the partition must be dependent on, probably be proportional to the velocity of the stirrup. If the velocity of the stirrup movement were extremely small, no point of the partition would move more readily than any other, and consequently none of them would move to a considerable extent; but the fluid would every time and all the time flow through the opening at the end of the tube which we called the safety valve, because there would then be practically no friction at any point within the tube, and an infinitesimal elastic force of displacement could keep the partition in place. On the other hand, if the velocity of the stirrup movement is not very small, the points of the partition near the windows receive the greatest push from the fluid, farther points only a slighter push, very quickly diminishing with increasing distance, and at some distance away the push could be regarded as practically infinitesimal; all this as the result of the friction of the fluid in the narrow tube, the total influence of which is the greater the longer the column of fluid in question, measuring this column from the windows.

As the stirrup moves away from E, the initial part of the partition yields upwards, as shown in figure 28 at I. By I, II, and so forth, are meant successive moments between E and G in figure 26. The increasing velocity of the stirrup results at II in an increased pressure at all the points of the partition which had yielded at I. Therefore, at II in figure 28 these points are somewhat farther displaced than they were at I, but not proportional to the increase of the velocity of the stirrup but much less, according to figure 27. At the same

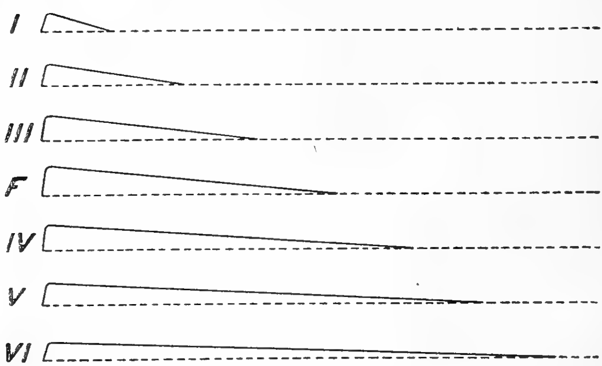


Fig. 28. Seven successive positions of the partition, three preceding and three following an inflection point (F)

time we notice that the part of the partition which has now yielded extends much farther to the right at II than at I; for the stirrup has displaced much more fluid at II than at the earlier moment I, and the slight increase in the displacement of those parts of the partition which were already displaced at I, can not nearly make room for all this fluid. Therefore the spreading of the displacement lengthwise over the partition. At III the velocity of the stirrup is still greater than at II. Therefore we notice again a slight increase in the displacement of the initial part of the partition. But as the stirrup approaches F, this increase of displacement of the initial parts must become less; for the velocity of the stirrup is now nearly constant, its increase very slight, and the increase of displacement is in any case much less than proportional to the increase of velocity, according to figure 27. As soon as the stirrup passes F, its velocity begins to decrease. Immediately the pressure on the whole piece of the partition which has yielded decreases; and this whole piece, therefore begins to move slowly back by its elasticity in the direction of its normal position. It is clear, however, from figure 27 that even a considerable decrease of the velocity of the stirrup causes only a slight decrease of the displacement until the stirrup approaches G, when its velocity approaches zero and the part of the partition in question can move more rapidly by its elasticity since it has no longer to overcome much pressure caused by the stirrup. It does not follow, however, that any point of the partition has returned to its normal position by the time the stirrup reaches G. The initial sections have merely moved in the direction of their normal position. And meanwhile, new points of the partition to the right must have yielded upwards to make room for the fluid being displaced all the time by the stirrup in moving towards G. Three positions of the partition between F and G are shown in figure 28 at IV, V, and VI.

One of the consequences of the decrease of pressure on the partition at the point of inflection between a maximum and a preceding or following minimum of the curve consists in the fact that the partition does not move up and down so suddenly as it appeared from our previous graphic representations. We had to point out this fact before in mentioning the irregularity with which stimuli often seem to be received by the nerve ends according to our simplified graphic representation. The exact time when a stimulus—a shock, as we called it—is received we now find to be dependent also on the location of each inflection point, not merely on the temporal location of the maxima and minima. Unfortunately, however, we can not determine the time of each shock with certainty even now, taking into account the inflection point. This important question of theoretical detail must be left open for future investigation.

Theoretic consequences of the inflection of the curve

Another consequence of the decrease of pressure on the partition marked by any point of inflection consists in the fact that a double movement—up and down—of the partition may result, not only from an alternation of maxima and minima of a curve, but also from an alternation of inflection points marking an increasing and decreasing velocity of the stirrup. This means that the number of shocks received by the nerve ends during one period of the curve may exceed the total number of maxima (or minima) in case any part of the curve from a maximum to a minimum or from a minimum to a maximum contains more than a single point of inflection. An example will be given at once.

The successive positions of the partition corresponding to figure 26

Let us return to the theoretical analysis of the whole curve in figure 26. From A to C the stirrup moves inwards, pushing down a certain length of the partition. The initial part of this length, however, begins a slow upward movement as soon as the velocity of the stirrup begins to decrease, at B. The same part moves up more quickly when, at C, the stirrup reverses its movement and begins to pull it upward. We therefore see at B in figure 29 the initial two sections in an extreme downward position. At C, we see them

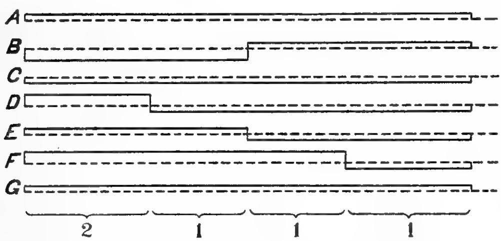


Fig. 29. The combination 1 and 2. Compare figure 26

only in a medium downward position, and at the same time we find the following two sections of the partition in a similar downward position since the stirrup has continued, from B to C, to move inwards. It is plain that to take into account, in our graphic representation, only two kinds of displacements in either direction, an extreme and a medium one, is again an artificial simplification, introduced merely to suit our momentary needs, in spite of the fact that thus we lose sight of some of the details of the movement. Actually, the movement probably occurs rather in the form of figure 28. But the simplification used in figure 29 not only renders the drawing of the figure easier, but also contributes towards a readier comprehension of the significance of the graphic representation, towards a quicker reading off of the tones to be heard.

At D we see the first section in an extreme upward position since the stirrup has moved outwards and has reached a maximum velocity. At E, the first section has returned to a medium displacement since the velocity of the stirrup has reached a minimum. At the same time the second section of the partition has moved upwards as a result of the continued outward movement of the stirrup. At F we find the initial three sections of the partition in an extreme upward position; for the stirrup has continued to move outwards and has also reached a maximum of velocity. At G all four initial sections of the partition are in an upward position since the stirrup has continued to move outwards. But they are only in a medium displacement since the velocity of the stirrup has again reached a minimum.

Looking now over the four columns in figure 29, we notice that the first shows an extreme upward position of this section of the partition at F, a medium upward position at G=A, an extreme downward position at B, a medium downward position at C, an extreme upward position at D, a medium upward position at E, an extreme upward position again at F. This section of the partition, therefore, has moved up and down twice during the period, the second upward movement occurring between E and F. It is quite probable, then, that the nerve ends located on this section receive two shocks during the period. The second section of the partition has an extreme upward position at F, a medium upward position at G=A, an extreme downward position at B, a medium downward position at C and D, and a medium upward position at E. It follows that this section moves up and down only once during the pe-

De we hear both tones 2 and 1?

riod, and that the nerve ends located there receive only one shock during the period. The third section has an extreme upward position at F, a medium upward position at G=A and also at B, a medium downward position at C, D, and E. The nerve ends of this section receive therefore one shock during the period. The fourth section has a medium upward position at G=A and at B, a medium downward position at C, D, E, and F. The nerve ends of this section receive therefore one shock during the period. It is plain, then, that from our theory we must expect to hear the tone 2 as well as the tone 1, the former conveyed by the first, the latter by the three following sections of the partition.

Sixth provisional assumption

To determine the relative intensities of the tones heard, we have to compare the length of the initial section of the partition with the total length of the three following sections when added together. For simplicity's sake, let us make this comparison again under the third and fourth provisional assumptions, and also under a new assumption, namely, that the fluid for which room is made or whose room is taken by a move of the partition from a medium to an extreme (or the reverse) displacement on the same side (either above or below the normal position) is a negligible quantity. That this assumption simplifies our representation of the successive positions of the several sections of the partition is clear, since we may thus take the length of each section proportional to the ordinate difference of the corresponding points of the curve. For instance, the third and fourth sections in figure 29, which move down at C, would be longer than proportional to the ordinate difference of the points B and C in figure 26 if the fluid displaced by the first and second sections in moving from an extreme position at B to a medium displacement at C were not a negligible quantity. In the latter case, the fluid displaced by the first and second sections during the time from B to C would have to be made room for by the third and fourth sections, which, then, by necessity would extend farther to the right than in proportion to the stirrup movement from B to C. To take this into account would extraordinarily complicate the graphic representation without offering, at present, a correspondingly great advantage. This additional extension of the third and fourth sections to the right could be but slight since the amount of fluid in question would be but slight. This becomes clear from a glance at figure 27. We have learnt from this figure that some pressure added to a given pressure does not cause a proportional, but a much smaller increment to be added to the previous displacement of the partition; and thus the amount of fluid in question may be entirely neglected without depriving us of the right to regard our representation as an approximation to the actual positions of the partition sections.

The relative intensities of 2 and 1

We may, then, under the third, fourth, and sixth provisional assumptions, regard the relative intensities of the tones as proportional to the ordinate differences in the table belonging to figure 26. We find in the table the value 1473 as expressing the ordinate difference of C and D, the value 1125 of D and E, 1125 of E and F, and 1473 of F and G, the sum of these last three being 3723. Therefore, under the above simplifying assumptions, the relative intensity of the tone 2 compared with 1 is about as fifteen to thirty-seven.

Let us now apply our theory to the ratio of the vibration rates 5:8. The curve in figure 30 represents the function

$$f(x) = \sin 5x + \sin 8x.$$

The combination 5 and 8. Equal amplitudes of stirrup movement

The table below contains all the abscissa and ordinate values of the maxima and minima as well as of the inflection points of the curve. The inflection points are computed as the maxima and minima of the first derivative curve, represented by the function

$$f'(x) = 5\cos 5x + 8\cos 8x.$$

It is impossible, in this case, to apply the simple method of

Fig. 34

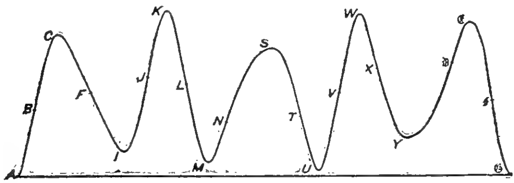


Fig. 32

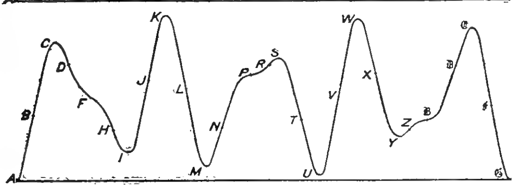


Fig. 30

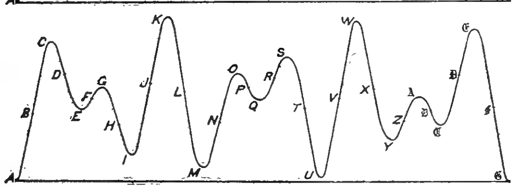


Fig. 36

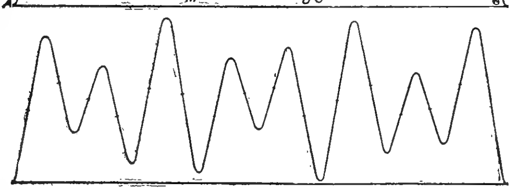
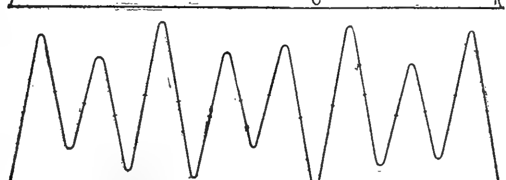


Fig. 38



The combination 5 and 8 with different amplitude ratios finding the corresponding ordinate and abscissa values of the maxima and minima of these two functions by making their derivatives equal to zero and solving the resultant equations

INTERVAL 5:8, EQUAL AMPLITUDES

	Ordinate	Abscissa	Ordinate		Ordinate Difference
Inf.	0	0	199	V	188
Max.	+ 188	131	387	W	188
Inf.	+ 24	249	223	X	164
Min.	— 100	385	99	Y	124
Inf.	— 51	474	148	Z	49
Max.	+ 3	576	202	$\mathfrak{A}$	54
Inf.	— 29	661	170	$\mathfrak{B}$	32
Min.	— 61	740	138	$\mathfrak{C}$	32
Inf.	+ 59	872	258	$\mathfrak{D}$	120
Max.	+ 167	983	366	$\mathfrak{E}$	108
Inf.	— 18	1116	181	$\mathfrak{F}$	185
Min.	— 199	1244	0	A	181
Inf.	— 36	1367	163	B	163
Max.	+ 137	1504	336	C	173
Inf.	+ 61	1603	260	D	76
Min.	— 26	1725	173	E	87
Inf.	0	1800	199	F	26
Max.	+ 26	1875	225	G	26
Inf.	— 61	1997	138	H	87
Min.	— 137	2096	62	I	76
Inf.	+ 36	2233	235	J	173
Max.	+ 199	2356	398	K	163
Inf.	+ 18	2484	217	L	181
Min.	— 167	2617	32	M	185
Inf.	— 59	2728	140	N	108
Max.	+ 61	2860	260	O	120
Inf	+ 29	2939	228	P	32
Min.	— 3	3024	196	Q	32
Inf.	+ 51	3126	250	R	54
Max.	+ 100	3215	299	S	49
Inf.	— 24	3351	175	T	124
Min.	— 188	3469	11	U	164
Inf.	0	3600	199	V	188

for x. This is impossible because the equations to be solved would be of the eighth degree. We have to use, therefore, the only method left, however great our sacrifice of time, and to calculate directly a sufficiently large number of values from which we then select the largest and smallest. In this way the values of the table have been obtained. By adding 199 to each of the values of the first column we get the third column, which offers the advantage of containing only positive ordinates. This procedure is equivalent to selecting a different horizontal coordinate, which is always dependent on our choice. The ordinate value zero, thus obtained, is the one which belongs to point A in figure 30. The successive positions of the partition corresponding, under the sixth provisional assumption, to all the maxima, minima, and inflection points of the curve are shown in figure 31.

What tones do we hear? The tone 8

Let us at once examine the movements of the three sections, the fiftieth, the fifty-first, and the fifty-second.* At A, we find these sections occupying a medium upward position. From A to B they move down. From B to C they begin to move up. From C to D they continue to move up. From D to E they begin to move down and continue to move down until G. From G to H they move up, completing thus the second down and up movement. From H to J they move down, and from J to L up, completing the third down and up movement. From L to N they move down, and from N to Q up, completing the fourth down and up movement. From Q to R they move down, and from R to T up, completing the fifth down and up movement. From T to V they move down, and from V to X up, completing the sixth

* For a perfect understanding of the details, the reader will have to draw figure 31 (and the similar figures following) for himself on a larger scale, and to inscribe the exact values as derived from each corresponding table.

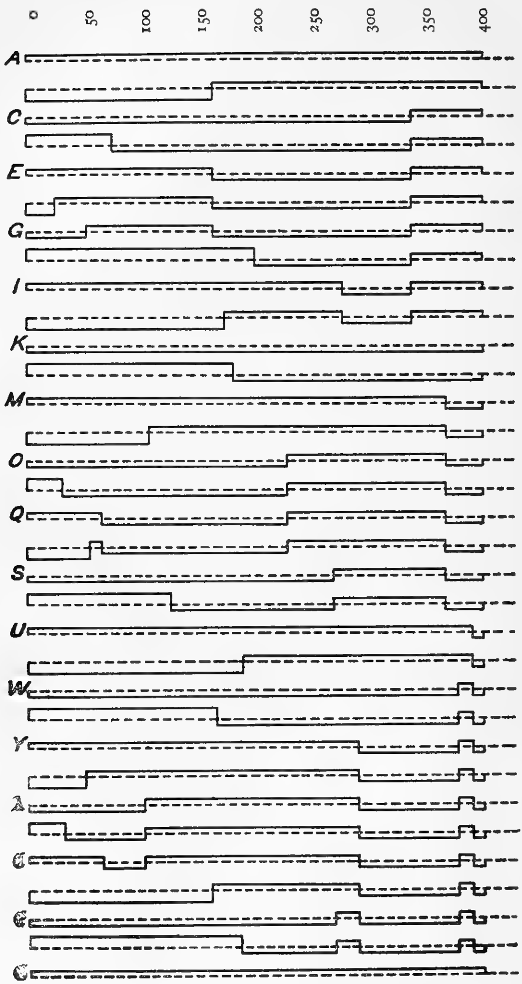


Fig. 31. Compare figure 30

down and up movement. From X to 𝔄 they move down, and from 𝔄 to 𝔈 up, completing the seventh down and up movement. From 𝔈 to 𝔇 they move down, and from 𝔇 to 𝔉 up, completing the eighth down and up movement. From 𝔉 to 𝔊=A they begin to move down and continue to move down after A, as we have seen.

The movements of the forty-nine initial sections are so similar to those of the three sections just discussed that we convince ourselves easily that the nerve ends located there receive the same number of shocks during the period.

The fifty-third and fifty-fourth sections move down from 𝔉 to B, and up from B to D. Down from D to G, and up from G to H. Down from H to J, and up from J to L. Down from L to N, and up from N to Q. Down from Q to R, and up from R to T. Down from T to V, and up from V to X. Down from X to 𝔄, and up from 𝔄 to 𝔈. Down from 𝔈 to 𝔇, and up from 𝔇 to 𝔉. The nerve ends located on these sections therefore receive eight shocks during the period.

The ten sections from the fifty-fifth to the sixty-fourth move down from 𝔉 to B, and up from B to D. Down from D to G, and up from G to H. Down from H to J, and up from J to L. Down from L to N, and up from N to Q. Down from Q to S, and up from S to T. Down from T to V, and up from V to X. Down from X to 𝔄, and up from 𝔄 to 𝔈. Down from 𝔈 to 𝔇, and up from 𝔇 to 𝔉. The nerve ends located on these sections therefore receive eight shocks during the period.

The tone 6

The twelve sections from the sixty-fifth to the seventy-sixth move down from 𝔉 to B, and up from B to D. Down from D to G, and up from G to H. Down from H to J, and up from J to L. Down from L to N, and up from N to T. Down from T to V, and up from V to X. Down from X to 𝔇, and up from 𝔇 to 𝔉. The nerve ends located on these sections therefore receive six shocks during the period.

The twenty seven sections from the seventy-seventh to the hundred and third move down from 𝔉 to C, and up from C to H. Down from H to J, and up from J to L. Down from L to N, and up from N to T. Down from T to V, and up from V to X. Down from X to 𝔇, and up from 𝔇 to 𝔉. The nerve ends located on these sections therefore receive five shocks during the period.

The tone 5

The five sections from the hundred and fourth to the hundred and eighth move down from 𝔉 to C, and up from C to H. Down from H to J, and up from J to L. Down from L to N, and up from N to T. Down from T to V, and up from V to X. Down from X to 𝔇, and up from 𝔇 to 𝔉. The nerve ends located on these sections therefore receive five shocks during the period.

All the following sections to the two hundred and sixty-seventh move down and up five times during the period. Let us study in detail only the movements of the last few of this group. The sections from the two hundred and twenty-eighth to the two hundred and sixty-seventh move down from A to C, and up from C to I. Down from I to K, and up from K to M. Down from M to S, and up from S to U. Down from U to W, and up from W to Y. Down from Y to 𝔈, and up from 𝔈 to 𝔊=A. The nerve ends located on these sections therefore receive five shocks during the period.

The seven sections from the two hundred and sixty-eighth to the two hundred and seventy-fourth move down from Y to C, and up from C to I. Down from I to K, and up from K to M. Down from M to W, and up from W to Y. The nerve-ends located on these sections therefore receive three shocks during the period.

The tone 3

The fourteen sections from the two hundred and seventy-fifth to the two hundred and eighty-eighth move down from Y to C, and up from C to M. Down from M to W, and up from W to Y. The sections from the two hundred and eighty-ninth to the three hundred and thirty-sixth move down from

The tone 2

A to C, and up from C to M. Down from M to W, and up from W to $\mathfrak{S}=A$. The sections from the three hundred and thirty-seventh to the three hundred and sixty-sixth move down from A to K, and up from K to M. Down from M to W, and up from W to $\mathfrak{S}=A$. The sections from the three hundred and sixty-seventh to the three hundred and seventy-sixth move down from A to K, and up from K to U. Down from U to W, and up from W to $\mathfrak{S}=A$. All these sections therefore receive two shocks during the period.

The tone 1

The sections from the three hundred and seventy-seventh to the three hundred and eighty-seventh move down from U to K, and up from K to U. The sections from the three hundred and eighty-eighth to the three hundred and ninety-eighth move down from A to K, and up from K to $\mathfrak{S}=A$. All these sections therefore receive one shock during the period.

The relative intensities

The relative intensities of the several tones, if we accept the third, fourth, and sixth provisional assumptions for this case, are shown in the following table, which contains the number of partition sections conveying each tone in absolute numbers as well as in percentages.

Tones	8	6	5	3	2	1
Intensities	64	12	191	7	102	22
Percentages	16.1	3.0	48.0	1.8	25.6	5.5

The combination 5 and 8. The amplitude of 8 is decreased

Let us now apply our theory to the same ratio of the vibration rates, but with different amplitudes of the two sinusoids. The curve in figure 32 represents the function

$$f(x) = 2\sin 5x + \sin 8x.$$

This signifies that the stirrup movement eight has an amplitude which is only one-half of the amplitude of the stirrup movement five. The table below contains all the abscissa and ordinate values of the maxima and minima and of the inflection points of the curve.

INTERVAL 5:8, AMPLITUDES 2:1

	Ordinate	Abscissa	Ordinate		Ordinate Difference
Inf.	0	0	298	V	281
Max.	+ 281	142	579	W	281
Inf.	+ 87	268	385	X	194
Min.	— 143	436	155	Y	230
Inf.	— 118	512	180	Z	25
Max.				𝔄	
Inf.	— 82	636	216	𝔅	36
Min.				ℭ	
Inf.	+ 110	846	408	𝔇	192
Max.	+ 248	962	546	𝔈	138
Inf.	— 34	1111	264	𝔉	282
Min.	— 298	1247	0	A	264
Inf.	— 62	1379	236	B	236
Max.	+ 200	1535	498	C	262
Inf.	+ 120	1638	418	D	80
Min.				E	
Inf.	0	1800	298	F	120
Max.				G	
Inf.	— 120	1962	178	H	120
Min.	— 200	2065	98	I	80
Inf.	+ 62	2221	360	J	262
Max.	+ 298	2353	596	K	236
Inf.	+ 34	2489	332	L	264
Min.	— 248	2638	50	M	282
Inf.	— 110	2754	188	N	138
Max.				O	
Inf.	+ 82	2964	380	P	192
Min				Q	
Inf.	+ 118	3088	416	R	36
Max.	+ 143	3164	441	S	25
Inf.	— 87	3332	211	T	230
Min.	— 281	3458	17	U	194
Inf.	0	3600	298	V	281

These values have been computed in the same manner as in the case immediately preceding. The successive positions of the partition corresponding, under the sixth provisional assumption, to the maxima, minima, and inflection points of the curve are shown in figure 33.

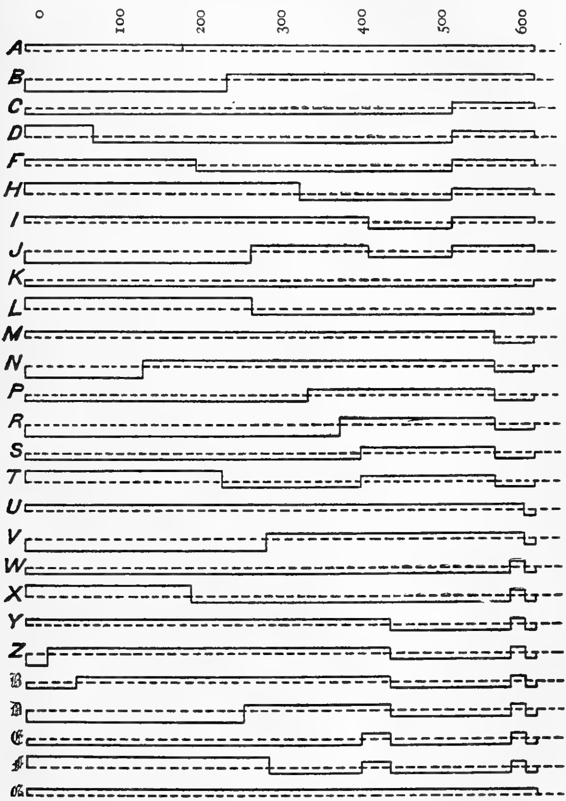


Fig. 33. The combination 5 and 8. Compare figure 32

Let us examine the movements of the twenty-five initial sections. From 𝔉 to B they move down, and from B to D up.

The tone 8

From D to F down, that is, from an extreme upward position to a medium upward position; and from F to H they move up again, that is, from a medium upward position to an extreme upward position. From H to J they move down, and from J to L up, completing thus the third down and up movement. From L to N they move down and from N to P up, completing thus the fourth down and up movement. From P to R they move down, and from R to T up, completing thus the fifth down and up movement. From T to V down, and from V to X up, completing thus the sixth down and up movement. From X to Z down, and from Z to 𝔅 up, completing thus the seventh down and up movement. From 𝔅 to 𝔇 down and from 𝔇 to 𝔉 up again. The nerve ends located on these twenty-five sections therefore receive eight shocks during the period, and accordingly, convey the sensation of the tone 8.

The thirty-six sections from the twenty-sixth to the sixty-first move down from 𝔉 to B, and up from B to D. Down from D to F, and up from F to H. Down from H to J, and up from J to L. Down from L to N, and up from N to P. Down from P to R, and up from R to T. Down from T to V, and up from V to X. Down from X to 𝔇, and up from 𝔇 to 𝔉. The nerve ends located on these sections therefore receive seven shocks during the period. But, in accordance with previous considerations, it is highly improbable that they could convey the sensation of the tone 7. When seven shocks are received in time intervals identical with those of the tone 8, and when the eighth shock, at the moment Z, chances to be omitted, it is rather to be expected that the tone 8 is heard, only with a little pause or, perhaps, merely a diminution of intensity at the moment Z. The sensation conveyed by these nerve ends, then, is probably the tone 8 slightly beating, that is, being characterized by a slight roughness.

The nineteen sections from the sixty-second to the eightieth move down from 𝔉 to B, and up from B to D. Down from D to F, and up from F to H. Down from H to J, and up from J to L. Down from L to N, and up from N to P. Down from P to R, and up from R to T. Down from T to V, and up from V to X. Down from X to 𝔇, and up from 𝔇 to 𝔉. The nerve ends located on these sections therefore receive seven shocks during the period; but, here as above, it is highly improbable that they could convey, merely because of the omission of the stimulus at Z, the sensation of the tone 7 instead of 8. Most probably the tone heard is 8 with a slight roughness.

The tone 6

The fifty-eight sections from the eighty-first to the one hundred and thirty-eighth move down from 𝔉 to B, and up from B to H. Down from H to J, and up from J to L. Down from L to N, and up from N to P. Down from P to R, and up from R to T. Down from T to V, and up from V to X. Down from X to 𝔇, and up from 𝔇 to 𝔉. The nerve ends located on these sections therefore receive six shocks during the period.

The tone 5

The fifty-six sections from the one hundred and thirty-ninth to the one hundred and ninety-fourth move down from 𝔉 to B, and up from B to H. Down from H to J, and up from J to L. Down from L to R, and up from R to T. Down from T to V, and up from V to X. Down from X to 𝔇, and up from 𝔇 to 𝔉. The nerve ends located on these sections therefore receive five shocks during the period.

All the following sections to the three hundred and ninety-first move down and up five times during the period. Let us examine only the last twenty-five of this group. They move down from A to C and up from C to I. Down from I to K, and up from K to M. Down from M to S, and up from S to U. Down from U to W, and up from W to Y. Down from Y to $\mathfrak{E}$, and up from $\mathfrak{E}$ to $\mathfrak{G}$=A.

The tone 3

The nine sections from the three hundred and ninety-second to the four hundredth move down from Y to C, and up from C to I. Down from I to K, and up from K to M. Down from M to W, and up from W to Y. The nerve ends located on these sections therefore receive three shocks during the period.

The tone 2

The sections from the four hundred and first to the four hundred and twenty-fourth move down from Y to C, and up from C to M. Down from M to W, and up from W to Y. The sections from the four hundred and twenty-fifth to the four hundred and ninety-eighth move down from A to C, and up from C to M. Down from M to W, and up from W to $\mathfrak{G}$=A. The sections from the four hundred and ninety-ninth to the five hundred and forty-sixth move down from A to K, and up from K to M. Down from M to W, and up from W to $\mathfrak{G}$=A. The sections from the five hundred and forty-seventh to the five hundred and sixty-second move down from A to K, and up from K to U. Down from U to W, and up from W to $\mathfrak{G}$=A. The nerve ends located on these sections of the partition therefore receive two shocks during the period.

The tone 1

The sections from the five hundred and sixty-third to the five hundred and seventy-ninth move down from U to K, and up from K to U. The sections from the five hundred and eightieth to the five hundred and ninety-sixth move down from A to K, and up from K to $\mathfrak{G}$=A. The nerve ends located on these sections therefore receive one shock during the period.

The relative intensities of the several tones, if we accept the third, fourth, and sixth provisional assumptions, are shown in the following table, which contains the number of partition sections conveying each tone in absolute numbers as well as in percentages.

The relative intensities

Tones	8, smooth	8, rough	6	5	3	2	1
Intensities	25	55	58	253	9	162	34
Percentages	4.2	9.2	9.7	42.5	1.5	27.2	5.7

Since in the case just studied the higher of the two primary tones, though weak, is yet audible, let us still further change the relative intensities of the objective tones in favor of the lower one. The curve in figure 34 represents the function

$$f(x) = 3\sin 5x + \sin 8x.$$

The combination 5 and 8. Amplitude of 8 still less

This signifies that the stirrup movement eight has an amplitude which is only one-third of the amplitude of the stirrup movement five. The table below contains all the abscissa and ordinate values of the maxima and minima and of the inflection points of the curve.

INTERVAL 5:8, AMPLITUDES 3:1

	Ordinate	Abscissa	Ordinate		Ordinate Difference
Inf.	0	0	397	V	376
Max.	+ 376	149	773	W	376
Inf.	+ 114	283	511	X	262
Min.	— 219	483	178	Y	333
Inf.				Z	
Max.				𝔄	
Inf.				𝔅	
Min.				ℭ	
Inf.	+ 140	820	537	𝔇	359
Max.	+ 336	949	733	𝔈	196
Inf.	— 41	1106	356	𝔉	377
Min.	— 397	1250	0	A	356
Inf.	— 77	1389	320	B	320
Max.	+ 281	1558	678	C	358
Inf.				D	
Min.				E	
Inf.	0	1800	397	F	281
Max.				G	
Inf.				H	
Min.	— 281	2042	116	I	281
Inf.	+ 77	2211	474	J	358
Max.	+ 397	2350	794	K	320
Inf.	+ 41	2494	438	L	356
Min.	— 336	2651	61	M	377
Inf.	— 140	2780	257	N	196
Max.				O	
Inf.				P	
Min.				Q	
Inf.				R	
Max.	+ 219	3117	616	S	359
Inf.	— 114	3317	283	T	333
Min.	— 376	3451	21	U	262
Inf.	0	3600	397	V	376

The successive positions of the partition corresponding, under the sixth provisional assumption, to the maxima, minima, and inflection points of the curve are shown in figure 35.

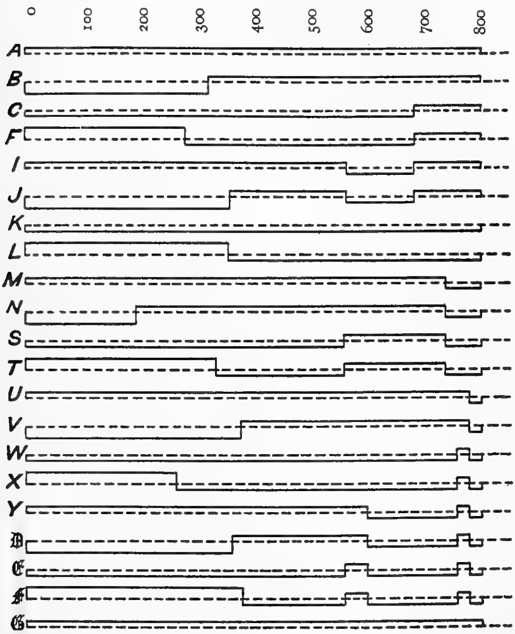


Fig. 35. The combination 5 and 8. Compare figure 34

The five hundred and fifty-five initial sections of the partition move down and up five times during the period. Let us here closely examine only the one hundred and ninety-six initial sections and the one hundred and seventy-eight most distant sections of this group. The initial sections move

The tone 5

down from $\mathfrak{F}$ to B, and up from B to F. Down from F to J, and up from J to L. Down from L to N, and up from N to T. Down from T to V, and up from V to X. Down from X to $\mathfrak{D}$, and up from $\mathfrak{D}$ to $\mathfrak{F}$. The sections from the three hundred and seventy-eighth to the five hundred and fifty-fifth move down from A to C, and up from C to I. Down from I to K, and up from K to M. Down from M to S, and up from S to U. Down from U to W, and up from W to Y. Down from Y to $\mathfrak{E}$ and up from $\mathfrak{E}$ to $\mathfrak{G}$=A. The nerve ends of all these sections therefore receive five shocks during the period.

The tone 3

The seven sections from the five hundred and fifty-sixth to the five hundred and sixty-second move down from Y to C, and up from C to I. Down from I to K, and up from K to M. Down from M to W, and up from W to Y. The nerve ends located on these sections therefore receive three shocks during the period.

The tone 2

The sections of the partition from the five hundred and sixty-third to the five hundred and seventy-second move down and up twice during the period. Let us here examine only the sections from the five hundred and sixty-third to the five hundred and ninety-fifth. They move down from Y to C, and up from C to M. Down from M to W, and up from W to Y. The nerve ends located on these sections therefore receive two shocks during the period.

The tone 1

The partition sections from the seven hundred and fifty-third to the seven hundred and seventy-third move down from U to K, and up from K to U. The sections from the seven hundred and seventy-fourth to the seven hundred and ninety-fourth move down from A to K, and up from K to $\mathfrak{G}$=A.

All the nerve ends on these sections therefore receive one shock during the period.

The relative intensities

The relative intensities of the several tones under the third, fourth, and sixth provisional assumptions are shown in the following table.

Tones	5	3	2	1
Intensities	555	7	190	42
Percentages	69.9	.9	23.9	5.3

Having studied the effect of changing the relative intensities of the objective tones in favor of the lower one, we shall now investigate the effect of increasing the intensity of the higher objective tone. The curve in figure 36 represents the function

$$f(x) = \sin 5x + 2\sin 8x.$$

The combination 5 and 8. The amplitude of 8 is greater than of 5

The stirrup movement eight has an amplitude which is twice the amplitude of the stirrup movement five. The table below contains the abscissa and ordinate values of the maxima, minima, and inflection points.

INTERVAL 5:8, AMPLITUDES 1:2

	Ordinate	Abscissa	Ordinate		Ordinate Difference
Inf.	0	0	298	V	286
Max.	+ 286	123	584	W	286
Inf.	+ 55	237	353	X	231
Min.	— 190	360	108	Y	245
Inf.	— 49	460	249	Z	141
Max.	+ 102	568	400	𝔄	151
Inf.	— 26	669	272	𝔅	128
Min.	— 152	767	146	ℭ	126
Inf.	+ 60	886	358	𝔇	212
Max.	+ 262	996	560	𝔈	202
Inf.	— 20	1120	278	𝔉	282
Min.	— 298	1241	0	A	278
Inf.	— 40	1359	258	B	258
Max.	+ 229	1484	527	C	269
Inf.	+ 60	1588	358	D	169
Min.	— 120	1702	178	E	180
Inf.	0	1800	298	F	120
Max.	+ 120	1898	418	G	120
Inf.	— 60	2012	238	H	180
Min.	— 229	2116	69	I	169
Inf.	+ 40	2241	338	J	269
Max.	+ 298	2359	596	K	258
Inf.	+ 20	2480	318	L	278
Min.	— 262	2604	36	M	282
Inf.	— 60	2714	238	N	202
Max.	+ 152	2833	450	O	212
Inf.	+ 26	2931	324	P	126
Min.	— 102	3032	196	Q	128
Inf.	+ 49	3140	347	R	151
Max.	+ 190	3240	488	S	141
Inf.	— 55	3363	243	T	245
Min.	— 286	3477	12	U	231
Inf.	0	3600	298	V	286

The successive positions of the partition corresponding, under the sixth provisional assumption, to the maxima, minima, and inflection points of the curve are shown in figure 37.

The two hundred and forty initial sections move down and up 8 times during the period. Let us here examine only the nine most distant sections of this group, from the two hundred and thirty-second to the two hundred and fortieth.

The tone 8

They move down from A to B, and up from B to E. Down from E to G, and up from G to I. Down from I to J, and up from J to L. Down from L to O, and up from O to Q. Down from Q to S, and up from S to T. Down from T to V, and up from V to Y. Down from Y to 𝔄, and up from 𝔄 to ℭ. Down from ℭ to 𝔈, and up from 𝔈 to 𝔊=A. The nerve ends located on these sections therefore receive eight shocks during the period.

The fourteen sections from the two hundred and forty-first to the two hundred and fifty-fourth do not move down from E to G. The nerve ends located on these sections do not, therefore, receive a shock between E and I, but receive the other seven shocks in the same manner as the two hundred and forty initial sections. For the same reasons as in the similar cases with which we have met before, it is not probable that these nerve ends convey the tone 7, but rather the tone 8 with a slight beat occurring once during the period, producing a slightly rough tone 8.

The sections of the partition from the two hundred and fifty-fifth to the four hundred and fifty-second move down and up five times during the period. Let us examine those from the two hundred and fifty-fifth to the two hundred and fifty-eighth.

The tone 5

They move down from A to B, and up from B to E. Down from E to J, and up from J to L. Down from L to O, and up from O to U. Down from U to V, and up from V

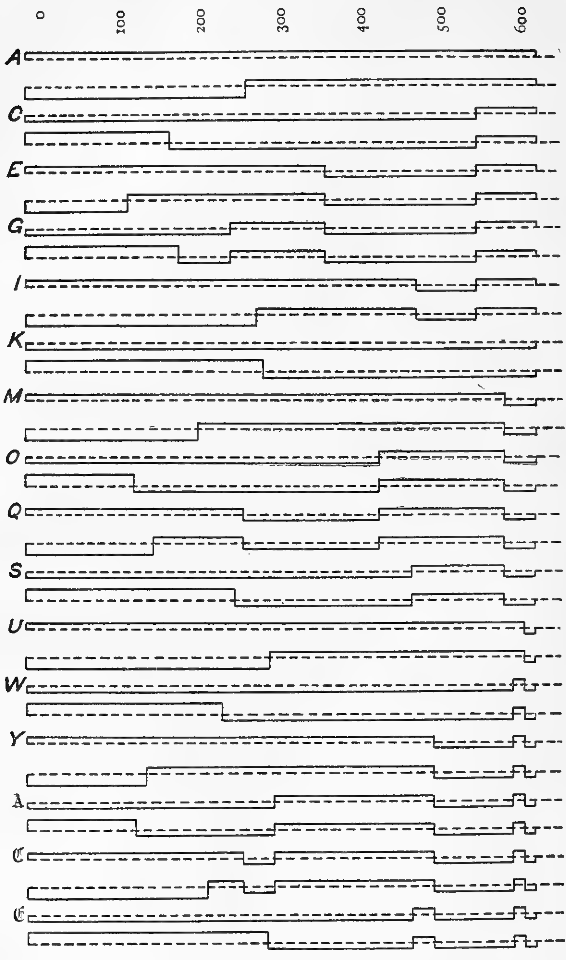


Fig. 37. The combination 5 and 8. Compare figure 36

to Y. Down from Y to 𝔄, and up from 𝔄 to 𝔊=A. The nerve ends located on these sections therefore receive five shocks during the period.

The tone 3

The sections from the four hundred and fifty-third to the four hundred and fifty-eighth move down from Y to C, and up from C to I. Down from I to K, and up from K to M. Down from M to W, and up from W to Y. The nerve ends located on these sections therefore receive three shocks during the period.

The tone 2

The sections of the partition from the four hundred and fifty-ninth to the five hundred and seventy-second move down and up twice during the period. Let us examine, for example, the four hundred and fifty-ninth and the four hundred and sixtieth. They move down from Y to C, and up from C to M. Down from M to W, and up from W to Y. The nerve ends located on these sections therefore receive two shocks during the period.

The tone 1

The sections of the partition from the five hundred and seventy-third to the five hundred and eighty-fourth move down from U to K, and up from K to U. The sections from the five hundred and eighty-fifth to the five hundred and ninety-sixth move down from A to K, and up from K to A. The nerve ends located on these sections therefore receive one shock during the period.

The relative intensities

The relative intensities of the several tones under the third, fourth, and sixth provisional assumptions are shown in the following table.

Tones	8 smooth	8 rough	5	3	2	1
Intensities	240	14	198	6	114	24
Percentages. ..	40.3	2.4	33.2	1.0	19.1	4.0

The curve in figure 38 represents the function

$$f(x) = \sin 5x + 3\sin 8x.$$

The combination 5 and 8. The amplitude of 8 is three times that of 5

The stirrup movement eight has an amplitude three times as great as that of five. The table below contains the abscissa and ordinate values of the maxima, minima, and inflection points.

The successive positions of the partition corresponding, under the sixth provisional assumption, to the maxima, minima, and inflection points of the curve are shown in figure 39.

The four hundred and thirty-eight initial sections of the partition move down and up eight times during the period.

The tone 8

Let us examine those from the three hundred and eighty-sixth to the four hundred and thirty-eighth. They move down from A to C and up from C to E. Down from E to G, and up from G to I. Down from I to K and up from K to M. Down from M to O, and up from O to Q. Down from Q to S, and up from S to U. Down from U to W, and up from W to Y. Down from Y to 𝔄, and up from 𝔄 to ℭ. Down from ℭ to 𝔈, and up from 𝔈 to 𝔊=A. The nerve ends located on these sections therefore receive eight shocks during the period.

The sections from the four hundred and thirty-ninth to the four hundred and fifty-first move down and up only seven times, since they do not make a double movement between E and I. In accordance with our former considerations, however, in similar cases, it does not seem probable that the nerve ends located on these sections should convey any other tone than the tone 8 of a slight roughness.

The sections of the partition from the four hundred and fifty-second to the six hundred and forty-seventh move down five times during the period.

The tone 5

Let us examine those from the four hundred and fifty-second to the four hundred and eighty-ninth. They move down from A to C, and up from

INTERVAL 5:8, AMPLITUDES 1:3

	Ordinate	Abscissa	Ordinate		Ordinate Difference
Inf.	0	0	398	V	385
Max.	+ 385	120	783	W	385
Inf.	+ 56	233	454	X	329
Min.	— 287	353	111	Y	343
Inf.	— 46	457	352	Z	241
Max.	+ 202	566	600	𝔄	248
Inf.	— 25	671	373	𝔅	227
Min.	— 249	774	149	ℭ	224
Inf.	+ 58	890	456	𝔇	307
Max.	+ 360	1001	758	𝔈	302
Inf.	— 18	1121	380	𝔉	378
Min.	— 398	1240	0	A	380
Inf.	— 42	1356	356	B	356
Max.	+ 326	1477	724	C	368
Inf.	+ 58	1584	456	D	268
Min.	— 219	1697	179	E	277
Inf.	0	1800	398	F	219
Max.	+ 219	1903	617	G	219
Inf.	— 58	2016	340	H	277
Min.	— 326	2123	72	I	268
Inf.	+ 42	2244	440	J	368
Max.	+ 398	2360	796	K	356
Inf.	+ 18	2479	416	L	380
Min.	— 360	2599	38	M	378
Inf.	— 58	2710	340	N	302
Max.	+ 249	2826	647	O	307
Inf.	+ 25	2929	423	P	224
Min.	— 202	3034	196	Q	227
Inf.	+ 46	3143	444	R	248
Max.	+ 287	3247	685	S	241
Inf.	— 56	3367	342	T	343
Min.	— 385	3480	13	U	329
Inf.	0	3600	398	V	385

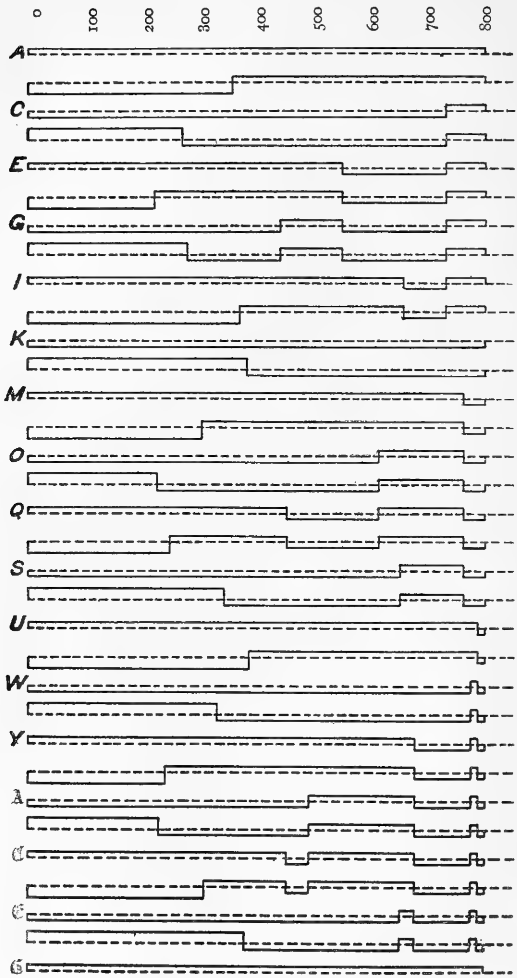


Fig. 39. The combination 5 and 8. Compare figure 38

C to E. Down from E to K, and up from to K to M. Down from M to O, and up from O to U. Down from U to W, and up from W to Y. Down from Y to $\mathfrak{A}$, and up from $\mathfrak{A}$ to $\mathfrak{G}$=A. The nerve ends located on these sections therefore receive five shocks during the period.

The tone 3

The five sections from the six hundred and forty-eighth to the six hundred and fifty-second move down from Y to C, and up from C to I. Down from I to K, and up from K to M. Down from M to W, and up from W to Y. The nerve ends located on these sections therefore receive three shocks during the period.

The tone 2

The sections of the partition from the six hundred and fifty-third to the seven hundred and seventieth move down and up twice during the period. Let us examine those from the six hundred and fifty-third to the six hundred and seventy-second. They move down from Y to C, and up from C to M. Down from M to W, and up from W to Y. The nerve ends located on these sections therefore receive two shocks during the period.

The tone 1

The sections from the seven hundred and seventy-first to the seven hundred and eighty-third move down from U to K, and up from K to U. The sections from the seven hundred and eighty-fourth to the seven hundred and ninety-sixth move down from A to K, and up from K to $\mathfrak{G}$=A. The nerve ends located on these sections therefore receive one shock during the period.

The relative intensities

The relative intensities of the several tones under the third, fourth, and sixth provisional assumptions are shown in the following table:

Tones	8 smooth	8 rough	5	3	2	1
Intensities	438	13	196	5	118	26
Percentages	55.0	1.6	24.6	.6	14.8	3.3

It is interesting to compare the intensities of the several tones in the last five cases, all representing the combination 8 plus 5 of stirrup movement, but differing in the relative amplitudes of 8 and 5. The table contains the percentages of the five preceding tables. The first two columns show the ratio of the amplitudes of the stirrup movements of 8 and 5 For example, in the first case this ratio is as 3:1 or seventy-five to twenty-five; in the fifth case as 1:3 or twenty-five to seventy-five. The columns to the right contain the relative intensities of the several tones calculated under the provisional assumptions.

Comparison of the last five cases

Amplitudes of stirrup movement		Subjective (theoretic) intensity					
8	5	8	6	5	3	2	1
75	25	56.6	—	24.6	.6	14.8	3.3
67	33	42.7	—	33.2	1.0	19.1	4.0
50	50	16.1	3.0	48.0	1.8	25.6	5.5
33	67	13.4	9.7	42.5	1.5	27.2	5.7
25	75	—	—	69.9	.9	23.9	5.3

We notice that the tone 8 decreases in intensity from 56.6 to 42.7, to 16.1, to 13.4, and finally disappears entirely. This latter case, however, does not mean that now the tone 5 is alone audible. We see from the table that even now, in addition to 5, the very weak difference tone 3 and the fairly strong difference tones 2 and 1 are to be expected by the observer.[1]

As to the several difference tones, the most favorable condition for 6 seems to be, to have the component 5 of the compound stirrup movement somewhat more pronounced than 8. It appears, however, that in no case will this difference tone become very conspicuous. The most favorable condition for the difference tone 3 seems to be, to have the component 8 of stirrup movement about as strong as 5. The difference tones 2 and 1, on the other hand, appear with a maximum of intensity when the component 5 of stirrup movement is somewhat greater than 8. But their intensities are but little less in case the amplitudes of the two stirrup movements 8 and 5 are equal. With respect to all the difference tones taken together, it appears that these tones are very unfavorably influenced by a considerable difference in the amplitudes of the component stirrup movements, for no difference tone has a maximum intensity in either the first or the fifth case. And

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[1]Although this booklet is devoted to theory and not to experimental methods of research, I cannot refrain from mentioning a way of testing the theoretical results just spoken of, because it is so easy for any one who possesses a skillful hand and a trained ear, and the observation to be made is so pretty. No instruments are required but two good tuning forks on resonance boxes, accurately tuned in the ratio of 5:8, and a bass bow. The fork 5 must be sounded first, as strongly as possible, and it is necessary to have a fork which continues to sound strongly for quite a while. Then the bow is applied with the most delicate touch to the fork 8. It is necessary for the success of the experiment that the intensity of the higher tone vibration be increased from zero very slowly and uniformly. If these conditions are fulfilled, one suddenly hears the low difference tones 1 and 2 being added distinctly to the tone 5, whereas of 8 no trace is yet audible. If now the fork 8 is left to itself, and the fork 5 is stopped by firmly touching it with a finger, the tone 5 together with the difference tones disappears, but immediately one hears with surprising clearness the tone 8, which a moment ago was entirely inaudible. No similar observation can be made with a strongly sounding fork 8 and a weakly sounding fork 5. According to our theoretic deduction the lower tone does not become inaudible when the amplitude of 8 is three times that of 5, but still has a respectable intensity.

a prevailing intensity of 8 seems to be even less favorable to the difference tones than a prevailing intensity of 5. All these conclusions have, of course, only a relative value, since taking into account the various provisional assumptions changes the result considerably.

The combination 3 and 8. The amplitude of 3 twice that of 8

Let us study one more combination of sinusoidal stirrup movements. We have had only one interval greater than an octave, the combination 4 and 9. But we did not, then, take into account the inflection points of the curve. Let us do this with the combination 3 and 8, taking the amplitude of 3 twice as great as that of 8. This ratio of the amplitudes is arbitrarily chosen. But the selection of equal amplitudes would be no less arbitrary. The curve in figure 40 represents the function

$$f(x) = 2\sin 3x + \sin 8x.$$

The table below contains the abscissa and ordinate values of the maxima, minima, and inflection points of the curve.

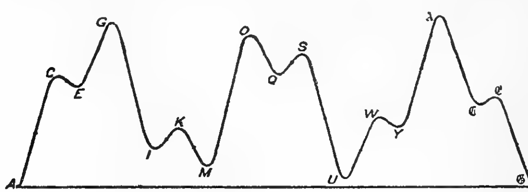

Fig. 40. The combination 3 and 8

The successive positions of the partition corresponding to the maxima, minima, and inflection points are shown in figure 41.

The thirteen initial sections of the partition move down from 𝔉 to B, and up from B to D. Down from D to F, and

INTERVAL 3:8, AMPLITUDES 2:1

	Ordinate	Abscissa	Ordinate		Ordinate Difference
Inf.	0	0	297	N	228
Max.	+ 228	152	525	O	228
Inf.	+ 164	245	461	P	64
Min.	+ 95	353	392	Q	69
Inf.	+ 131	435	428	R	36
Max.	+ 165	510	462	S	34
Inf.	— 60	668	237	T	225
Min.	— 273	812	24	U	213
Inf.	— 171	920	126	V	102
Max.	— 55	1054	242	W	116
Inf.	— 73	1117	224	X	18
Min.	— 90	1177	207	Y	17
Inf.	+ 113	1337	410	Z	203
Max.	+ 297	1471	594	𝔄	184
Inf.	+ 152	1593	449	𝔅	145
Min.	— 13	1745	284	ℭ	165
Inf.	0	1800	297	𝔇	13
Max.	+ 13	1855	310	𝔈	13
Inf.	— 152	2007	145	𝔉	165
Min.	— 297	2129	0	A	145
Inf.	— 113	2263	184	B	184
Max.	+ 90	2423	387	C	203
Inf.	+ 73	2483	370	D	17
Min.	+ 55	2546	352	E	18
Inf.	+ 171	2680	468	F	116
Max.	+ 273	2788	570	G	102
Inf.	+ 60	2932	357	H	213
Min.	— 165	3090	132	I	225
Inf.	— 131	3165	166	J	34
Max.	— 95	3247	202	K	36
Inf.	— 164	3355	133	L	69
Min	— 228	3448	69	M	64
Inf.	0	3600	297	N	228

up from F to H. Down from H to J, and up from J to L. Down from L to N, and up from N to P.

The tone 8

Down from P to R, and up from R to T. Down from T to V, and up from V to X. Down from X to Z, and up from Z to 𝔅. Down from 𝔅 to 𝔇, and up from 𝔇 to 𝔉. The nerve ends located on these sections therefore receive eight shocks during the period.

Let us examine the sections from the sixty-fifth to the sixty-ninth. They move down from 𝔉 to B, and up from B to E. Down from E to F, and up from F to H. Down from H to K, and up from K to L. Down from L to N, and up from N to Q. Down from Q to S, and up from S to T. Down from T to V, and up from V to Y. Down fom Y to Z, and up from Z to 𝔅. Down from 𝔅 to 𝔈, and up from 𝔈 to 𝔉. The nerve ends located on these sections therefore receive eight shocks during the period.

The seventieth section moves down from 𝔉 to B, and up from B to E. Down from E to F, and up from F to H. Down from H to K, and up from K to M. Down from M to N, and up from N to Q. Down from Q to S, and up from S to T. Down from T to V, and up from V to Y. Down from Y to Z, and up from Z to 𝔅. Down from 𝔅 to 𝔈, and up from 𝔈 to 𝔉. The nerve ends located on this section therefore receive eight shocks during the period.

The sections of the partition from the seventy-first to the one hundred and second move down from 𝔉 to B, and up from B to E. Down from E to F, and up from F to H. Down from H to N, and up from N to T. Down from T to V, and up from V to Y. Down from Y to Z, and up from Z to 𝔅. Down from 𝔅 to 𝔈, and up from 𝔈 to 𝔉. The nerve ends located on these sections therefore receive six shocks during the period.

The tone 6

The sections from the one hundred and third to the one

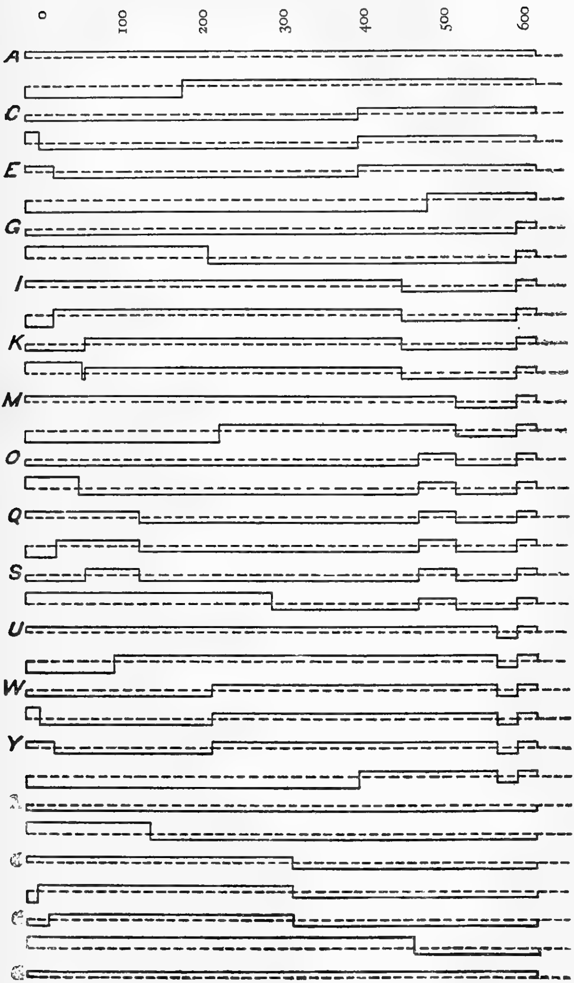

Fig. 41. The combination 3 and 8. Compare figure 40

The tone 5

hundred and forty-fifth move down from $\mathfrak{F}$ to B, and up from B to E. Down from E to F, and up from F to H. Down from H to N, and up from N to T. Down from T to Z, and up from Z to $\mathfrak{B}$. Down from $\mathfrak{B}$ to $\mathfrak{E}$, and up from $\mathfrak{E}$ to $\mathfrak{F}$. The nerve ends located on these sections therefore receive five shocks during the period.

The tone 4

The sections from the one hundred and forty-sixth to the one hundred and eighty-fourth move down from $\mathfrak{F}$ to B, and up from B to E. Down from E to F, and up from F to H. Down from H to N, and up from N to T. Down from T to Z, and up from Z to $\mathfrak{F}$. The nerve ends located on these sections therefore receive four shocks during the period.

The tone 3

The sections from the one hundred and eighty-fifth to the four hundred and fifty-sixth move down and up three times during the period. Let us examine those from the one hundred and eighty-fifth to the two hundred and thirteenth. They move down from $\mathfrak{F}$ to F, and up from F to H. Down from H to N, and up from N to T. Down from T to Z, and up from Z to $\mathfrak{F}$. The nerve ends located on these sections therefore receive three shocks during the period.

The tone 2

The sections from the four hundred and fifty-seventh to the four hundred and sixty-eighth move down from A to F, and up from F to M. Down from M to $\mathfrak{A}$, and up from $\mathfrak{A}$ to $\mathfrak{G}$=A. The sections from the four hundred and sixty-ninth to the five hundred and first move down from A to G, and up from G to M. Down from M to $\mathfrak{A}$, and up from $\mathfrak{A}$ to $\mathfrak{G}$=A. The sections from the five hundred and second to the five hundred and forty-sixth move down from A to G, and up from G to U. Down from U to $\mathfrak{A}$ and up from $\mathfrak{A}$ to $\mathfrak{G}$=A. The nerve ends located on these sections therefore receive two shocks during the period.

The sections of the partition from the five hundred and forty-seventh to the five hundred and seventieth move down from A to G, and up from G to 𝔊=A. The sections from the five hundred and seventy-first to the five hundred and ninety-fourth move down from A to 𝔄, and up from 𝔄 to 𝔊=A. The nerve ends located on these sections therefore receive one shock during the period.

The tone 1

The relative intensities

The relative intensities of the several tones under the third, fourth, and sixth provisional assumptions are shown in the following table:

Tones	8	6	5	4	3	2	1
Intensities	70	32	43	39	272	90	48
Percentages	11.8	5.4	7.2	6.6	45.8	15.1	8.1

We notice that the tone 3 is theoretically by far the strongest, as is to be expected. Of the difference tones, the tones 2, 1, and 5 appear to be somewhat more pronounced than 4 and 6. Under different assumptions concerning the physical properties of the partition these results would, of course, be somewhat different.

Weber's law in audition

Throughout our previous discussions we have never taken into account the possibility of the tone intensities being further modified by a more central nervous condition like the one usually referred to as Weber's law. All our various approximations towards the intensities of the nervous processes take into consideration only conditions in the peripheral organ. Whether the intensities thus found are modified more centrally in accordance with Weber's law or not, is a question which at present must be left entirely open, like so many others, because of lack of experimental data.

Whenever we have spoken of "amplitudes" we have meant exclusively the amplitudes of stirrup movement. In order to make use of our theory in experimental investigations we must remember the fact that the stirrup movements result from movements of the tympanum, transmitted by a rather complicated system of levers, the auditory ossicles. It is quite probable that the vibratory movements of the stirrup—even when these movements are highly complex—are approximately like those received by the hammer, the ossicle attached to the tympanum. But no one knows as yet how close or remote this approximation is. We certainly have no right to regard this approximation as infinitely close, save by way of a provisional assumption.

Sounding bodies and stirrup movement

The movements of the tympanum result from rhythmical changes of the density of the external air. These density changes, in experimental investigations, are sometimes produced by the vibrations of gaseous bodies, as in labial organ pipes; more frequently, however, by the vibrations of solid bodies, particularly of tuning forks on resonance boxes. Now, we must not think that by graphically recording—which is a comparatively easy method—the vibrations of a tuning fork, we obtain a record of the exact form of the resulting air waves. It has been experimentally and mathematically proved that the form of the resulting air waves must be more or less different from the form of the vibratory movement of the fork or other solid body. The cause of this alteration of the form is to be found in the fact that the layer of air which adjoins the solid body and therefore directly receives the impulses from that body, is unsymmetric with respect to its elastic properties, because it is in contact on one side with a practically unyielding body, on the opposite side with the easily yielding air.

It is of the utmost importance, therefore, if we wish to develop the theory by experimental investigation, to keep free from the delusion that any of the above theoretic results, say, in the case of the combination 5 and 8 with equal amplitudes, applies to what we hear in case two tuning forks of the vibration ratio 5 : 8, standing at an arbitrary distance from our ears and from the reflecting walls of our laboratory, vibrate with equal amplitudes. It is only by way of approximation that we can derive any theoretic conclusion from such an experiment. The starting point of our theory is the form of movement of the stirrup, not of external sounding bodies.

The duality of our auditory organ

Under ordinary conditions, it is a great advantage that we possess two organs of hearing, some distance apart. In experimental investigations, however, for the development of a theory of audition, this fact is often a serious obstacle. Since we cannot make experiments on audition while soaring like an eagle, any source of sound is likely to surround our body with standing waves, resulting from reflection. Let us regard the velocity of sound as three hundred and thirty meters, the distance between our ears as about fifteen centimeters. A tone of five hundred and fifty complete vibrations, that is, a tone representing the ordinary human voice quite well, has therefore a wave length of about sixty centimeters. The distance between a nodal point, where the rhythmic density changes of the air occur with full intensity, and a point of maximum vibratory movement, where there are practically no density changes affecting the tympanum, is then about fifteen centimeters. That is, it might happen with standing waves—if the head was kept perfectly still—that the amplitude of one of the components of stirrup movement would be almost zero in one ear, but very large in the other, and every movement of the head would greatly alter these conditions; while the resulting consciousness would be, of course, the sum total of the tones heard by each ear. It is unnecessary to point out in further detail how this fact of hearing with two ears complicates the comparison of experimental results with the theoretical deductions of the present study, which refer only to one stirrup and one inner ear, and to an unalterable form of the components of stirrup movement in a given case.

The fact that we have two ears would be irrelevant only with exceedingly high tones, whose wave lengths in air would be so small as to be negligible quantities in comparison with the distance between our ears, as the wave lengths of light are negligible quantities in comparison with the distance between our eyes and even with the sensory elements of each eye.

Hearing without the ear drum

Every one is familiar with the comparative clearness with which the ticking of a watch or the sound of a tuning fork is perceived if the vibrating body is firmly pressed on the head or against the teeth. Some believe that the physiological function of the ear in such a case is not essentially different from hearing under ordinary conditions; that the sound waves, the rhythmic changes of molecular density, which pass through the head, naturally pass also through the cavities of the head, of which one, the middle ear, particularly concerns us here. As soon as rhythmic changes of density occur in the air of the middle ear, the tympanum adjusts itself to them by rhythmically moving back and forth. The stirrup cannot help following the tympanum, and so on. The only difference between this case and a case of ordinary hearing consists in the fact that the changes of density of the air affecting the tympanum originate on the inside of the tympanum instead of on the outside, and that they must, on the whole, be much weaker in the former case.

There can be little doubt that the process just spoken of actually occurs. Some have insisted also on the possibility of hearing when the middle ear is destroyed and no movements of the stirrup occur. There is no reason why we should a priori deny the possibility of a shock being received by the nerve ends whenever a rhythmical change of molecular density takes its path directly through them. Such a molecular wave might originate from a vibrating solid body being pressed against skull or teeth, or from sound waves in the air striking the head and passing through it.

We must not overlook the fact, however, that even when the tympanum is totally destroyed, if sounds are perceived, the perception need not be the result of the sound waves simply passing through the nerves. Even in such a case stirrup movements are not excluded. If we blow over the mouth of a bottle, we cause rhythmical changes of density within the bottle, and, as a natural consequence, the air in the neck of the bottle rushes back and forth. These movements may often be observed with the naked eye when a fiber adherent to the inside of the neck of a bottle is forced by friction to follow the movements of the air. Now, when rhythmic changes of density occur in a middle ear whose tympanum is destroyed, there must naturally occur a back and forth movement of the air in the air passage, just as in the neck of a bottle. These back and forth movements of the air may cause by friction corresponding movements of the hammer and anvil and thus of the stirrup. No doubt, stirrup movements which are caused in this way must be of small magnitude. But no one who knows the surprisingly small amount of mechanical energy which is sufficient to call forth a response of the auditory organ will deny that they might result in an auditory sensation.

If not only a part or the whole of the tympanum is destroyed, but the chain of ossicles is also lost, the mechanical processes in the inner ear could be brought about by pressure differences on the two windows. An air wave, coming in through the external passage and the open middle ear, would at any given moment affect the two windows with a slightly different phase, arriving at one window a little earlier than at the other. This difference of phase means, of course, a difference of air pressure on the windows, and a difference of air pressure on the windows, according to the laws of mechanics, results in a movement of the internal fluid from the point of higher to that of lower pressure. It is plain, however, that this difference of phase, owing to the small distance between the two windows, must be very slight; and hearing which results in this way must be rather weak. But its possibility cannot be doubted.

Few cases, therefore, will be found where a sound is heard and we have to have recourse to the rather improbable assumption that the mere passing of molecular waves of density changes through the head and, thus, through the auditory nerve ends directly results in some weak response of the nerves. Nevertheless at least we may admit this assumption as possible. To admit it as possible would not cause any difficulty in comprehending the ordinary phenomena of audition, which might thus seem to become more complicated because such density waves must, of course, pass through the head whenever anybody hears anything. But such effects on the nerve ends, granted that they always exist, must ordinarily be overpowered by the incomparably stronger stimulations simultaneously received by the nerve ends by way of the stirrup movement.

Having studied the function of the human ear, it is in-

Comparative anatomy of the auditory organ

teresting to compare this with the organ of hearing of the lower vertebrates. Figure 42 indicates the manner of evolution of the cochlea. An original pit (Fig. 42 a) as found in a frog is gradually lengthened and assumes in the birds a banana-like shape (Fig. 42 b), showing a distinct tendency to coil. In mammals the process of lengthening and coiling has proceeded so far that the organ (Fig. 42 c), if it were transparent, would appear as a spiral. It is clear that the coiling can have little influence on the mechanical function of the organ. The lengthening of the organ, however, is of the utmost functional importance. The original pit does not differ materially from the other cavities which we find within

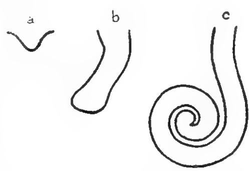

Fig. 42. Evolution of the auditory organ

the labyrinth, communicating with the semicircular canals. In this pit movements of the fluid caused by movements of the stirrup—or rather columella plate, since the lower vertebrates have a much simpler connection of tympanum and oval window—produce, probably by mere friction, stimulation of the endings of the auditory nerve. The organ of the birds must function more nearly like the human organ, excepting the difference of function resulting from the fact that the endings of the auditory nerve are spread out over a small linear extent, whereas in the mammals they are distributed over a long distance.

In birds one can hardly speak of some nerve ends being farther away from the windows than others.

It is of some interest, in this connection, to note that animals with a short tube, as the birds, do not possess in the partition of the tube the pillars of Corti. They can get along without these pillars. And naturally. The longer the tube, the greater is the maximum pressure which may act upon the partition near the windows, in case the bulging of the partition is forced to proceed far towards the end of the tube. The greater the possible pressure, the greater is, of course, the need of a skeleton-like support in order to protect the sensitive cells from collapsing. Thus the mammals need the pillars because of the greater length of the tube.

Comparative psychology of the sense of hearing

What must be the difference of sound perception resulting from these anatomical differences in various species of animals? We saw that the human ear can perceive several tones at the same time because the linear extension of the auditory organ permits the compound mechanical processes, transmitted from the stirrup to the fluid of the cochlea, to be analyzed into much simpler mechanical processes taking place in successive sections of the partition. It is plain, then, that in the auditory pit of a frog no analysis is possible. The result must be that the frog's ear can perceive only one tone at any moment; and this tone is most probably, as a rule, the highest of the several tones heard simultaneously under the same circumstances by the human ear.

The bird's ear, as we have seen, is intermediate between the frog's ear and the human ear. But it does not seem very probable that even birds can perceive very many tones simultaneously. The fact that birds sing is no indication to the contrary, since their song does not consist—like orchestral music—of simultaneous, but only of successive tones. Of more significance, in this respect, is the fact that some birds, for example, parrots, are able to imitate human speech sounds. Speech sounds are characterized, according to the present state of phonetics, by particular groupings of tones in both simultaneity and succession. It is not certain that the rough imitation of human speech sounds by parrots is more than an imitation of the successive groupings of tones. Granted even that the birds possess the ability to perceive more than one tone simultaneously, the anatomical facts would make it probable that this ability is very limited in comparison with the human ear which perceives the most varied combinations of tones in speech sounds and in harmonic music.

The need of experimental data

Let us now briefly look back upon what we have done. We have regarded the organ of hearing as a long and narrow tube, filled with a practically incompressible fluid and divided lengthwise by an imperfectly elastic partition which is the seat of the auditory nerve ends. We have found that the problem of determining exactly, for each given form of stirrup movement, the mechanical processes taking place in the tube is from the mathematical side an almost hopelessly complex one, made still more difficult by the lack of data concerning the mere facts of hearing as well as the elastic and other physical properties of the partition. In order to overcome the intrinsic and accidental difficulties standing in our way, we have introduced six simplifying provisional assumptions; not using all six in every case, but now some of them, now others, according as the purpose of the moment seems to warrant. We have thus obtained a superficial, but for a beginning satisfactory, insight into the wonderful machinery by which we analyze the complicated sound waves with a result which—for example, with respect to the hearing of difference tones—is most surprizing to one who knows nothing of the mechanics of the inner ear.

The theory thus developed does not pretend to be the ultimate solution of the problems attacked. We do not possess the data upon which to found a final theory. But we shall scarcely obtain these data without the guidance of a theory. Experimental research must be systematic, must start from a theory, however imperfect this may be, in order to lead to scientific advancement. If the theory here offered succeeds in stimulating experimental research in a field somewhat neglected for many years, the author's hope will be realized.

The necessity of a theory

APPENDIX

A list of former publications by the same author concerning the mechanics of the inner ear:

Über Kombinationstöne und einige hierzu in Beziehung stehende akustische Erscheinungen. Zeitschrift für Psychologie und Physiologie der Sinnesorgane **11**, 177-229. 1896.

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Zur Theorie des Hörens. Archiv für die Gesammte Physiologie **78**, 346-362. 1899.

Karl L. Schäfer's "Neue Erklärung der subjectiven Combinationstöne." Ibid. **81**, 49-60. 1900.

E. ter Kuile's Theorie des Hörens. Ibid. **81**, 61-75. 1900.

Zur Theorie der Geräuschempfindungen. Zeitschrift für Psychologie und Physiologie der Sinnesorgane **31**, 233-247. 1903.

Über Kombinations-und Asymmetrietöne. Annalen der Physik (Vierte Folge) **12**, 889-892. 1903.

The significance of wave-form for our comprehension of audition. American journal of psychology **18**, 170-176. 1907.

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3. **The Evolution of the Northern Part of the Lowlands of Southeast Missouri,** by C. F. MARBUT, A. M., Professor of Geology. pp. viii, 63. 1902. $1.25.
4. **Eileithyia,** by PAUL V. C. BAUR, Ph. D., Acting Professor of Classical Archaeology. pp. vi, 90. 1902. $1.00.
5. **The Right of Sanctuary in England,** by NORMAN MACLAREN TRENHOLME, Ph. D., Professor of History. pp. viii, 106. 1903. 75 cents.

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THE UNIVERSITY OF MISSOURI STUDIES

EDITED BY
W. G. BROWN
Professor of Industrial Chemistry

THE FLORA OF BOULDER, COLORADO, AND VICINITY

BY
FRANCIS POTTER DANIELS
Professor of the Romance Languages, Wabash College
Formerly Assistant in the University of Missouri

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II

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1911

TO
PROFESSOR T. D. A. COCKERELL
THIS STUDY IS RESPECTFULLY DEDICATED

PREFACE

During the summer of 1906 I was employed by the Department of Botany of the University of Missouri to collect plants in Colorado for the Herbarium of the University. I spent, therefore, a period of two months and a half in this work. I arrived at Boulder, Colorado, June eighteenth, and departed thence September third. All the collecting was done in Boulder County, and the greater part of it within a radius of five miles from the city of Boulder. I collected altogether about 1,036 species of flowering plants and ferns. The vernal plants, of course, had blossomed before my arrival, but except for these the flora of Boulder is fairly well shown in the collection.

In the list of plants here given there have been included all that are known to occur in Boulder County; but inasmuch as the boundary between Grand and Boulder Counties lies along the summits of the main range of mountains it is impossible often to tell in what county a given plant has been collected. Similarly Long's Peak lies partly in Larimer County and partly in Boulder County. In all cases in which plants have been cited from a mountain lying partly in Boulder County, these have been included in the list, unless a definite locality in the other county is given. Plants admitted to the list because of the citations given in Rydberg's Flora of Colorado are ascribed to Rydberg; it is of course understood that this ascription does not imply that these plants were collected by Rydberg in the localities named, but merely that by examination of the plants or otherwise he is satisfied that they occur in those places. In the case of plants collected by myself I have added the collection number, so that these can be identified at any time. I may add that besides the set of Boulder plants in the Herbarium of the University of Missouri, there is a duplicate set in the Herbarium of the Michigan Agricultural College; there is also a set in my own possession. The Herbarium of the Missouri Botanical Garden has an incomplete set. As the numbers are the same for all plants of the same species, the identification of any of these plants can be made out from the number given in the list.

In the introduction I have sought to present what knowledge I have of the distribution of plants in Boulder County. I have tried to present them in their natural plant-societies. I saw, however, too little of the montane, subalpine, and the alpine floras to be able to give a comprehensive account of these, and it must be remembered that I did not see the vernal facies of any portion of the vegetation.

As to nomenclature I have followed, except where plainly deficient in the light of later investigation, that of Rydberg's Flora of Colorado. While I feel that in the case of both genera and species there has been an over-multiplication—as for instance the splitting up of such a natural group as the pines into several genera, yet at the time of the preparation of this Flora the only convenient guide was Rydberg's work.

It is to Professor T. D. A. Cockerell of the University of Colorado to whom I am most indebted for assistance in this work. Remote both from the vegetation itself and from an adequate library, I could not have carried on the work at all without his cheerful coöperation. He has examined every page of the manuscript, and I owe much to his apt suggestions and kindly criticism. My thanks are also due to Professor Francis Ramaley for his kindness in examining the proof-sheets, and to Professor J. Henderson who has perused the article on the physiography. Both have given me notes of much value.

ERRATA

Page 15, line 13, for Chrysopogon, read Sorghastrum.

Page 18, line 3 from bottom of page, for C. umbellata brevirostris, read C. umbellata brachyrhina.

Page 26, line 4, for Cogswellia Grayi read Cogswellia orientalis.

Page 27, line 22, for F. confinis, read F. Kingii.

Line 12 for Agropyron Vaseyi, read Agropyron spicatum inerme.

Page 31, line 2 from bottom of page, for Trisetum subspicatum, read Trisetum spicatum.

Page 33, line 14, same correction.

Page 39, line 8 from bottom of page, for Pseudocymopterus tenuifolius, read Pseudocymopterus multifidus.

Page 41, line 9, for Trisetum subspicatum, read Trisetum spicatum.

Page 42, line 6 from bottom of page, for Polemonium scopulinum, read Polemonium pulcherrimum.

INTRODUCTION

I. PHYSIOGRAPHY

Boulder, Colorado, lies nestling close to the Rocky Mountains just north of the 40th parallel. There the foothills are strikingly beautiful and high, and only twenty miles away Arapahoe Peak, clasping to its bosom the best glacier of the southern Rockies, gleams whitely in full view, while twenty-four miles to the northwest towers jaggedly Long's Peak, 14,271 ft. high, the highest point in Boulder County, and one of the highest peaks of the Rocky Mountains. Away to the eastward the plain stretches unbrokenly, save for an occasional butte, till lost to vision. There is then room for a great diversity of vegetation, ranging from the semi-desert plants of the arid plains to the arctic plants that grow at the wasting edge of the perpetual snow.

The Continental Divide, which, due west of Boulder, touches its easternmost point in North America, is only from twenty to twenty-four miles away. It rises as a vast snow-covered wall of rock to an average height of from 11,000 to 12,000 feet; the highest points in the Divide in this region are Long's Peak, 14,271 ft., Mt. Audubon, 13,173 ft., Mt. Baldy, 11,470 ft., Arapahoe Peak, 13,520 ft., and James' Peak, 13,283 ft. Due west of Boulder Arapahoe Pass crosses the Divide at an altitude of 12,000 feet. It will be seen, therefore, that there is an almost impassable barrier between the vegetation of the Pacific slope and that of the Atlantic. Since this barrier is almost everywhere above timberline, only a few Pacific species are found on the Atlantic side of the slope within the region about Boulder. Perhaps the most interesting exception is the occurrence of one of the orchids, *Piperia Unalaschensis* (Spreng.) Rydb., a few individuals of which I found in the foot-hills near Boulder, and which is not known to occur elsewhere east of the mountains of Utah, it having its main range from Alaska to California.

All the streams of Boulder County flow ultimately into the South Fork of the Platte river, and thence into the Missouri and the Mississippi. Boulder creek, the chief stream of the region, and one of the headwaters of the Platte, is fed from the snows of the Divide, especially between Arapahoe and James' Peaks. Just over the other side of the Divide are some of the headwaters of Grand river, which flows into the Colorado, and thence into the Gulf of California.

All the main streams in Boulder County have their sources in the wasting snows of the Main Range. These have cut gorges, in most cases over a thousand feet deep, into the elevated plateau between the main range and the foot-hills proper, and by means of these deep valleys have transformed this plateau into what are now really mountain masses, having an average altitude of about 8,000 feet, the eastern and western slopes of which are long longitudinal valleys, and the northern and southern ones the precipitous gorges cut by the streams. Between Boulder and the Main Range there are about four of these mountain ridges, the first, or that of the foot-hills proper, rising to a height of from 7,000 to 8,600 feet, the others slightly lower, having an altitude of about 7,500 to 8,000 feet. Among these Sugarloaf Mountain stands out prominently as an isolated peak a thousand feet higher, it being a porphyry dike, and thus weathering more slowly than the granitic peaks. This whole elevated plateau, cut by streams into what now appear as definite mountain ridges, we shall call the foot-hills, although the foot-hills proper are the ridges of sandstone at the edge of this granite plateau. The flora, however, is the same, save for a few ferns and other rock-plants which are confined to certain kinds of rocks, some to the limestones, others to the sandstones, still others to the granite.

The main range of mountains as well as the high plateau at its base is composed of granite, granite-porphyry, and granite-gneiss, gray or reddish in color. Dikes are frequent, either of pegmatite or of felsitic porphyry. When the uplift or uplifts occurred, which made the Rocky Mountains, the sedimentary rocks resting upon the basement of granite, were tilted until they stood nearly on end. The jagged crags of the foot-hills proper are, then, the ends of these sedimentary layers. Thus it happens, too, that the oldest beds lie next the granite, while the younger underlie the plains.

The oldest and lowest, that is, the one lying directly upon, or rather against the granite, is a layer of quartzite 550 feet thick, and of Algonkin age. This, however, is absent in front of Boulder and occurs in but two places in the county.

The next, and of Pennsylvanian (Carboniferous) age, is the red Fountain sandstone, 500 to 1,500 feet thick. In the immediate vicinity of Boulder it lies directly upon the granite. On the east slope of Green Mountain it hangs in five triangular blocks of about 500 feet in thickness at an angle of about 52°. These, called the Flat-irons, are each about 1,000 feet high and about 1,500 feet wide; the third Flat-iron, however, rises to an altitude of nearly 8,000 feet, or about 2,000 feet above the mesa. At

Boulder Cañon the red sandstone walls are vertical. These perpendicular sandstone crags are the most striking feature of the scenery of the foot-hills.

Lying next to the Fountain sandstone, and also of Pennsylvanian age, is the creamy Lyons sandstone, which is quarried in large amounts. It has a maximum thickness of almost 300 feet.

Next in order, and still of Pennsylvanian age, is the Lykins formation, about 800 feet thick and consisting of sandstones, sandy shales, and a little limestone. It is easily weathered and is consequently thickly covered with waste.

The Morrison formation occurs next, and consists of sandstone, clays, and limestone, and is a little less than 600 feet thick. It is of Jurassic age.

Then come various Cretaceous beds, the first of which, the "Dakota," is a firm sandstone of about 350 feet in thickness. Its resistance to weathering causes the characteristic hogback of the foot-hills, consisting of one, two, or even three distinct combs, or crags.

Then follow in succession the Benton shales, 500 feet thick; the Niobrara shales and limestones, 400 feet thick; the Pierre shales, 5,000 feet thick; the Fox Hills shales, 1,300 feet thick; and the Laramie beds, which are coal-bearing and about 115 feet thick. Lastly are the Quaternary deposits of alluvium and terrace gravels. The various shales have weathered and eroded rapidly and underlie the plain, while the more resistant beds next the granite persist as crags, while the high mesas at the base of the foot-hills are shale outliers left by stream-erosion and are really stream terraces.

The soil of the region, outside of the alluvium and terrace gravels, is granitic in the mountains, while in the foot-hills it is apt to be brick-red from the detritus of the red sandstones. The soft Lykins formation yields a very red soil. The Jurassic and Cretaceous rocks have layers of sand and clay.

II. CLIMATE AND RAINFALL*

The climate of Boulder, however enjoyable it may be to human beings, can hardly be said to be highly favorable to plant-life. At least this is true of the foot-hills, the mesas, and the plains. The Main Range, however, is well watered, but here the high elevation and the low temperature repress plant-life. The montane and subalpine slopes have a dense vegetation, and yet even here the shallow soil and the rapid run-off of the water cause portions of them to have the aspect of deserts. A subalpine meadow has an opulent luxuriance; an adjoining slope may be gray with sage brush. In part the apparent thinness of vegetation in the mountains may be due to the superabundance of naked rock. In many portions of the Rockies the greater part of the surface has no soil whatever, and only a cranny-and-crevice vegetation is possible. The Rocky Mountains are new; their rocks are sharp and jagged; even lichens are rare on their surfaces. About Eldora and Arapahoe Peak, however, the rocks are beautifully rounded by glacial action.

In the summer of 1906 there were rains almost daily, many of them soaking rains, but their distribution was uneven and capricious. In general the rainfall decreases as the distance from the snowy range increases. The alpine and subalpine

*For the climatology of the region, consult the article by Professor Ramaley on the Climatology of the Mesas near Boulder, Univ. of Colo. Studies, **6**, 19-35, also, the paper by Ramaley and Robbins on Redrock lake near Ward, Univ. of Colo. Studies, **6**, 138-147.

regions receive most; the foot-hills less; the mesas receive some from every shower; the plains for five or six miles get a portion of the larger showers; but beyond that for several hundred miles good rains are very few. The summer of 1906 was exceptional,* for even the plains about Boulder seemed to receive more water than do many parts of the eastern United States in midsummer. When I left Boulder the third of September, the native vegetation for five or six miles out on the plain was as green as a prevailingly gray vegetation well can be; there was no sign of drouth, while when I reached Missouri and Iowa, the pastures were parched.

In fact what I shall remember most about Colorado is its exuberance of water. It courses down all the mountain cañons, roaring and bubbling and dashing into foam. Springs are frequent and of a pureness and coolness that make them perfect. On the plains everywhere that one goes, a ditch full to the brim runs beside one. From the top of Green Mountain a hundred lakes may be seen gleaming on the plain. It is plainly a land of abundant rain and water.

And yet why this feverish haste to irrigate the fields, why these ditches, these sluices, these storage-reservoirs? Why is land with a water-right worth several hundred dollars an acre, and land without one but five dollars? And why, to ask a still deeper question, why does nearly every kind of native plant have some means of conserving water, or some contrivance for preventing too rapid transpiration? Why do desert plants meet one at every hand: cacti, yuccae, sages, and xerophytic grasses? No, this region cannot be a land of abundant rain and water, in spite of the fact that I have never

*In 1906 the greatest rainfall was recorded (26.17 inches), while 1901 was the driest year (13.67 inches).

seen so much anywhere else, nor anywhere else have had such drenchings to the skin. It is a semi-arid land, parched and thirsty. And the farmer, whom I saw flooding his land the morning after an all night's pouring rain, knew from long experience that there could not be too much water. The rapid drainage, the light dry air, the fierce light of the high elevation, the hot sun, the soil unfitted for the retention of water, all these things parch and wither our cultural plants, for while the native vegetation has organs for storing water and for diminishing transpiration, the cultivated plants have none of these. Nevertheless for the native vegetation in 1906 there was ample water-supply; it grew with an almost incredible luxuriance, so much so that I found the measurements given in the manuals were often valueless for my purpose, as many of my plants were taller and larger than the books say that they grow. I was told that after the first of July there would be no botanizing as everything on the plains and foot-hills would dry up; but I remained till September first and the plants did not dry up, and I was able to collect over a thousand species in about two months and a half.

The following table, which I use by the kind permission of Professor Ramaley, will furnish the data requisite to an understanding of the temperature and rainfall of the region. The data holds true only for the city of Boulder.

TABLE

COMPILED BY DR. FRANCIS RAMALEY

Summary of data on temperature and rainfall at Boulder, Colorado, for eleven years, ending August, 1908.

MONTH	Normal mean temp., degrees	Warmest mean on record.		Coldest mean on record.		Normal mean rainfall.	Greatest rainfall on record.		Least rainfall on record.	
		Year	Degs	Year	Degs		Year	Inc's	Year	Inc's
January	34.1	1906	39.0	1905	29.3	0.4	1899	0.87	1903	0.08
February	32.9	1907	42.8	1899	18.0	0.66	1903	1.52	1908	0.09
March	39.4	1907	48.1	1906	30.2	1.6	1899	2.79	1908	0.23
April	47.7	1908	52.5	1900	45.6	3.58	1900	9.18	1908	1.71
May	56.4	1898	60.5	1907	51.0	3.02	1904	5.35	1899	0.55
June	64.6	1902	66.8	1907	62.1	1.53	1897	3.71	1908	0.29
July	70.1	1901	75.3	1906	67.2	1.72	1906	3.81	1901	0.46
August	71.0	1898	73.2	1906	68.0	1.3	1897	3.3	1900&1905	0.22
September	64.0	1897	66.8	1900	61.5	1.55	1902	2.7	1901	0.10
October	53.0	1900	57.2	1905	48.5	1.47	1903	3.43	1900	0.13
November	43.0	1904	48.3	1898	38.1	0.59	1906	1.87	1899&1901	0.00
December	37.0	1906	41.0	1898	29.0	0.68	1902	0.54	1905&1906	0.00
Annual	51.0					18.0				

Highest recorded temperature is 97 degrees, July 15, 1902.

Lowest recorded temperature is —20 degrees, January 8, 1902, and again February 20, 1905.

Greatest rainfall recorded, 26.17 inches, 1906.

Smallest rainfall recorded, 13.67 inches, 1901.

III ZONES OF VEGETATION*

There are six great zones of vegetation about Boulder, which, proceeding from east to west, are: A. The Zone of

*These zones of vegetation are practically those of Robbins (Climatology and Vegetation in Colorado, Bot. Gaz., **49**, 256-280), who recognized (1) plains, (2) eastern lower foothills and mesas, (3) eastern upper foothills, 6,000 to 8,000 feet, (4) montane zone, (5) subalpine zone, (6) alpine zone. Professor Ramaley, however, would unite the mesas and foothills into one zone (Univ. of Colo. Studies, **5**, 50-51).

the Plains, **CAMPESTRES**; B. The Zone of the Mesas, **MENSALES**; C. The Zone of the Foot-hills and Mountain Plateau, **SUBMONTANAE**; fourth, The Zone of the Lower Mountain Slopes, **MONTANAE**; fifth, The Zone of the Sub-alpine Mountain Slopes, **SUBALPESTRES**; sixth, The Zone of the Alpine Summits, **ALPESTRES**. Of these the Plains Flora, the Foot-hill Flora, the Montane Flora, the Sub-alpine Flora, and the Alpine Flora are primary, while that of the Mesas is a transition from the Flora of the Plains to the Flora of the Foot-hills. The Alpine corresponds to the Arctic Circumpolar vegetation, the Subalpine to the Hudsonian, the Montane to the Canadian, the Foot-hill and the Mesa to the Upper Transition, and that of the Plains to the Lower Transition with some Upper Sonoran forms.

A. CAMPESTRES

The plains are not so arid about Boulder as they are farther east. In fact after riding for hundreds of miles through a desert of dried up grass, it is with a feeling of inutterable joy that one sees this narrow ribbon of green from six to twelve miles wide at the foot of the mountains. This greenness and freshness is due mainly to two causes: First, this strip receives more rain than does the rest of the Great Plains. The clouds do not quite rain out before reaching the plains. These rains are, however, capricious. The clouds are narrow. The southern part of Boulder may receive a thorough drenching, the northern part may not have a drop. One Sunday there was a cloud-burst in Sunshine Cañon, farms and bridges were washed away; from three to five feet of water came dashing through the main street of Boulder, while it scarcely sprinkled where I was a half mile to the south. The second cause is the abundant irrigation.

The Plains Flora falls into five main societies: The Aquatic (**Aquatiles**); The Palustrous (**Palustres**); The Riparian (**Ripariae**); The Prairie Meadow, the plains flora proper, (**Campanales**); and the Alkali Flat (**Alkalinae**).

a. **Aquatiles.** The Aquatic Flora is found in lakes and streams. It consists of submerged or floating aquatics—pondweeds, duckweeds, water-milfoils, hornworts, water starworts, besides various algae. It is seen best in Owen's lake and Boulder lake, which while about twenty feet deep, are very brackish. The slower streams also have aquatic plants, as do likewise the aqueous nuclei of swamps and swales. The following is a list of typical species:

Potamogeton lonchites
P. heterophyllus
P. foliosus
P. pectinatus
P. Spirillus
Zanichellia palustris
Lemna gibba
L. minor
Ceratophyllum demersum
Callitriche palustris
C. bifida
Myriophyllum spicatum
Limosella aquatica

All the above species occur in the eastern United States.

b. **Palustres.** The Palustrous, or Swamp Flora is found in bogs, in swales, along ditches, and about the miry margins of ponds and lakes and streams. It consists of rushes, bulrushes, sedges, swamp grasses, sweet flags, cat-tails, sticktights, swamp asters, water peppers, and various other plants. I have included here the whole subaquatic flora, since the formation is so slight that it is best treated as a whole without separation into amphibious, limose, paludose, and uliginose societies. The following are characteristic species:

Equisetum arvense
E. laevigatum
Typha latifolia
Alisma Plantago

Sagittaria arifolia
Homalocenchrus oryzoides
Phalaris arundinacea
Muhlenbergia racemosa
Alopecurus aristulatus
Spartina cynosurioides
Poa triflora
Panicularia nervata
P. Americana
P. borealis
Cyperus inflexus
Scirpus Americanus
S. lacustris
S. atrovirens pallidus
Eleocharis palustris
E. glaucescens
E. acicularis
E. acuminata
Carex vulpinoidea
C. stipata
C. stricta
C. lanuginosa
Acorus Calamus
Heteranthera limosa
Juncus Balticus montanus
J. longistylis
J. nodosus
J. Torreyi
J. marginatus
Iris Missouriensis
Rumex occidentalis
R. salicifolius
Persicaria lapathifolia
P. emersa.
P. punctata
Crunocallis Chamissoi
Ranunculus sceleratus eremogenes
R. Macounii
Halerpestes Cymbalaria
Nasturtium Nasturtium-aquaticum
Radicula calycina
R. hispida
Hypericum majus
Lythrum alatum
Epilobium adenocaulon
Cicuta occidentalis
Berula erecta
Verbena hastata
Phyla cuneifolia
Teucrium occidentale
Scutellaria galericulata
Prunella vulgaris
Stachys scopulorum
Lycopus lucidus
L. Americanus
Mentha spicata
M. Penardi
Mimulus Geyeri
M. floribundus
Gratiola Virginiana

Lobelia syphilitica
  Ludoviciana
Iva xanthifolia
I. axillaris
Ambrosia trifida
Xanthium commune
Aster caerulescens
A. Osterhoutii
Bidens vulgata
B. glaucescens
Helenium montanum
Lactuca pulchella
L. spicata

It will be noted that all but a very few of the above species are common palustrous species of the eastern United States.

c. **Ripariae.** The Riparian Flora occurs along the banks of streams. It consists of trees, shrubs, and herbs. There are no trees nor shrubs proper on the Great Plains, except those that grow along the streams. Here occur various cottonwoods, box-elders, and willows. The herbs are partly marsh herbs and partly plants from the plains, especially grasses. The following are typical riparian species:

Equisetum laevigatum
Eatonia robusta
Agropyron riparium
Elymus Canadensis
E. robustus
Populus Sargentii
P. acuminata
P. angustifolia
Salix amygdalioides
S. exigua
S. luteosericea
Betula fontinalis (only near the foot-hills)
Urtica gracilis
Cardamine vallicola
Rulac Negundo
R. Texanum
Vitis vulpina
Pesedera vitacea
Solidago Pitcheri
S. Canadensis

d. **Campanales.** The Prairie Flora is that which is proper to the greater part of the plains region. In aspect it is a vast meadow, above which now and then a yucca rises with its bayonet-like leaves and its large cluster of flowers. But this aspect changes according to the season of the year, nor is it uniform at any season. As various plants come into bloom, so is it tinged red or purple, white or yellow; here it is an upland meadow of broom-grasses with purplish leaves; there it is dark green with meadow-grasses; yonder it is white and hoar with sages. In early summer it is red, or purple, or blue with loco-weeds, beard-tongues, and thistles, yellow with golden asters, orange with cone-flowers and gaillardias, or white with Mexican poppies. In midsummer the psoraleas are numerous; here and there are large clumps of lupines; the tall porcupine grasses abound, and sunflowers rear their heads of gold. In late summer it is yellow with gumweeds of all kinds, with golden-rods and rabbit-brushes, or purple with blazing-stars and turkey-foot grasses. In autumn the gray sages put forth their inconspicuous flowers, the late composites ripen their achenes and whiten the landscape with their pappus. But the chief plants of this formation are those not seen—the little buffalo and mesquite grasses only a few inches high, but forming the turf of these vast plains. There are no shrubs proper in this flora. At most there are a few undershrubs and suffrutescent plants, such as roses, yuccas, and the like. It should be added that the vegetation of the moister portions of the plains differs, especially in aspect and also somewhat in species, from that of the drier portions; but while it is possible to distinguish these two elements of the flora in the extreme cases of moistness and dryness, yet in the greater part of the area the two vegetations mingle inextricably. I shall, however, arrange the plants typical of the Great Plains into two classes, **Humidae** and **Aridae**, although the two classes occur quite commonly together:

i. **Humidae.**

Andropogon furcatus
Panicum virgatum
Agrostis alba
A. asperifolia
Bouteloua olgostachya
Bulbilis dactyloides
Koeleria cristata
Poa pratensis
P. triflora
P. interior
P. pseudopratensis
Festuca elatior
Bromus marginatus latior
B. Pumpellianus
Agropyron pseudorepens
A. occidentale
Hordeum jubatum
Elymus Macounii
Carex marcida
C. scoparia
C. athrostachya
C. pratensis
C. festucacea
Juncus interior
J. Arizonicus
J. confusus
J. Dudleyi
Sisyrinchium angustifolium
Argemone intermedia
A. hispida
Sophia intermedia
Potentilla Hippiana
Drymocallis arguta
Rosa pratincola
Lupinus decumbens
L. decumbens argentatus
Astragalus goniatus
Homalobus Salidae
Aragallus Lambertii
A. patens
Psoralea tenuiflora
P. argophylla
Petalostemon oligophyllus
P. purpureus
P. pubescens
Poinsettia dentata
Malvastrum dissectum
Oenothera strigosa
Anogra rhizomata
A. coronopifolia
Gaura parviflora
G. coccinea
G. glabra
Asclepias speciosa
Lithospermum canescens
Onosmodium occidentale
Verbena bracteosa
V. ambrosifolia
Salvia lanceolata
Physalis lanceolata

P. Virginiana
Androcera rostrata
Pentstemon unilateralis
Gerardia Besseyana
Grindelia serrulata
G. perennis
Oligoneuron canescens
Aster commutatus
Erigeron divergens
E. flagellaris
Ratibida columnaris
Helianthus lenticularis
H. grosseserratus
Gaillardia aristata
Artemisia gnaphalodes
Cirsium megacephalum
C. ochrocentrum
Agoseris glauca

ii. **Aridae.**

Schizachyrium scoparium
Andropogon chrysocomus
Chrysopogon nutans
Aristida fasciculata
A. longiseta
Stipa comata
S. viridula
S. Nelsonii
Muhlenbergia cuspidata
Sporobolus airoides
S. cryptandrus
S. heterolepis
S. asperifolius
Agrostis hiemalis
Merathrepta spicata
Bouteloua hirsuta
B. oligostachya
Munroa squarrosa
Eragrostis pectinacea
Poa crocata
P. juncifolia
P. confusa
Festuca octoflora
Agropyron molle
Hordeum pusillum
Sitanion longifolium
S. brevifolium
Elymus brachystachys
Carex Douglasii
C. siccata
C. straminea
Yucca glauca
Eriogonum effusum
Paronychia Jamesii
Allionia linearis
Delphinium Penardii
Stanleya glauca
Xylophacos Shortianus
Amorpha nana
Psoralea tenuiflora
Linum Lewisii

Chamaesyce Fendleri
C. serpyllifolia
Tithymalus Arkansanus
Acerates viridiflora
A. angustifolia
Asclepias pumila
Evolvulus Nuttallianus
Lappula occidentalis
L. cupulata
Cryptanthe crassisepala
Lithospermum breviflorum
Monarda pectinata
Hedeoma hispida
Physalis rotundata
Quincula lobata
Pentstemon secundiflorus
P. gracilis
P. humilis
Orthocarpus luteus
Plantago Purshii
Ambrosia psilostachya
Gaertneria tomentosa
Kuhnia Hitchcockii
K. glutinosa
Laciniaria punctata
Gutierrezia longifolia
G. scoparia
Chrysopsis villosa
C. hispida
Chrysothamnus pulcherrimus
Sideranthus annuus
S. spinulosus
Solidago glaberrima
S. nana
Townsendia exscapa
Aster exiguus
A. crassulus
A. polycephalus
Erigeron ramosus
Wyomingia cana
Helianthus petiolaris
H. pumilus
Thelesperma gracile
Boebera papposa
Artemisia dracunculoides
A. Brittonnii
Senecio Riddellii
S. multicapitatus
S. spartioides
Cirsium undulatum

e. **Alkalinae.** The best examples of the Flora of the Alkali Flats occur in the vicinity of Owen's lake and Boulder lake, where large tracts are white as snow with alkali. The plants are mainly succulent chenopods, but a few other plants also occur. The following species are characteristic:

Distichlis stricta
Puccinellia airoides
Polygonum buxiforme
Chenopodium rubrum

Monolepis Nuttalliana	Iva axillaris
Atriplex carnosa	Chrysothamnus graveolens
A. argentea	C. pulcherrimus
Dondia depressa	Solidago gilvocanescens
Sophora sericea	

B. MENSALES*

The Flora of the Mesas is a transitional flora; the mesas have most of the plants of the plains and in addition many of the plants of the foot-hills. There are, however, a considerable number of species, which are peculiar to the mesas. These mesas are flat tablelands rising abruptly a hundred feet or so above the plains in successive terraces. The altitude of the plains in Boulder County is from 5,000 to 5,500 feet. The lowest mesa, at an altitude of about 5,600 feet, has the flora of the plains, but at the next mesa, at an altitude of 5,700 feet, the flora begins to change, and from then on to the foot of the crags, 6,000 feet, the plains plants gradually tend to disappear and the foot-hill flora to come in. The highest mesas are so filled with waste from landslips from the crags, that they may be said to be an integral part of the foot-hills. And so, too, the streams have made deep cañons through the mesas, the flora of which is not so very unlike that of the cañons of the foot-hills. West of Marshall there is a high bog on the mesa, but as its plants differ in no wise from the bog plants of the plains, it will be dismissed with this notice.

Six plant-societies are to be found upon the mesas: a. The meadow (**Pratenses**), which differs little from the plains meadow, although certain mountain species, such as the Mari-

*For a detailed account of the vegetation of the mesas, see the papers by Dodds, Ramaley, and Robbins, Univ. of Colo. Studies, **6**, 11-49.

posa lily, the painted cups, and the wool-joints are present. b. The cactus mesa (**Spinosae**). c. The Yucca mesa (**Ensiformes**). d. The wooded mesa (**Sylvestres**). e. The brush mesa (**Arbustales**). f. The mesa cañon (**Vallicolae**).

a. **Pratenses.** The flora of the mesa meadow is composed of an admixture of plants both from the plains and the foot-hills. Typical plants are:

Sorghastrum nutans	Calochortus Gunnisonii
Stipa comata	Comandra pallida
S. viridula	Eriogonum alatum
Bouteloua hirsuta	E. flavum
B. oligostachya	E. umbellatum
Atheropogon curtipendulus	Polygonum Douglasii
Koeleria cristata	Silene antirrhina
Poa triflora	Lychnis Drummondii
P. interior	Delphinium Penardii
P. pseudopratensis	D. camporum
P. juncifolia	D. Nelsonii
P. confusa	Anemone cylindrica
Festuca octoflora	Pulsatilla hirsutissima
Agropyron tenerum	Argemone intermedia
A. pseudorepens	Potentilla effusa
Elymus brachystachys	Drymocallis fissa
E. villiflorus	Lupinus Plattensis
Carex marcida	L. decumbens
C. pratensis	Geoprumnon succulentum
C. straminea	Astragalus nitidus
C. straminiformis	A. goniatus
C. Pennsylvanica vespertina	Tium Drummondii
C. umbellata brevirostris	Aragallus Lambertii
Tradescantia Universitatis	A. sericeus
Yucca glauca	Psoralea tenuiflora

P. argophylla	P. gracilis
Geranium Fremontii	P. humilis
Linum Lewisii	Castilleja linariaefolia
Tithymalus philorus	Campanula petiolata
Nuttallia multiflora	Gutierrezia longifolia
N. stricta	G. scoparia
Epilobium paniculatum	Chrysopsis resinolens
Gayophytum intermedium	Solidago pallida
Meriolix serrulata	Townsendia grandiflora
Gaura parviflora	Rudbeckia flava
Gilia candida	Ratibida columnaris
G. pinnatifida	Helianthus subrhomboideus
G. sinuata	Gaillardia aristata
Collomia linearis	Artemisia dracunculoides
Phacelia heterophylla	A. Forwoodii
Oreocarya virgata	A. frigida
Mertensia linearis	A. Brittonii
M. lanceolata	Senecio Plattensis
Pentstemon unilateralis	S. Nelsonii
P. secundiflorus	S. Fendleri

b. **Spinosae.** The vegetation of the cactus mesa consists of a few species of cacti, of the prickly *Ceanothus Fendleri,* and a few other xerophytic plants and undershrubs. The principal cacti are:

Echinocereus viridiflorus	O. polyacantha
Opuntia mesacantha	O. fragilis
O. rhodantha	O. Greenei

c. **Ensiformes.** The best example of the Yucca mesa occurs near the entrance of Bear Cañon. There the ground is practically denuded, and only sparse clumps of Yuccas and bunch-grasses occupy the ground. The two species of importance are *Yucca glauca* and *Eriocoma cuspidata.*

d. **Sylvestres.** A good example of the wooded mesa lies immediately back of the Chautauqua grounds. There the bull pine has descended from the foot-hills and taken possession of the mesa. Besides the bull pine, *Pinus scopulorum,* the low juniper, *Juniperus Sibirica,* is of rare occurrence. Of herbs the most noteworthy is *Arnica pedunculata,* which is frequent under the pines. I found also only there *Centunculus minimus,* perhaps the only known station of this plant in Colorado, since it is not included in Rydberg's Flora of Colorado. It is growing with *Linaria Canadensis,* which is likewise an eastern plant.

e. **Arbustales.** The brush mesa assumes various forms. Ordinarily some one species is in control. Occasionally it consists of various haws, as at the entrance of Gregory Cañon, or of a thicket of juneberries, wax-currants, and skunk-bushes. South of Bluebell Cañon is a mesa covered with the peculiar mountain mahogany. Wild cherries and plums are frequent, and the hackberry occasional in these shrubby thickets. The principal species are:

Celtis reticulata
Ribes pumilum
R. longifolium
Oreobatus deliciosus
Batidaea laetissima
Cercocarpus parvifolium
Rosa Sayi
Amelanchier oreophila
Crataegus occidentalis
C. Coloradensis
C. erythropoda
Prunus Americana
P. melanocarpa
Toxicodendron Rydbergii
Schmaltzia trilobata
Ceanothus Fendleri
C. mollissimus
C. subsericeus
Symphoricarpos occidentalis

Of herbs the vetches and vetchlings are the most important:

Vicia sparsifolia	V. producta
V. dissitifolia	Lathyrus leucanthus
V. oregana	

f. **Vallicolae.** The mesa cañon has a bewildering diversity of floral elements, now consisting of thickets of haws with extremely vicious thorns, wild briers, the long-beaked hazel, and dwarf maples, now with a fontinal vegetation strikingly like our own Carolinian. One little gulch at the base of Flagstaff Hill has a vegetation composed quite wholly of eastern plants. Here occur *Phragmites Phragmites, Sanicula Marilandica, Steironema ciliatum, Veronica Americana. Eupatorium maculatum,* and a form of *Apios Apios,* the last of which was not known to occur west of eastern Kansas previous to this collection. Since the streams have cut deeply into the surface, the cañon of the mesa resembles greatly the cañon of the foot-hills. There are riparian, rupestrine, clivose, and fontinal elements compressed within the space of a few feet. Mountain forms follow these streams often for some distance into the plain. And yet the facies of the flora is distinctly eastern. Here are haws, hazels, maples, grapes, wild cherries, willows, cottonwoods, dogwoods, nine-barks. The herbs, too, have an eastern look—sweet cicelies, false Solomon's seals, water-leafs, fragile ferns, avens, bog-orchids. It is true that a closer examination reveals the fact that many of these plants belong to species which are strictly western, yet the fact remains that there is little in the vegetation that impresses as strange, one who is familiar only with the eastern flora, while all about him in plain, mesa, foot-hill, and mountain are utterly unfamiliar types of vegetation. So in this narrow zone of gulches and cañons is alone to be found the exact analogue of the Carolinian flora. The following are the important species:

Filix fragilis
Phragmites Phragmites
Carex festiva
Allium Nuttallii
A. Geyeri
A. reticulatum
Vagnera stellata
Nemexia lasioneuron
Limnorchis viridiflora
L. laxiflora
Corallorrhiza Corallorrhiza
Populus Sargentii
P. acuminata
P. angustifolia
Corylus rostrata
Parietaria Pennsylvanica
P. obtusa
Humulus lupulus Neo-Mexicanus
Cerastium occidentale
Ranunculus abortivus
Thalictrum purpurascens
Sedum stenopetalum
Heuchera parvifolia
Ribes pumilum
R. longifolium
Opulaster intermedius
O. Ramaleyi
Oreobatus deliciosus
Potentilla Pennsylvanica strigosa
Geum scopulorum
Rosa Sayi
Amelanchier oreophila
Crataegus Coloradensis
C. occidentalis
C. erythropoda
C. Doddsii
C. Coloradoides
Prunus Americana
P. Pennsylvanica
P. melanocarpa
Thermopsis divaricarpa
Amorpha fruticosa
Vicia oregana
V. producta
Apios Apios Boulderensis
Geranium Parryi
Toxicodendron Rydbergii
Acer glabrum
Rulac Negundo
R. Texanum
Vitis vulpina
Pesedera vitacea
Calceolaria linearis
Circaea alpina

Aralia nudicaulis
Svida stolonifera
Sanicula Marilandica
Osmorrhiza longistylis
O. obtusa
Ligusticum Porteri
Heracleum lanatum
Steironema ciliatum
Collomia linearis
Hydrophyllum Fendleri
Macrocalyx Nyctelea
Mertensia lanceolata
Dracocephalum parviflorum
Mimulus Hallii
Veronica Americana
Galium Vaillantii
G. boreale
G. flaviflorum
Viburnum Lentago
Ambrosia trifida
Eupatorium maculatum

C. SUBMONTANAE

The Foot-hill Flora covers not only the true foot-hills of the sandstone crags, but also the lower part of the mountain plateau. The flora is rich but monotonous. In most places the vegetation is thin; it is mainly a forest, but the trees are strewn but sparsely over the steep slopes. The amount of naked rock is very great. The altitude ranges from 5,800 to 8,600 feet. Some of the main streams, such as Boulder creek, have cut down to about 5,500 feet. Directly west of Boulder, and lying between Boulder and Gregory Cañons, is Flagstaff Hill with an altitude of about 6,500 feet. Southwest of Boulder is Green Mountain, lying between Gregory and Bear Cañons and having an altitude of 8,100 feet. South of Green Mountain is Bear Mountain, which attains a height of 8,600 feet, and is the loftiest peak in the first range of foot-hills in the vicinity of Boulder.

The Foot-hill Flora merges rather abruptly into that of the mesas at the foot of the crags, and melts insensibly into the Subalpine Flora as it approaches the Main Range. It reaches its maximum development between an altitude of 6,500 and

7,000 feet. Below 6,500 feet there occur still many species belonging to the Great Plains; above 7,000 feet there is a rapid thinning out of species, and subalpine species become occasional, although it is not rare for such species in cold situations to go down to the 6,000 foot level. Yet at the summit of Green Mountain (8,100 feet) I found the flora still consisting in the main of the genuine foot-hill species. The Foot-hill Flora may be gathered into four main societies: a. The wooded slope (**Sylvestres**). b. The foot-hill meadow (**Pratenses**). c. The foot-hill cañon (**Vallicolae**). d. The crevice and cranny vegetation of the rocks (**Rimosae**).

a. **Sylvestres.*** The wooded slope society consists quite purely of bull pine and Douglas spruce, with now and then a few trees of other species of pine, and spruce, and fir. The trees stand usually at wide intervals, oftenest in rows, where some fault in the rock enables them to get a secure foothold. Occasionally on the north slopes, which are moister than any other, the trees stand in such close formation that it is almost impossible to make one's way through them. Ordinarily it is the Douglas spruce that behaves in this way, since the bull pine prefers a more open formation. Often two rather dis-

*Young (Bot. Gaz. **44**, 321-352) finds the following forest associations about Boulder: 1. Populus occidentalis—Salix fluviatilis, riparian upon the plains, but extending somewhat up the cañons. 2. Populus angustifolia—Salix Nuttallii, riparian in the foothills. 3. Pinus scop u lorum, sylvan on the dry slopes of the foothills. 4. Pinus Murrayana, sylvan on the dry mountain sides. 5. Apinus flexilis, dry mountain slopes up to timber line. 6. Pseudotsuga—Picea Engelmanni, lower cañons (submontane and montane). 7. Picea Engelmanni—Abies lasiocarpa, upper cañons (high montane and subalpine to timber line). 8. Aspen society, throughout (north slopes at low altitudes, all slopes higher altitudes).

tinct forms of forest are discernible, the one of bull pine, the other of Douglas spruce; at other times the two are mixed. The Douglas spruce is at its best in moist ravines, and ascends to timber-line on the mountains, while the bull pine seldom gets above 9,000 feet. The following are characteristic species:

Botrychium Virginianum	Atragene occidentalis
Pteridium aquilinum pubescens	Ranunculus abortivus
Pinus scopulorum	R. micrantha
P. Murrayana (rare)	Cyrtorrhyncha ranunculina
Apinus flexilis (rare)	Odostemon repens
Picea Parryana	Erysimum Cockerellianum
Pseudotsuga mucronata	Bosseckia parviflora
Oryzopsis micrantha	Oreobatus deliciosus
Muhlenbergia gracilis	Batidaea laetissima
Melica bella	Potentilla Hippiana
Carex Deweyana	Amelanchier oreophila
Toxicoscordion falcatum	Sorbus scopulina (rare)
Vagnera racemosa	Thermopsis divaricarpa
V. amplexicaulis	T. pinetorum
Piperia Unalaschensis	Tium alpinum
Peramium ophioides	Homalobus tenella
Populus tremuloides	H. decumbens
Betula papyrifera Andrewsii	Lathyrus leucanthus
Chenopodium Fremontii	Xanthoxalis stricta
Blitum capitatum	Ceanothus velutinus
Actaea arguta	Viola vallicola
A. arguta eburnea	V. Canadensis Rydbergii
Aquilegia coerulea (rare)	Lepargyraea Canadensis
Anemone globosa	Chamaenerion angustifolium
	Harbouria trachypleura

Aletes obovata
A. acaulis
Ligusticum Porteri
Cogswellia Grayi
Pterospora Andromedea
Chimaphila umbellata
Pyrola secunda
P. uliginosa
Arctostaphylos Uva-ursi
Frasera stenosepala
Apocynum scopulorum
Phlox depressa
Lappula floribunda
L. angustata
Scutellaria Brittoni
Dracocephalum parviflorum
Prunella vulgaris
Monarda menthaefolia
M. mollis
Scrophularia occidentalis
Pentstemon oreophilus
P. alpinus
P. humilis
Castilleja linariaefolia
C. cognata
C. integra
C. confusa
Galium boreale
G. triflorum
Sambucus microbotrys
Linnaea Americana
Symphoricarpos occidentalis
Campanula petiolata
Specularia perfoliata
Laciniaria ligulistylis
Oreochrysum Parryi
Solidago oreophila
S. viscidula
S. radulina
S. trinervata
Eucephalus glaucus
Aster polycephalus
A. laevis
A. Porteri
Machaeranthera Bigelovii
M. aspera
Erigeron salicinus
E. macranthus
Antennaria oxyphylla
Anaphalis subalpina
Gnaphalium Wrightii
Rudbeckia flava
Achillaea lanulosa
Arnica cordifolia
Senecio salicinus
S. Nelsonii
S. Fendleri
Cirsium Americanum
C. erosum
Crepis petiolata
C. angustata
Hieracium albiflorum
H. Fendleri
Agoseris rostrata

b. **Pratenses.** The foot-hill meadow is not very unlike the mesa meadow; the species are in part the same, but there is no sharp line between the flora of the foot-hill forest and the foot-hill meadow, on account of the openness of the former. Only where the forest is dense enough to have a truly sylvan floor, are the light-loving plants absent. The foot-hill meadow society includes various grasses and certain herbs, such as painted-cups, fleabanes, Mariposa lilies, anemones, gaillardias, and the like. The following are the characteristic grasses and sedges:

Stipa comata	B. Pumpellianus
S. viridula	Agropyron Vaseyi
S. Nelsonii	A. Richardsoni
S. Scribneri	A. violaceum
Calamagrostis purpurascens	A. pseudorepens
Koeleria cristata	Elymus ambiguus
Poa platyphylla	E. strigosus
P. crocata	E. villiflorus
P. longiligula	Carex marcida
P. longipedunculata	C. Douglasii
Festuca brachyphylla	C. festiva
F. confinis	C. petasata
Bromus lanatipes	C. pratensis
B. Richardsonii	C. siccata

c. **Vallicolae.** The foot-hill cañon society consists of dense thickets of hazel, dwarf birch, willows, dogwoods, alders, and the like. About springs and along small rills is found a brief fontinal vegetation, the most delicate of all the plant-groups—mosses, liverworts, ferns, tway-blades, adder's-mouths, twisted-stalks, mountain lilies, shooting stars, cresses, sedges, and bog-orchids. The foot-hill cañon flora differs from the mesa cañon principally in the absence of the chaparral element, the haws and wild plums being absent. Most of the remaining shrubs and arborescent plants are identical—the dwarf maple, the birch, the dogwood, the beaked hazel, the wild cherries, and the cottonwoods. The following are the chief species:

Equisetum laevigatum
Cinna latifolia
Avena striata
Eatonia Pennsylvanica
Poa triflora
Panicularia nervata
P. Holmii
Carex tenella
C. Hoodii
C. festiva
C. aurea
Juncus Balticus montanus
Juncoides parviflorum
Allium Geyeri
A. reticulatum
Lilium Philadelphicum montanum
Vagnera stellata
Streptopus amplexifolius
Disporum majus
Limnorchis viridiflora
L. laxiflora
Ibidium Romanzoffianum strictum
Ophrys borealis
Acroanthes monophylla
Populus Sargentii
P. angustifolia
Salix caudata
S. perrostrata
S. Bebbiana
Betula fontinalis
Alnus tenuifolia
Corylus rostrata
Crunocallis Chamissoi
Clematis ligusticifolia
Ranunculus reptans
R. abortivus
Thalictrum Fendleri
Thlaspi Nuttallii
T. Coloradense
Draba streptocarpa
Ribes Purpusi
Opulaster intermedius
O. Ramaleyi
O. glabratus
O. monogynus
Rubus triflorus
Fragaria bracteata
Geum strictum
G. Oregonense
Rosa Macounii

R. Fendleri
R. aciculata
R. Maximiliani
Prunus Pennsylvanica
P. melanocarpa
Geranium Richardsonii
Acer glabrum
Epilobium adenocaulon
Circaea alpina
Aralia nudicaulis
Svida stolonifera
Heracleum lanatum
Angelica ampla
Dodecatheon radicatum
D. sinuatum
Amarella scopulorum
Mertensia punctata
M. viridula
M. lanceolata
Collinsia tenella
Mimulus floribundus
Veronica Americana
Distegia involucrata
Adoxa Moschatellina
Solidago Pitcheri
S. polyphylla
Gymnolomia multiflora
Rudbeckia laciniata
Bahia dissecta
Senecio hydrophyllus
S. perplexus

d. **Rimosae.** The crevice and cranny vegetation of the rocks consists of lichens, rupestrine ferns, alum roots, orpines, selaginellas, and many shrubs, such as the Jamesia, the wax-currant, juneberries, flowering raspberries, salmonberries, roses, and gooseberries. The Rocky Mountain red cedar stands often in grotesquely gnarled and twisted forms at the verges of the crags. It mav be remarked that this flora is of prime importance, since so large a portion of the region consists of naked rock. In fact the foot-hill flora in general is more or less rupestrine in character. There is gathered here only the strictly rock-loving vegetation. These are typical species:

Polypodium hesperium
Dryopteris Filix-mas
Woodsia scopulina
W. oregana
Filix fragilis
Cryptogramma acrostichoides

Cheilanthes Féei
C. Fendleri
Asplenium Trichomanes
A. Andrewsii
Belvisia septentrionalis
Selaginella Underwoodii
Sabina scopulorum
Parietaria Pennsylvanica
Talinum parviflorum
Physaria didymocarpa
P. floribunda
Sedum stenopetalum
Heuchera bracteata
Micranthes rhomboidea
Edwinia Americana
Ribes Purpusi
R. pumilum
Oreobatus deliciosus
Rosa melina
Amelanchier oreophila
Xylophacos Parryi
Androsace puberulenta
A. pinetorum
Coleosanthus minor
C. albicaulis
Chrysopsis caudata
Senecio Nelsonii
S. longipetiolatus

D. MONTANAE

The Montane Flora begins at about the 8,000 foot level, though, as we have seen, on the isolated peaks of the first range of foot-hills the Foot-hill Flora still largely persists even to the summits, or some 600 feet higher. The Montane Flora extends upward to the approximate altitude of 10,000 feet. It is for the most part a forest of lodgepole pine. The zone includes the slopes of the main range below 10,000 feet, and also the higher portions of the adjacent mountain plateau. Some of its characteristic species, indeed, tend to spread throughout the mountain plateau, and in cold valleys may even go as low as 6,000 feet. The montane as also the subalpine slopes have abundant rainfall, showers occurring nearly every afternoon. At least this was true of the summer of 1906. The ground is often boggy and springy, and cold with snow water. On north and east slopes the snow remains in the higher and deeper valleys till midsummer;

hence the flowering season is short. In a period of about six weeks, from the middle of July to the first of September, the main part of the vegetation in these cool valleys is brought to perfection. Species, which on the mesas had bloomed before my arrival on the eighteenth of June, I found just in blossom at Eldora on the mountainsides August thirty-first.

I saw too little of the Montane Flora, since I spent only six days in collections, where it occurs, to be able to separate it definitely into plant-societies. But the chief types as I saw it at Ward, Eldora, and Glacier lake, will be briefly described. In the Montane Subzone there are, perhaps, six tolerably distinct types of vegetation-association: a. The montane forest (**Sylvales**). b. The montane bog (**Paludosae**). c. The montane lake (**Lacustres**). d. The arid brush slope (**Arbustales**). e. The montane meadow (**Pratenses**). f. The montane stream (**Amnicolae**).

a. **Sylvales.** The montane sylva consists of a close forest of lodgepole pine interspersed with some bull pine and Rocky Mountain white pine, as well as with the various spruces and firs. The spruces and firs occur principally in the valleys, while on the barren ridges, the pines assume a scrub-like form. On these ridges occur many peculiar species of dwarf herbs—golden rods, asters, fleabanes, cat's-feet, actinellas, groundsels. A few of the more characteristic species of the montane sylva are the following:

Pinus scopulorum	Pseudotsuga mucronata
P. Murrayana	Abies lasiocarpa
Apinus flexilis	Calamagrostis purpurascens
Picea Engelmanni	Trisetum subspicatum
P. Parryana	Avena striata

Poa longipedunculata
Agropyron Arizonicum
A. andinum
A. violaceum
Carex Geyeri
Cytherea bulbosa
Populus tremuloides
Aquilegia coerulea
Delphinium occidentalis
Erysimum Cockerellianum
Draba streptocarpa
D. aurea
Ribes lentum
Potentilla concinna
Fragaria glauca
Thermopsis divaricarpa
Tium alpinum
Atelophragma elegans
Aragallus deflexus
Conioselinum scopulorum
Eutoca sericea
Pentstemon oreophilus
P. alpinus
Castilleja integra
C. confusa
C. lauta
C. lancifolia
C. sulphurea
Pedicularis racemosa
P. Grayi
Symphoricarpos oreophilus
Chrysopsis Bakeri
Oreochrysum Parryi
Solidago decumbens
S. oreophila
Eucephalus Engelmannii
Aster Underwoodii
A. Porteri
A. Andrewsii
Erigeron multifidus
E. trifidus
E. glandulosus
E. superbus
E. macranthus
E. speciosus
E. subtrinervis
E. eximius
Antennaria concinna
A. parvifolia
A. aprica
Anaphalis subalpina
Tetraneuris lanigera
Artemisia silvicola
Senecio pudicus
S. lanatifolius
S. ambrosioides
Cirsium Coloradense
Hieracium albiflorum
Agoseris Leontodon
A. humilis

b. **Paludosae.** The montane bog is characterized by the presence of the quaking aspen and other Hudsonian plants.

The aspen, however, is not confined to the bogs, but forms groves in slight depressions throughout the mountains, and occurs on Green Mountain not much, if any, above 6,000 feet. The aspen occurs in the drier portions of the bogs along with other uliginose plants. The bog vegetation is very rich in species. A fine specimen of the montane bog is found just west of Eldora at an elevation of 8,600 feet. The following are characteristic species:

Muhlenbergia simplex	Betula glandulosa
M. filiformis	Rumex densiflorus
Phleum alpinum	Polygonum confertiflorum
Cinna latifolia	Alsine longifolia
Trisetum montanum	Aconitum Columbianum
T. subspicatum	A. insigne
Merathrepta intermedia	A. ochroleucum
Poa reflexa	Ranunculus cardiophyllus
P. Vaseyana	R. inamoenus
Carex canescens	R. micropetalus
C. occidentalis	R. pedatifidus
C. ebenea	Pectianthia pentandra
C. Goodenovii	Micranthes arguta
C. utriculata	Parnassia fimbriata
Juncus Saximontanus	Dasiphora fruticosa
Juncoides parviflorum	Sidalcea candida
Limnorchis stricta	Viola palustris
L. borealis	V. pallens
Ibidium strictum	Epilobium adenocaulon
Populus tremuloides	E. rubescens
Salix Scouleriana	E. anagallidifolium
S. brachycarpa	Oxypolis Fendleri
S. glaucops	Dodecatheon philoscia
S. chlorophylla	Anthopogon barbellatus

Amarella plebeja	E. jucundus
Pleurogyne fontana	Gnaphalium palustre
Allocarya scopulorum	Artemisia biennis
Mimulus puberulus	Senecio triangularis
Veronica Wormskjoldii	S. admirabilis
Elephantella Groenlandica	S. cymbalarioides
Erigeron minor	Crepis denticulata
E. lonchophyllus	

c. **Lacustres.*** The montane lacustrine and marginal vegetation I saw only at Glacier lake. Besides some aquatic grasses, notably *Deschampsia caespitosa,* there occur the floating bur-reed, *Sparganium angustifolium,* the white water-crowfoot, *Batrachium flaccidum,* and the aquatic mudwort, *Limosella aquatica.* The yellow pond-lily, *Nymphaea polysepala,* grows also in some of these high lakes.

d. **Arbustales.** The arid brush slope vegetation consists quite wholly of the true sage-brush, *Artemisia tridentata.* This community is rare in the region, and I have seen it only between Glacier lake and Eldora near Bluebird mine.

e. **Pratenses.** The montane meadow is truly a paradise of flowers. It is not uncommon to see acre upon acre of meadow glorious with purple and blue and red and yellow and white and scarlet. Never have I seen flowers anywhere else in such profusion nor with such gorgeous hues—monkshoods, larkspurs, louseworts, milk-vetches, locoweeds, squawweeds, death-camasses, grasses, rushes, sedges, and blue-eyed grasses. The following species are typical:

*For a detailed account of the vegetation of these high lakes, consult the paper by Ramaley and Robbins on Redrock lake near Ward (Univ. of Colo. Studies, **6.** 133-168).

Muhlenbergia Richardsonis
M. simplex
Phleum alpinum
Agrostis asperifolia
Deschampsia caespitosa
Poa pratensis
P. reflexa
P. leptocoma
P. interior
P. Vaseyana
Festuca rubra
Carex occidentalis
C. Hoodii
C. festiva
C. ebenea
C. petasata
C. lanuginosa
Anticlea Coloradensis
Juncus longistylis
J. parous
J. Saximontanus
Sisyrinchium alpestre
S. angustifolium
Delphinium occidentale
Aconitum porrectum
A. Columbianum
A. insigne
A. ochroleucum
Anemone globosa
Clementsia rhodantha
Potentilla pulcherrima
P. Hippiana
P. propinqua
Dasiphora fruticosa
Geum Oregonense
Erythrocoma ciliata
Tium alpinum
Homalobus tenellus
Aragallus Lambertii
A. patens
A. Richardsonii
Geranium Richardsonii
Sidalcea candida
Dodecatheon radicatum
Castilleja sulphurea
Elephantella Groenlandica
Pedicularis Grayi
Valeriana ceratophylla
Erigeron Smithii
Arnica subplumosa
Senecio scopulinus
S. chloranthus
S. pseudaureus
Agoseris parviflora
A. laciniata
A. humilis

There is, of course, a montane rupestrine society, **Rupestres**, but I am too little acquainted with it to be able to give an adequate account of it. I, however, noted the austromontane saxifrage, *Leptasea austromontana,* and the glandular phacelia, *Phacelia glandulosa.* There is also a brief campestrian vegetation about Eldora, reproducing, in other species, the facies of the Great Plains, **Campestres**; I may instance as species: *Grindelia subalpina, G. Eldorae, Chrysothamnus Parryi,* and *C. elegans.*

f. **Amnicolae.** The montane stream vegetation is seen at its best about small rills. Along the larger streams it assumes a typical riparian aspect, much like that of the cañon society of the foot-hills along the large streams. Since the water in these streams is very cold inasmuch as they are fed from the wasting snows of the alpine valleys, the montane vegetation can scarcely be distinguished from the true subalpine vegetation of the streams. The list of species will, therefore, be deferred until the subalpine stream vegetation is reached.

E. SUBALPESTRES

The Subalpine zone extends from about the 10000 foot level to timberline, and hence coincides with the upper slopes of the Main Range. It is in the main a forest of Engelmann spruce, with occasional high meadows and bogs. Lakes, too, are numerous.

I have personal knowledge of only two formations: a. The subalpine forest (**Sylvales**). b. The subalpine stream (**Amnicolae**).

a. **Ses. lval.** The subalpine forest consists mainly of Engelmann spruce, *Picea Engelmanni,* and balsam fir, *Abies lasiocarpa.* I have but a very slight knowledge of the herbs characterizing this formation, but I noticed along the Arapahoe Trail the following species, which I had not seen in the montane forest: *Eriogonum subalpinum, Arnica Parryi,* and *Senecio atratus.* A large number of the montane sylvan species were observed.

b. **Amnicolae.** The subalpine stream vegetation is very luxuriant. It has on the one hand a very close affinity with the montane stream vegetation, and on the other with that of the wet alpine tundra. Not only does the snow linger late in these high valleys, the water of the streams is also very cold. In the list that follows the montane species are included as well:

Poa platyphylla
P. alpina
Carex Goodenovii
Populus balsamifera
P. angustifolia
Salix caudata
S. Scouleriana
Betula fontinalis
Alnus tenuifolia
Bistorta bistortioides
Alsine Baicalensis
Caltha leptosepala
Trollius albiflorus
Anemone Canadensis
Ranunculus reptans
R. inamoenus
R. micropetalus
Cardamine cordifolia
C. incana
Clementsia rhodantha
Pectianthia pentandra
Micranthes arguta
Parnassia fimbriata
Sidalcea candida
Oxypolis Fendleri
Primula Parryi
Swertia palustris
Polemonium robustum
Mertensia polyphylla
Mimulus Langsdorfii
M. puberulus
Helianthella quinquenervis
Senecio triangularis

I am almost wholly unacquainted with the remaining subalpine formations, such as the lacustrine, palustrous, rupestrine, the subalpine summit and high ridge floras. I saw a little of these at Ward and on the high slopes above Bloomerville, and on Arapahoe Peak just below timberline, but I am unable to give any clear account of the vegetation.*

F. ALPESTRES†

Between 11,000 and 12,000 feet tree-growth ceases abruptly. The spruces and firs bend and hug the ground. The willows branch and fork underground and rise to the height of but a few inches. The precise altitude of the timberline depends somewhat on the exposure, and differs, therefore, from peak to peak, but 11,500 feet is, perhaps, on an average the lower limit of the alpine zone. I am acquainted with this zone only on Arapahoe Peak, where I spent one day, September first, and collected some 110 species, most of them above timberline. The total number of species known to reach an altitude of 12,000 feet, or above, in Colorado is 386.‡

The alpine flora may be conveniently gathered into two societies: a. The wet alpine tundra (**Tundrales**). b. The dry rock-desert (**Alpinae**) of the summits.

a. **Tundrales.** The wet tundra occupies the region of cold water-soaked soil. The water from the wasting snows collects in depressions, streams are formed, and along these the

*I refer the reader to the excellent paper on Redrock lake near Ward, by Ramaley and Robbins (Univ. of Colo. Studies, **6**, 133-168).

†Consult for the Alpine Flora Cooper's Alpine vegetation in the vicinity of Long's Peak, Colorado (Bot. Gaz., **45**, 319-337). He recognizes three plant formations: 1. The dry meadow. 2. The wet meadow. 3. The Krummholtz. The latter, while striking enough, is rather but the upper level of the spruce forest, striving to persist in Alpine conditions.

‡For a list of these see the article by Cockerell on the Alpine Flora of Colorado (Am. Nat., **40**, 86-873).

vegetation clings. Often the streams flow concealed under the dwarf spruces and firs, their existence there being known only by their roaring underneath. Parry's primrose, saxifrages, globeflowers, white cowslips, gentians, red elephants, several sedges, grasses, and rushes are examples of the wet tundra vegetation. The Krummholtz of spruce and fir at the timberline consists chiefly of Engelmann spruce, *Picea Engelmanni,* and balsam fir, *Abies lasiocarpa.* The wet tundra continues down to the lower edge of the alpine zone, whence it descends and coalesces with the subalpine stream vegetation. The following are characteristic species:

Lycopodium annotinum	Trollius albiflorus
Picea Engelmanni	Ranunculus pedatifidus
Abies lasiocarpa	R. alpeophilus
Alopecurus occidentalis	Thlaspi Coloradense
Trisetum majus	Draba Fladnizensis
Poa reflexa	Clementsia rhodantha
P. leptocoma	Pectianthia pentandra
P. alpicola	Saxifraga debilis
P. alpina	Micranthes arguta
Carex festiva	Viola Canadensis Neo-Mexicani
C. ebenea	Angelica Grayi
C. bella	Pseudocymopterus tenuifolius
Juncus Drummondii	Kalmia microphylla
Juncoides spicatum	Primula Parryi
Salix glaucops	Androsace subumbellata
S. chlorophylla	A. diffusa
Bistorta bistortioides	Anthopogon elegans
B. vivipara	A. barbellatus
Alsine Baicalensis	
Caltha leptosepala	

Amarella monantha	Erigeron jucundus
A. plebeja Holmii	E. salsuginosus
Swertia palustris	E. superbus
Mertensia polyphylla	Senecio carthamoides
Veronica Wormskjoldia	S. blitoides
Castilleja Arapahoensis	S. pseudaureus
Elephantella Groenlandica	Hieracium gracile
Pedicularis Parryi	

b. **Alpinae.** The dry rock-desert lies mingled with or above the wet tundra and extends to the summit, wherever there is soil not covered with snow. The vegetation suffers from extreme exposure, and grows close to the ground, seldom, unless sheltered by rocks, rising more than an inch or two in height. In sheltered places under rocks, even at this extreme altitude, I found several beautiful clusters of the blue columbine, the state flower of Colorado, with stems twelve to eighteen inches high, and with blossoms two inches across. The wooly-headed thistle, too, was found of the same height. But in general the vegetation is much dwarfed. Next to the wet tundra the Krummholtz of spruce and fir still persists, under which I detected some fine specimens of club-moss; but farther up there is no shrubby vegetation except the underground willows. The vegetation grows in little rounded tussocks, and consists of the alpine catch-fly, rock-primrose scarcely half an inch high, sibbaldia, dryas, alpine clovers, dwarf sedges, grasses, and rushes, and, last of all, the little yellow saxifrages and the snowflowers, which are often blossoming at the snow-line. Now and then on the high exposed ridges the beautiful rydbergia rises five or six inches above the mountain turf, its stems and leaves and large yellow flowers swathed in dense wool. For what must be the tribulations of this alpine vegetation at the line of perpetual snow, with the alternate freezing by night and thawing by day, with the keen light, and bleak winds, and the fierce fury of the storms? And yet the alpine flora is exquisitely beautiful. It shares the fascination of its sublime mountain home, to which it lends the only touch of delicate grace. I append a list of alpine summit species, most of which I found on Arapahoe Peak or are known to grow there:

Trisetum subspicatum	Salix pseudolapponicum
Poa crocata	S. petrophila
P. rupicola	S. Saximontana
P. Pattersonii	Monolepis Nuttalliana
P. longipedunculata	Oxyria digyna
Festuca brachyphylla	Paronychia pulvinata
F. minutiflora	Claytonia megarrhiza
Agropyron violaceum	Oreobroma pygmaea
Carex incurva	Arenaria Tweedyi
C. atrata	A. Fendleri
C. chalciolepis	Alsinopsis propinqua
C. rigida	A. obtusiloba
C. chimaphila	Silene acaulis
C. nigricans	Aquilegia coerulea
C. Pyrenaica	Ranunculus adoneus
C. rupestris	Thlaspi Nuttallii
C. obtusata	T. purpurascens
C. capillaris	Erysimum nivale
Juncus triglumis	E. Cockerellianum
J. castaneus	Draba crassifolia
Allium Pikeanum	D. cana
Erythronium parviflorum	D. streptocarpa
Lloydia serotina	D. luteola

D. aureiformis
D. aurea
D. decumbens
Sedum stenopetalum
Heuchera Hallii
H. parvifolia
Micranthes rhomboidea
Leptasea chrysantha
L. austromontana
L. flagellaris
Potentilla dissecta
Sibbaldia procumbens
Erythrocoma ciliata
Acomastylis turbinata
A. Arapahoensis
Dryas octopetala
Amelanchier polycarpa
Trifolium lividum
T. dasyphyllum
Epilobium anagallidifolium
Vaccinium scoparium
Primula angustifolia
P. Parryi
Dasystephana Romanzovii
D. Parryi
Polemonium scopulinum
P. delicatum
P. Brandegeei
Eutoca sericea
Mertensia alpina
M. perplexa
Pentstemon glaucus stenosepalus
Chionophila Jamesii
Besseya alpina
Castilleja occidentalis
Pedicularis scopulorum
Campanula uniflora
Tonestus pygmaeus
Solidago decumbens
Erigeron pinnatisectus
E. multifidus
E. melanocephalus
E. simplex
E. leucotrichus
Antennaria media
A. umbrinella
A. imbricata
A. corymbosa
A. aprica
A. anaphaloides
Tetraneuris lanigera
Rydbergia grandiflora
Artemisia spithamea
Arnica platyphylla
A. Parryi
Senecio crassulus
S. atratus
S. crocatus
Cirsium scopulorum
C. griseum
Crepis alpicola

IV. SPECIAL CLASSES OF PLANTS

Independent of the five great zones of vegetation are two special classes of plants: A. The saprophytic and parasitic plants (**SAPROPHYTICALES ET PARASITICALES**). B. The plants which largely owe their presence to human agency (**ANTHROPOPHYTICALES**). These consist of the various cultural plants, of weeds, and of escapes.

A. SAPROPHYTICALES ET PARASITICALES

Besides the saprophytic and parasitic fungi there are a few phanerogams, which are destitute of chlorophyl and are true saprophytes or parasites. The following are known to occur in the region:

Corallorrhiza Corallorrhiza (saprophytic in rich soil)

C. multiflora (saprophytic in rich soil)

Razoumofskya Americana (parasitic on lodgepole pine)

R. cryptopoda (parasitic on bull pine)

Pterospora Andromedea (parasitic on the roots of bull pine)

Cuscuta curta (parasitic on *Iva xanthifolia* and other coarse herbs)

C. indecora (parasitic on *Thermopsis pinetorum* and other legumes)

Thalesia fasciculata (parasitic on *Artemisia frigida* and other Composites)

There are also a few root-parasites with green foliage, notably *Comandra pallida, Gerardia Besseyana,* and the Castillejas.

B. ANTHROPOPHYTICALES

Only three kinds of anthropophytic plants need concern us here: a. Forage plants (**Faenales**), which have become thoroughly naturalized. b. Weeds (**Ruderales**). c. Cultural and ornamental plants that have escaped (**Fugitivae**).

a. **Faenales.** Most of the common forage grasses and clovers have become thoroughly established about Boulder. I have noted the following:

Phleum pratense	Festuca elatior
Agrostis alba	Lolium Italicum
Dactylis glomerata	Trifolium pratense
Poa pratensis	T. repens
P. compressa	T. hybridum
P. trivialis	Medica sativa

b. **Ruderales.** In the appended list of weeds only those that have been introduced from elsewhere, or, if native, are also common weeds in many parts of the United States, have been included. However, many native species, such as the various gum-weeds and spurges, must often be bad weeds in cultivated grounds. But to do justice to the ruderal aspects of the native flora would require much special study, such as one is unable to make in the course of a few weeks, and especially one who is unfamiliar with agriculture as carried on in Colorado. I noted the following weeds:

Syntherisma sanguinale	B. secalinus
Panicum capillare	B. hordeaceus
Echinochloa Crus-galli	B. tectorum
Chaetochloa glauca	Rumex Acetosella
C. viridis	R. crispus
Cenchrus Carolinianus	R. obtusifolius
Avena fatua	Polygonum erectum
Eragrostis major	P. aviculare
Poa annua	Persicaria Persicaria
Bromus brizaeformis	Tiniaria Convolvulus

Chenopodium leptophyllum
C. album
C. hybridum
C. Botrys
Salsola Tragus
Amaranthus retroflexus
A. blitoides
A. graecizens
Mollugo verticillata
Portulaca oleracea
P. retusa
Alsine media
Silene antirrhina
S. noctiflora
Vaccaria Vaccaria
Thlaspi arvense
Bursa Bursa-pastoris
Sisymbrium officinale
Brassica juncea
B. nigra
Camelina sativa
Tridophyllum Monspeliensis
Medicago Lupulina
Melilotus alba
M. officinale
Erodium cicutarium
Malva rotundifolia
Pastinaca sativa
Convolvulus arvensis
Nepeta Cataria
Glecoma hederacea
Leonurus Cardiaca
Mentha spicata
Physalis Virginiana
P. heterophylla
Datura Stramonium
D. Tatula
Verbascum Thapsus
V. Blattaria
Veronica serpyllifolia
V. Byzantina
Plantago major
P. lanceolata
Micrampelis lobata
Iva xanthifolia
I. axillaris
Ambrosia trifida
A. artemisifolia
A. psilostachya
Xanthium commune
Erigeron ramosus
Leptilon Canadense
Helianthus petiolaris
Bidens vulgata
Boebera papposa
Anthemis Cotula
Tragopogon pratensis
T. porrifolius
Cichorium Intybus
Taraxacum Taraxacum
Lactuca integrata
Sonchus arvense
S. asper

c. **Fugitivae.** I noted the following escapes:

Chaetochloa Italica
Avena sativa
Triticum vulgare
Hordeum sativum hexastichon
Asparagus officinale
Atriplex hortensis
Saponaria officinalis
Delphinium Ajacis
Papaver Argemone
Armoracia Armoracia
Brassica campestris
Koniga maritima
Raphanus sativus
Ribes vulgare
Althaea rosea
Carum Carvi
Pharbitis purpurea
Lycopsis arvensis
Lycium vulgare
Lycopersicon Lycopersicon

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FLORA OF BOULDER, COLORADO, AND VICINITY

Subkingdom I. PTERIDOPHYTA. Fern-worts.

Order 1. OPHIOGLOSSALES.

Family 1. **OPHIOGLOSSACEAE** Presl. **Adder's-tongue family.**

1. **BOTRYCHIUM** Swartz. MOONWORT.

1. **B. Virginianum** (L.) Swartz. VIRGINIA GRAPE-FERN.

Forested slopes of Green Mt., above 7000 ft.; very scarce, only two or three plants discovered (Daniels, 606).*

LABRADOR to BRITISH COLUMBIA; FLORIDA to TEXAS and WASHINGTON.

Order 2. FILICALES.

Family 2. **POLYPODIACEAE** R. Br. **Polypody family.**

2. **POLYPODIUM** L. POLYPODY.

2. **P. hesperium** Maxon. WESTERN POLYPODY.

On a single rock in a cañon on the north slope of Green Mt., 7500 ft. (Daniels, 605).

MONTANA to BRITISH COLUMBIA and WASHINGTON; COLORADO to ARIZONA.

3. **DRYOPTERIS** Adans. SHIELD-FERN.

3. **D. Filix-mas** (L.) Schott [*Aspidium Filix-mas* (L.) Swartz]. MALE-FERN.

Summit of South Boulder Peak; Bear Cañon; high cañons of Green Mt.; Boulder Cañon near Falls; apparently quite

* See preface for explanation of numbers.

evenly, but not abundantly distributed throughout in moist rocky cañons, 6000-8600 ft. (Daniels, 555).

NOVA SCOTIA and MICHIGAN to ALASKA; NEW MEXICO and COLORADO to CALIFORNIA.

4. WOODSIA R. Br.

4. **W. scopulina** D. C. Eaton. CLIFF WOODSIA.

The most abundant fern of the foot-hills and lower mountainsides, occurring wherever rocks are exposed to the surface, 5700-8100 ft. (Daniels, 156).

MICHIGAN to BRITISH COLUMBIA; COLORADO and ARIZONA to CALIFORNIA.

5. **W. Oregana** D. C. Eaton. MOUNTAIN WOODSIA.

With the preceding, but much scarcer, and ranging to the timberline or above, 5600-11000 ft. (Daniels, 361). Long's Peak (Coulter in Wabash College Herb.).

MICHIGAN to BRITISH COLUMBIA; COLORADO and ARIZONA to CALIFORNIA.

5. FILIX Adans. BLADDER-FERN.

6. **F. fragilis** (L.) Underw. [*Cystopteris fragilis* Bernh.]. FRAGILE-FERN.

Throughout on the moister rocks; apparently the only fern of the plains region, 5100-13000 ft. (Daniels, 23).

Almost cosmopolitan.

6. PTERIDIUM Scop. BRACKEN.

7. **P. aquilinum pubescens** Underw. HAIRY BRAKE.

Cañons of Green Mt., and gulches at the foot of the Flatirons; Bear Cañon; local, but abundant where found, 5800-10000 ft. (Daniels, 277).

MONTANA and COLORADO to ARIZONA and CALIFORNIA.

7. CRYPTOGRAMMA R. Br. PARSLEY-FERN.

8. **C. acrostichoides** R. Br. ROCK PARSLEY-FERN.

High ridges of rock, descending on Green Mt. to about 6500 ft., thence to above 11000 ft. (Daniels, 271).

MICHIGAN to ALASKA; COLORADO to CALIFORNIA.

8. **CHEILANTHES** Swartz. LIP-FERN.

9. **C. Féei** Moore [*C. gracilis* Mett.; *C. lanuginosa* Nutt.]. WOOLLY LIP-FERN.

Growing with *Asplenium Andrewsii* A. Nelson on the south face of a white sandstone (alkaline) cliff extending along Boulder creek for a mile or more (Andrews, in Nelson, Proc. of the Biol. Soc. of Wash., **17**, 175).

ILLINOIS and MINNESOTA to BRITISH COLUMBIA; MISSOURI to TEXAS and ARIZONA.

10. **C. Fendleri** Hook. FENDLER'S LIP-FERN.

Dry rocks, Boulder, 5900-8500 ft. (Rydberg).

COLORADO and TEXAS to CALIFORNIA.

9. **ASPLENIUM** L. SPLEENWORT.

11. **A. Trichomanes** L. MAIDEN-HAIR SPLEENWORT.

Limestone rocks, South Boulder Cañon, 5400-7000 ft. (Rydberg).

NORTH AMERICA: EUROPE: ASIA: SOUTH AFRICA: PACIFIC ISLANDS.

12. **A. Andrewsii** A. Nelson. ANDREWS'S SPLEENWORT.

Growing abundantly in crevices with *Cheilanthes Féei* Moore (Andrews, in Nelson, loc. cit. pp. 174-175).

Known only from the type locality as above.

10. **BELVISIA** Mirb. GRASS-FERN.

13. **B. septentrionalis** (L.) Mirb. [*Asplenium septentrionalis* (L.) Hoffm.] NORTHERN GRASS-FERN.

Bald ridges of Green Mt.; south slope of Bear Mt.; South Boulder Cañon, 6000-7000 ft. (Daniels, 358).

SOUTH DAKOTA to MONTANA; NEW MEXICO to ARIZONA.

Order 3. EQUISETALES.

Family 3. **EQUISETACEAE** Michx. **Horsetail family.**

11. **EQUISETUM** L. HORSETAIL.

14. **E. arvense** L. FIELD HORSETAIL.

Swales and shores of streams; sandy moist meadows, 5100-10000 ft. (Daniels, 260).

NORTH AMERICA: EUROPE: ASIA.

15. **E. laevigatum** A. Br. SMOOTH SCOURING RUSH.

Along streams and railway embankments in the plains and on the mountains, 5100-12500 ft. (Daniels, 392).

NEW JERSEY to BRITISH COLUMBIA; NORTH CAROLINA to MEXICO and CALIFORNIA.

Order 4. LYCOPODIALES.

Family 4. **LYCOPODIACEAE** Michx. **Clubmoss family.**

12. **LYCOPODIUM** L. CLUBMOSS.

16. **L. annotinum** L. STIFF CLUBMOSS.

Under dwarf and procumbent shrubs, hidden almost completely from view, Arapahoe Peak, above timberline, 11000-11500 ft. (Daniels, 879).

LABRADOR to ALASKA; WEST VIRGINIA to COLORADO and WASHINGTON: EUROPE: ASIA.

Family 5. **SELAGINELLACEAE** Underw. **Selaginella family.**

13. **SELAGINELLA** Beauv. LITTLE CLUBMOSS.

17. **S. densa** Rybd. [*S. Engelmanni* Hieron.] DENSE SELAGINELLA.

Forests, Redrock lake, 10100 ft. (Ramaley & Robbins).

SOUTH DAKOTA to MONTANA; NEBRASKA to COLORADO.

17½. **S. Underwoodii** Hieron. [*S. rupestris Fendleri* Underw.]. UNDERWOOD'S SELAGINELLA.

Common on exposed rocks, 6000-8100 ft. (Daniels, 151). Redrock lake 10100 ft. (Ramaley and Robbins).

COLORADO to NEW MEXICO.

Subkingdom II. SPERMATOPHYTA. Seed plants.

Class I. GYMNOSPERMAE.

Order 5. PINALES.

Family 6. PINACEAE Lindl. Pine family.

14. PINUS L. Pine.

18. **P. scopulorum** (Engelm.) Lemmon [*P. ponderosa scopulorum* Engelm.]. Bull pine.

Common on the higher mesas, foothills, and mountains, 5700-10000 ft. (Daniels, 97).

South Dakota and Nebraska to Montana; Texas to Arizona.

19. **P. contorta Murrayana** (Oreg. Com.) Engelm. Lodge pole pine.

Mountains about Ward, and between Sugarloaf Mt. and Glacier Lake, 7000-10000 ft. (Daniels, 302).

Montana to Alaska; Colorado to California.

15. APINUS Necker. Cembra pine.

20. **A. flexilis** (James) Rydb. [*Pinus flexilis* James]. Rocky Mountain white pine.

Rare on high ridges of Green Mt.; also at Ward, 7300-11000 ft. (Daniels, 771).

Alberta to Texas and California.

16. PICEA Link. Spruce.

21. **P. Engelmanni** (Parry) Engelm. Engelmann spruce.

Bear Cañon; Boulder Cañon near Falls; common upon the main range of the mountains, 7000 (Bear Cañon) -11000 ft. (Daniels, 294).

Alberta to British Columbia; New Mexico to Arizona.

22. **P. Parryana** (Andrée) Sarg. [*P. pungens* Engelm.]. Blue spruce.

Common in cañons throughout, 6500-10000 ft. (Cockerell); Fourth of July Mine; South Boulder Cañon (Ramaley).

Wyoming and New Mexico to Utah.

17. **PSEUDOTSUGA** Carr. Red fir.

23. **P. mucronata** (Raf.) Sudw. [*P. Douglasii* Carr.]. Douglas spruce.

Abundant on the foothills and mountains; some trees have green foliage, others glaucous blue, 6000-10000 ft. (Daniels, 142).

Alberta to British Columbia; Texas to Mexico and California.

18. **ABIES** Miller. Balsam fir.

24. **A. lasiocarpa** (Hook.) Nutt. Western balsam fir.

North slope of Green Mt.; Bear Cañon; Boulder Cañon near Falls and above them; common on the main mountain range, 7000 (Bear Cañon) -11000 ft. (Daniels, 303).

Alberta to Alaska; New Mexico to Arizona.

Family 7. **JUNIPERACEAE** Horan. **Juniper family.**

19. **JUNIPERUS** L. Juniper.

25. **J. Sibirica** Burgsd. Mountain juniper.

Mesa at the foot of the Flat-irons, 5700-6000 ft. (Daniels, 182). Mountains between Sunshine and Ward (Rydberg).

Labrador to Alaska; Massachusetts and Michigan to Utah: Europe: Asia.

20. **SABINA** Haller. Savin.

26. **S. scopulorum** (Sarg.) Rydb. [*Juniperus scopulorum* Sarg.]. Rocky Mountain red cedar.

High mesas and mountain crags; some trees have green foliage, others glaucous blue, 5700-8500 (Daniels, 217).

Alberta to British Columbia; Texas to Arizona and Oregon.

Class II. ANGIOSPERMAE.

Subclass I. MONOCOTYLEDONES.

Order 6. PANDANALES.

Family 8. TYPHACEAE J. St. Hil. Cattail family.

21. TYPHA L. CATTAIL.

27. **T. latifolia** L. BROAD-LEAVED CATTAIL.

Swales and bogs in the plains, common, 5100-5600 ft. (Daniels, 408).

NORTH AMERICA, except the far north: EUROPE: ASIA.

Family 9. SPARGANIACEAE Agard. Bur-reed family.

22. SPARGANIUM L. BUR-REED.

28. **S. angustifolium** Michx. [*S. simplex angustifolium* (Michx.) Engelm.]. NARROW-LEAVED BUR-REED.

Floating in a pond at Glacier Lake, 9000 ft. (Daniels, 620). Also Redrock lake, 10100 ft. (Ramaley and Robbins).

NEWFOUNDLAND to OREGON; NEW YORK to CALIFORNIA.

Order 7. NAIADALES.

Family 10. ZANICHELLIACEAE Dumort. Zanichellia family.

23. POTAMOGETON L. PONDWEED.

29. **P. lonchites** Tuckerm. [*P. fluitans* Roth.] LONG-LEAVED PONDWEED.

Owen's lake; Boulder lake, 5300 ft. (Daniels, 683).

NEW BRUNSWICK to WASHINGTON; FLORIDA to CALIFORNIA.

29½. **P. alpinus** Balbis [*P. rufescens* Schrad.]. ALPINE PONDWEED.

Redrock lake, 10100 ft. (Ramaley and Robbins.).

NOVA SCOTIA to ALASKA; NEW JERSEY to CALIFORNIA.

30. **P. heterophyllus** Schreb. VARIOUS-LEAVED PONDWEED.
Near Boulder, 5100-6000 ft. (Rydberg).
NORTH AMERICA, except extreme north: EUROPE.

31. **P. foliosus** Raf. [*P. pauciflorus* Pursh]. LEAFY PONDWEED.
Streams and ditches east of Boulder, 5100-5500 ft. (Daniels, 736).
NEW BRUNSWICK to BRITISH COLUMBIA; FLORIDA to CALIFORNIA.

32. **P. Spirillus** Tuckerm. SPIRAL PONDWEED.
Swales along railroad between Boulder and Marshall, 5400 ft. (Daniels, 486). Not included in Rydberg's Flora of Colorado.
NOVA SCOTIA to MINNESOTA; VIRGINIA to COLORADO.

33. **P. pectinatus** L. FENNEL-LEAVED PONDWEED.
Owen's lake; Boulder lake, 5300 ft. (Daniels, 681).
NORTH AMERICA: EUROPE.

24. ZANICHELLIA L.

34. **Z. palustris** L. MARSH ZANICHELLIA.
Owen's lake; Boulder lake, 5300 ft. (Daniels, 682). Redrock lake, 10100 ft. (Ramaley & Robbins).
NORTH TEMPERATE ZONE.

Order 8. ALISMALES.

Family 11. ALISMACEAE D C. Water-plantain family.

25. ALISMA L. WATER-PLANTAIN.

35. **A. Plantago** L. COMMON WATER-PLANTAIN.
Bogs west of Marshall; swales, ditches, streams, and ponds east of Boulder, 5100-6000 ft. (Daniels, 424).
NORTHERN HEMISPHERE.

26. SAGITTARIA L. ARROWHEAD.

36. **S. arifolia** J. G. Smith. ARUM-LEAVED ARROWHEAD.
With the preceding, 5100-6000 ft. (Daniels, 441).
QUEBEC to BRITISH COLUMBIA; MAINE and MICHIGAN to NEW MEXICO and CALIFORNIA.

Order 9. POALES.

Family 12. POACEAE R. Br. Meadowgrass family.

27. SCHIZACHYRIUM Nees. BUNCH-GRASS.

37. **S. scoparium** (Michx.) Nash [*Andropogon scoparius* Michx.]. BROOM-GRASS.

Common in dry plains and mesas; occasional in the lower foothills, 5100-6300 ft. (Daniels, 478).

NEW BRUNSWICK to SASKATCHEWAN; FLORIDA to TEXAS.

28. ANDROPOGON L. BEARD-GRASS.

38. **A. furcatus** Muhl. TURKEY-FOOT GRASS.

Common on the plains, mesas and foothills, 5100-8000 ft. (Daniels, 512).

MAINE to SASKATCHEWAN; FLORIDA to TEXAS and COLORADO.

39. **A. chrysocomus** Nash. GOLDEN BEARD-GRASS.

Common on the plains and mesas, 5100-6000 ft. (Daniels, 486).

NEBRASKA to COLORADO; KANSAS to TEXAS.

29. SORGHASTRUM Nash. INDIAN GRASS.

40. **S. nutans** (L.) Nash [*Chrysopogon nutans* (L.) Benth.]. NODDING INDIAN GRASS.

Frequent on the plains and mesas, 5100-6000 ft. (Daniels, 655).

ONTARIO to MANITOBA; FLORIDA to ARIZONA.

30. SYNTHERISMA Walt. CRAB GRASS.

41. **S. sanguinale** (L.) Dulac. [*Panicum sanguinale* L.]. FINGER GRASS.

Along roadsides, and in yards and fields, still uncommon, 5300-5700 ft. (Daniels).

OLD WORLD, thence to the NEW.

31. PANICUM L. PANIC-GRASS.

42. **P. capillare** L. WITCH GRASS.

Along roads and railroads, and in yards and fields, appearing as if introduced, 5100-6500 ft. (Daniels, 586).

A form, undoubtedly native, with somewhat narrower leaves, slenderer stems, which are branched from the root, the sheaths less hairy and less prominently papillose, the spikelets acute and greenish, or the uppermost purplish, occurs in swales in the plains region, 5100-5500 ft. (Daniels, 985). An analogous, or perhaps identical form, gathered by P. A. Rydberg in the sand-hills of Nebraska, is referred by him (somewhat doubtfully) to *P. capillare agreste* Gatt. with the remark that the form is named var. *occidentale* in the National Herbarium with no published description (Rydberg U. S. Nat. Herb. Cont. 3, 186).

Throughout SOUTHERN CANADA and the UNITED STATES.

43. **P. virgatum** L. TALL SWITCH GRASS.

Frequent on the plains and mesas, 5100-6000 ft. (Daniels, 397).

MAINE to ASSINIBOIA; FLORIDA to ARIZONA.

43½. **P. Tennesseense** Ashe. TENNESSEE PANIC-GRASS.

Collected by Jones at South Boulder (Hitchcock and Chase).

MAINE to MINNESOTA and UTAH; GEORGIA to ARIZONA.

44. **P. Scribnerianum** Nash [*P. scoparium* Auct., not Lam.]. SCRIBNER'S PANIC-GRASS.

Common among rocks on the foot-hills, but occurring occasionally on the mesas and plains, 5400-7000 ft. (Daniels, 99).

MAINE to BRITISH COLUMBIA; VIRGINIA to ARIZONA and OREGON.

32. ECHINOCHLOA Beauv. BARNYARD GRASS.

45. **E. Crus-galli** (L.) Beauv. [*Panicum Crus-galli* L.]. COCKSPUR GRASS.

Common in waste places and along irrigation ditches, 5100-6000 ft. (Daniels, 741).

EUROPE, thence to NORTH AMERICA.

45a. **E. Crus-galli mutica** (Vasey) Rydb.

With the type (Daniels, 997).

Range of the type.

33. **CHAETOCHLOA** Scribn. Foxtail.

46. **C. glauca** (L.) Scribn. [*Setaria glauca* (L.) Beauv.]. Yellow foxtail.

Along streets and waste places, 5100-5700 ft. (Daniels, 773).

Europe, thence to North America.

47. **C. viridis** (L.) Scribn. [*S. viridis* (L.) Beauv.]. Green foxtail.

With the preceding, but far more common, 5100-6000 ft. (Daniels, 507).

Europe, thence to North America.

48. **C. Italica** (L.) Scribn. [*S. Italica* (L.) Kunth.]. Italian millet.

Escaped to roads and waste places, 5100-5700 ft. (Daniels).

The Old World, thence to the New.

34. **CENCHRUS** L. Bur-grass.

49. **C. Carolinianus** Walt. [*C. tribuloides* Auct., not L.]. Sand-bur.

Along railroads and on the sandy shores of streams, 5100-6500 ft. (Daniels, 776).

Maine to Minnesota; Florida to Texas and Colorado.

35. **HOMALOCENCHRUS** Mieg. Catch-fly grass.

50. **H. oryzoides** (L.) Poll. [*Leersia oryzoides* (L.) Sw.]. Rice cut-grass.

Swales, streams, and irrigation ditches, 5100-6000 ft. (Daniels, 786).

Nova Scotia to Washington; Florida to California: Europe: Asia.

36. **PHALARIS** L. Canary-grass.

51. **P. arundinacea** L. Reed canary-grass.

Swales and wet meadows near Boulder lake, 5300 ft. (Daniels, 732).

Temperate North America: Europe: Asia.

36½. **HIEROCHLOE** Gmel. HOLY GRASS.

51½. **H. odorata** (L.) R. and S. [*Savastana odorata* (L.) Scribn; *H. borealis* R. and S.] SWEET HOLY GRASS.

Redrock lake, 10100 ft. (Ramaley & Robbins).

LABRADOR to ALASKA; NEW JERSEY to ARIZONA; EUROPE: ASIA.

37. **ARISTIDA** L. TRIPLE-AWNED GRASS.

52. **A. fasciculata** Torr. BUSHY POVERTY-GRASS.

In the plains, scarce, 5100-5700 ft. (Daniels, 777).

KANSAS to CALIFORNIA; TEXAS to MEXICO.

53. **A. longiseta** Steud. LONG-AWNED POVERTY-GRASS.

Abundant on the plains, mesas and foothills, 5100-8500 ft. (Daniels, 300). Also on the mountains between Sunshine and Ward (Rydberg).

ILLINOIS to WASHINGTON; TEXAS to MEXICO.

38. **STIPA** L. PORCUPINE GRASS.

54. **S. comata** Trin. & Rupr. WESTERN PORCUPINE GRASS.

Common on the plains and foothills, 5100-8500 ft. (Daniels, 197).

ALBERTA to ALASKA; NEW MEXICO to CALIFORNIA.

55. **S. viridula** Trin. [*S. parviflora Americana* Schultes]. GREENISH PORCUPINE GRASS.

Common on the plains, mesas, and foothills, 5100-8500 ft. (Daniels, 301). Also at Gato (Rydberg).

SASKATCHEWAN to MONTANA; KANSAS to UTAH.

56. **S. Nelsonii** Scribn. NELSON'S PORCUPINE GRASS.

On the mesas, foothills, and mountain sides, 5700-10000 ft. (Daniels, 365).

ASSINIBOIA to IDAHO and COLORADO.

57. **S. Scribneri** Vasey. SCRIBNER'S PORCUPINE GRASS.

On the plains, mesas, foothills and mountainsides, 5100-9500 ft. (Daniels, 749).

COLORADO to NEW MEXICO.

58. **S. Lettermannii** Vasey. LETTERMANN'S PORCUPINE GRASS.
Barren hilltops east of the Flat-irons, 5800 ft. (Daniels, 184).
WYOMING to IDAHO; COLORADO to UTAH.

39. ORYZOPSIS Michx. MOUNTAIN RICE.

59. **O. micrantha** (Trin. & Rupr.) Thurber. SMALL-FLOWERED MOUNTAIN RICE.
Rocky soil on the mesas and foothills, 5700-8500 ft. (Daniels, 269).
ASSINIBOIA to MONTANA; NEBRASKA to ARIZONA.

40. ERIOCOMA Nutt.

60. **E. cuspidata** Nutt. [*Oryzopsis cuspidata* (Nutt.) Benth.]. SILKY MOUNTAIN RICE.
Barren mesa near entrance to Bear Cañon, 5800-6000 ft. (Daniels, 765).
SASKATCHEWAN to WASHINGTON; TEXAS and MEXICO to CALIFORNIA.

41. MUHLENBERGIA Schreb. DROP-SEED GRASS.

61. **M. racemosa** (Michx.) B. S. P. [*M. glomerata* Trin.]. MARSH DROP-SEED GRASS.
Cañon on Green Mt.; subalpine meadows at Eldora, 6000-10000 ft. (Daniels, 526).
NEWFOUNDLAND to BRITISH COLUMBIA; NEW JERSEY to NEW MEXICO.

62. **M. cuspidata** (Torr.) Rydb. [*Sporobolus cuspidatus* (Torr.) Woods]. PRAIRIE RUSH-GRASS.
Dry ledges, Gregory Cañon, 6000 ft. (Daniels, 371).
MANITOBA to ALBERTA; MISSOURI to COLORADO.

63. **M. Richardsoni** (Trin.) Rydb. [*Vilfa Richardsonii* Trin.; *Sporobolus depauperatus* Coulter in part]. RICHARDSON'S RUSH-GRASS.
Subalpine meadows and open bogs, Eldora, 8600 ft. (Daniels, 840).
ANTICOSTI to BRITISH COLUMBIA; NEW MEXICO to CALIFORNIA.

64. **M. simplex** (Scribn.) Rydb. [*Sporobolus simplex* Scribn.]. SIMPLE RUSH-GRASS.

In shallow water, aspen bogs about Glacier Lake, 9000 ft. (Daniels, 708). Also mountains between Sunshine and Ward, (Rydberg).

NEBRASKA to WYOMING and NEW MEXICO.

65. **M. filiformis** (Thurber) Rydb. [*Vilfa depauperata filiformis* Thurber]. FILIFORM RUSH-GRASS.

Subalpine bogs, Eldora, 8600 ft. (Daniels, 366).

WYOMING to OREGON; COLORADO to CALIFORNIA.

66. **M. gracilis** Trin. SLENDER DROP-SEED.

Summits of crags on the foot-hills, thence to subalpine mountain-ridges, the most characteristic grass of such places, 6000-10000 ft. (Daniels, 208).

COLORADO to CALIFORNIA; TEXAS to MEXICO.

42. LYCURUS H. B. K.

67. **L. phleoides** H. B. K. FALSE TIMOTHY.

Meadow Park, 6500 ft. (Rydberg).

COLORADO and TEXAS to ARIZONA and MEXICO.

43. PHLEUM L. TIMOTHY.

68. **P. pratense** L. COMMON TIMOTHY.

Throughout the area of cultivation, but has penetrated distant cañons, 5100-11000 ft. (Daniels, 504).

Temperate OLD WORLD, thence to all temperate lands.

69. **P. alpinum** L. MOUNTAIN TIMOTHY.

Subalpine meadows from Glacier Lake to Eldora; above timber-line, Arapahoe Peak, 8500-12000 ft. (Daniels, 632).

Circumboreal and alpine, EUROPE: ASIA: NORTH AMERICA.

44. ALOPECURUS L. FOXTAIL.

70. **A. aristulatus** Michx. [*A. fulvus* J. E. Smith]. SWAMP FOXTAIL.

Along irrigation ditches and at the margins of ponds and puddles, 5100-5600 ft. (Daniels, 246).

MAINE to ALASKA; PENNSYLVANIA to CALIFORNIA.

71. **A. occidentalis** Scribn. [*A. alpinus* Coulter, not L.]. WESTERN FOXTAIL.

Above timber-line, Arapahoe Peak, 11000-11500 ft. (Daniels, 942).

ALBERTA to BRITISH COLUMBIA; COLORADO to UTAH.

45. SPOROBOLUS R. Br. DROPSEED.

72. **S. airoides** Torr. HAIR-GRASS DROPSEED.

Alkaline flats about Boulder lake, scarce, 5300 ft. (Daniels, 731).

NEBRASKA and TEXAS to CALIFORNIA.

73. **S. cryptandrus** (Torr.) Gray. SAND DROPSEED.

Common on the plains, mesas, and grassy slopes of the foothills, 5100-8000 ft. (Daniels, 513).

MASSACHUSETTS to WASHINGTON; PENNSYLVANIA to ARIZONA and MEXICO.

74. **S. heterolepis** Gray. NORTHERN DROPSEED.

Common along the railroad between Boulder and Marshall, 5400 ft. (Daniels, 518).

QUEBEC to SASKATCHEWAN; PENNSYLVANIA to COLORADO.

75. **S. asperifolius** (Nees & Meyen) Thurber. ROUGH DROPSEED.

Common on the plains, 5100-5600 ft. (Daniels, 493).

ASSINIBOIA to BRITISH COLUMBIA; MISSOURI and TEXAS to CALIFORNIA.

46. POLYPOGON Desf. BEARD-GRASS.

76. **P. Monspeliensis** (L.) Desf. DITCH FOXTAIL.

Common along irrigation ditches east of Boulder, 5100-5500 ft. (Daniels, 676).

EUROPE and ASIA, thence to NORTH AMERICA.

47. CINNA L. WOOD REED-GRASS.

77. **C. latifolia** (Trev.) Griseb. [*C. pendula* Trin.]. SLENDER WOOD REED-GRASS.

Deep cañons in shade, frequent; in aspen bogs at Glacier lake and Eldora, 5700-8600 ft. (Daniels, 987).

NEWFOUNDLAND to BRITISH COLUMBIA; NORTH CAROLINA to UTAH: EUROPE.

48. AGROSTIS L. BENT-GRASS.

78. **A. alba** L. WHITE BENT-GRASS. RED-TOP.

Common about ditches and swales throughout the cultivated area, and already penetrating remote cañons, where the smaller forms are quite possibly native. The larger cultivated form is *A. alba vulgaris* (With.) Thurber, 5100-8600 ft. (Daniels, 689).

Mostly naturalized from EUROPE, and now in all temperate lands; there are indigenous boreal and alpine forms in NORTH AMERICA.

79. **A. asperifolia** Trin. [*A. exarata* Coult. in part, not Trin.]. HARSH BENT-GRASS.

Moist meadows throughout, 5100-10500 ft. (Daniels, 376)
MANITOBA and NEW MEXICO to CALIFORNIA.

79½. **A. Rossae** Vasey [*A. varians* Trin.]. MISS ROSS'S BENT-GRASS.

Long's Peak (Holm).
BRITISH COLUMBIA to COLORADO and CALIFORNIA.

80. **A. hyemalis** (Walt.) B. S. P. [*A. scabra* Willd.]. HAIR-GRASS.

Common throughout in both dry and moist soil, 5100-11000 ft. (Daniels, 374). Also on the mountains between Sunshine and Ward (Rydberg).

NORTH AMERICA, except the extreme north.

80½. **A. tenuiculmis** Nash [*A. tenuis* Vasey]. THIN BENT-GRASS.

Redrock lake, 10100 ft. (Ramaley and Robbins).
MONTANA to WASHINGTON; COLORADO to CALIFORNIA.

49. CALAMAGROSTIS Adans. REED-GRASS.

81. **C. purpurascens** R. Br. [*Deyeuxia sylvatica* Vasey, not DC.]. PURPLE BLUE-JOINT.

Barren ridges in the foothills and mountains, common, 6000-12500 ft. (Daniels, 700). Long's Peak (Holm).
GREENLAND to ALASKA; COLORADO to CALIFORNIA.

82. **C. Canadensis** (Michx.) Beauv. [*Deyeuxia Canadensis* (Michx.) Munro]. CANADA BLUE-JOINT.

Along streams in the plains; also in deep cañons and aspen bogs in the foothills and mountains, 5100-11000 ft. (Daniels, 649).

LABRADOR to BRITISH COLUMBIA; NORTH CAROLINA to CALIFORNIA.

50. DESCHAMPSIA Beauv. HAIR-GRASS.

83. **D. caespitosa** (L.) Beauv. TUFTED HAIR-GRASS.

Wet margins of Glacier lake, often in water of some depth, 9000 ft. (Daniels, 617). Redrock lake, 10100 ft. (Ramaley and Robbins).

NEWFOUNDLAND to ALASKA; NEW JERSEY to CALIFORNIA.

51. TRISETUM Pers. FALSE OAT.

84. **T. spicatum** (L.) Richter [*T. subspicatum molle* Gray]. NARROW FALSE OAT.

Mountainsides at Ward, Bloomerville, Glacier Lake, and Eldora, 8600-13000 ft. (Daniels, 330).

GREENLAND to ALASKA; NEW HAMPSHIRE to COLORADO and CALIFORNIA: EUROPE: ASIA.

85. **T. majus** (Vasey) Rydb. [*T. subspicatum majus* Vasey]. LARGER FALSE OAT.

Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 988).

MONTANA to BRITISH COLUMBIA; COLORADO to UTAH.

86. **T. montanum** Vasey. MOUNTAIN FALSE OAT.

Deep cañons and aspen bogs, local, 7000 (Bear Cañon) -10000 ft. (Daniels, 631).

WYOMING to NEW MEXICO.

52. AVENA L. OAT.

87. **A. striata** Michx. PURPLE OAT.

Rare in deep cañons and aspen bogs, usually with the preceding; Bear Cañon; Eldora, 7000-11000 ft. (Daniels, 665).

NEW BRUNSWICK to BRITISH COLUMBIA; PENNSYLVANIA to COLORADO.

88. **A. fatua** L. WILD OAT.

Common along streets and waste places in the city of Boulder, 5300-5700 ft. (Daniels, 387).

EUROPE: ASIA, thence to NORTH AMERICA.

89. **A. sativa** L. COMMON OAT.

Adventitious along railroads, 5300-5400 ft. (Daniels, 479).

OLD WORLD, thence universal in cultivation.

53. MERATHREPTA Raf. WILD OAT-GRASS.

90. **M. Californica** (Bolander) Piper [*Danthonia Calfornica* Bolander]. CALIFORNIA WILD OAT-GRASS.

Arapahoe Pass, 12000 ft. (Rydberg).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

91. **M. intermedia** (Vasey) Piper [*Danthonia intermedia* Vasey]. INTERMEDIATE WILD OAT-GRASS.

Aspen bogs at Glacier Lake and Eldora, 8600-11500 ft. (Daniels, 621).

ALBERTA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

92. **M. spicata** (L) Raf. [*Danthonia spicata* (L) Beauv.]. COMMON WILD OAT-GRASS.

Common on dry slopes in the foothills, 6000-8000 ft. (Daniels, 370). Also mesas at foot of the Flat-irons.

NEWFOUNDLAND to BRITISH COLUMBIA; NORTH CAROLINA to LOUISIANA and CALIFORNIA.

54. SPARTINA Schreb. CORD-GRASS.

93. **S. cynosuroides** (L.) Willd. TALL MARSH GRASS. FRESH-WATER CORD-GRASS.

Swales and bogs in the plains, infrequent, 5100-5500 ft. (Daniels, 522).

NOVA SCOTIA to MACKENZIE; NEW JERSEY to TEXAS and COLORADO.

55. SCHEDONNARDUS Steud. CRAB-GRASS.

94. **S. paniculatus** (Nutt.) Trelease [*S. Texanus* Steud.]. WILD CRAB-GRASS.

Frequent on the plains and mesas, 5100-6000 ft. (Daniels, 175).

MANITOBA to ASSINIBOIA; ILLINOIS to TEXAS and NEW MEXICO.

56. BOUTELOUA Lag. GRAMA-GRASS. MESQUIT-GRASS.

95. **B. hirsuta** Lag. HAIRY MESQUIT.

Dry plains and mesas, less common than the next, 5100-6000 ft. (Daniels, 956). Also at Meadow Park, 6500 ft. (Rydberg).

ILLINOIS to SOUTH DAKOTA; TEXAS to ARIZONA.

96. **B. oligostachya** (Nutt.) Torr. COMMON GRAMA-GRASS, or MESQUIT-GRASS.

Common on the plains and mesas; occasional on the foothills, 5100-8000 ft. (Daniels, 220). One of the most characteristic grasses of the Great Plains.

WISCONSIN to ASSINIBOIA; MISSISSIPPI to ARIZONA and MEXICO.

57. ATHEROPOGON Muhl. TALL MESQUIT.

97. **A. curtipendulus** (Michx.) Fourn [*Bouteloua racemosa* Lag.]. PRAIRIE GRAMA-GRASS.

Frequent on the plains, mesas and foothills, 5100-7000 ft. (Daniels, 299). Meadow Park (Rydberg).

ONTARIO and MICHIGAN to MANITOBA; NEW JERSEY to TEXAS, ARIZONA, and MEXICO.

58. BULBILIS Raf. BUFFALO GRASS.

98. **B. dactyloides** (Nutt.) Raf. [*Buchloe dactyloides* (Nutt.) Eng.]. COMMON BUFFALO GRASS.

Abundant on the plains and mesas, 5100-6000 ft. (Daniels, 198).

MINNESOTA to NORTH DAKOTA; ARKANSAS to NEW MEXICO and MEXICO.

59. PHRAGMITES Trin. REED.

99. **P. Phragmites** (L.) Karst. [*P. communis* Trin.]. COMMON REED.

About a spring at foot of Flagstaff Hill, only three or four plants, 6000 ft. (Daniels, 834).

EUROPE: ASIA: temperate NORTH AMERICA.

60. MUNROA Torr. False buffalo grass.

100. **M. squarrosa** (Nutt.) Torr. Munro's grass.

Dry plains and mesas, 5100-6000 ft. (Daniels, 359). Also at Lafayette (Rydberg).

North Dakota to Assiniboia; Texas to Arizona.

61. KOELERIA Pers.

101. **Koeleria cristata** (L.) Pers. [*K. nitida* Nutt., as to some of the forms]. Prairie-grass.

Throughout below 10000 ft., but especially common on the foothills, 5100-10000 ft. (Daniels, 133).

Ontario to British Columbia; Pennsylvania to California.

62. ERAGROSTIS Beauv. Stink-grass.

102. **E. major** Host. Skunk grass.

Waste places and along railroads, 5100-6000 ft. (Daniels, 588). Also at Longmont (Rydberg).

Europe, thence to North America.

103. **E. pectinacea** (Michx.) Steud. Purple stink-grass.

Meadow Park, 6500 ft. (Rydberg).

Massachusetts to South Dakota: Florida to Texas and Colorado.

63. EATONIA Raf. Eaton grass.

104. **E. robusta** (Vasey) Rydb. [*E. obtusata robusta* Vasey]. Stout Eaton grass.

Along streams and springy cañons, 5100-7000 ft. (Daniels, 416).

Nebraska to Washington; New Mexico to Arizona.

105. **E. obtusata** (Michx.) Gray. Blunt-scaled Eaton grass.

About Boulder, 5100-6000 ft. (Rydberg).

Massachusetts to Montana; Florida to Arizona.

106. **E. Pennsylvanica** (DC.) Gray. Pennsylvania Eaton grass.

Deep mountain cañons, 5600-7000 ft. (Daniels, 718).

NEW BRUNSWICK to BRITISH COLUMBIA; GEORGIA to COLORADO.

64. MELICA L. MELIC-GRASS.

107. **M. bella** Piper [*M. bulbosa* Geyer]. BULBOUS MELIC-GRASS.

North slopes of Flagstaff Hill along Boulder Cañon, 6000-7000 ft. (Daniels, 144). Spikelets often monstrous.

MONTANA to WASHINGTON; COLORADO and UTAH to OREGON.

65. DACTYLIS L. ORCHARD GRASS.

108. **D. glomerata** L. COMMON ORCHARD GRASS.

Throughout the whole cultivated district and penetrating into shady cañons; 5100-9000 ft. (Daniels, 235).

EUROPE, thence to NORTH AMERICA.

66. DISTICHLIS Raf. SALT-GRASS.

109. **D. stricta** (Torr.) Rydb. [*D. maritima stricta* (Torr.) Thurber]. MARSH SPIKE-GRASS.

Alkali flats about Boulder lake, 5300 ft. (Daniels, 728).

SASKATCHEWAN to WASHINGTON; MISSOURI to TEXAS and CALIFORNIA.

67. POA L. MEADOW-GRASS.

110. **P. annua** L. LOW SPEAR-GRASS.

Roadsides and at the entrance to Gregory Cañon, 5100-6000 ft. (Daniels, 250).

EUROPE and ASIA, thence to NORTH AMERICA.

111. **P. pratensis** L. KENTUCKY BLUE-GRASS.

Meadows throughout, 5100-11500 ft. (Daniels, 558). Probably naturalized in the irrigated district.

EUROPE: ASIA: NORTH AMERICA, but only the boreal and alpine forms native.

112. **P. trivialis** L. ROUGH MEADOW-GRASS.

About ponds and ditches, 5400-5500 ft. (Daniels, 245). Not in Rydberg's Flora.

EUROPE, thence naturalized in many places in the UNITED STATES.

112½. **P. cenisia** All. [*P. flexuosa* Wahl.]. FLEXUOUS MEADOW-GRASS.

Long's Peak (Holm).

GREENLAND to ALASKA; COLORADO.

113. **P. callichroa** Rydb. FAIR-HUED MEADOW-GRASS.

Mountain-sides at Eldora, 8600-11500 ft. (Daniels, 647).

COLORADO.

114. **P. reflexa** V. & S. REFLEXED MEADOW-GRASS.

In mountain meadows descending to the slopes of the foothills, 6400 (Flagstaff Hill) -13000 ft. (Daniels, 952).

MONTANA to NEW MEXICO and OREGON.

115. **P. leptocoma** Trin. SMOOTH-GLUMED MEADOW-GRASS.

In mountain meadows with the preceding, 6300 (Flagstaff Hill) -12500 ft. (Daniels, 225).

MONTANA to ALASKA; COLORADO to CALIFORNIA.

116. **P. alpicola** Nash [*P. laxa* Thurber]. MOUNTAIN MEADOW-GRASS.

Above timberline, Arapahoe Peak, 11500-13000 ft. (Daniels, 941). Also on Long's Peak (Rydberg).

COLORADO to UTAH; CALIFORNIA.

117. **P. platyphylla** Nash & Rydb. [*P. occidentalis* Vasey]. WESTERN MEADOW-GRASS.

Along mountain streams, 5600 (Boulder Cañon) -10500 ft. (Daniels, 150).

COLORADO to NEW MEXICO.

118. **P. compressa** L. ENGLISH BLUE-GRASS.

Common throughout the irrigated district, but not noticed in the mountains, 5100-6000 ft. (Daniels, 242).

EUROPE, thence to NORTH AMERICA.

119. **P. triflora** Gilib. [*P. serotina* Ehr.]. FOWL MEADOW-GRASS.

Common in swales and wet meadows, 5100-8600 (Eldora) ft. (Daniels, 482).

NEWFOUNDLAND to BRITISH COLUMBIA; NEW JERSEY to CALIFORNIA: EUROPE.

120. **P. interior** Rydb. INLAND MEADOW-GRASS.

Along streams and in wet meadows, 5100-10000 ft. (Daniels, 28).

MACKENZIE to WASHINGTON and NEW MEXICO.

121. **P. crocata.** Michx. [*P. caesia strictior* Gray]. WOOD MEADOW-GRASS.

High mesas, dry slopes of the foothills, and mountain ridges, 6000-13000 ft. (Daniels, 154). Mountains between Sunshine and Ward (Rydberg).

LABRADOR to ALASKA; MASSACHUSETTS to MINNESOTA and ARIZONA.

122. **P. rupicola** Nash [*P. rupestris* Vasey]. CRAG MEADOW-GRASS.

Dry tundras above timberline, Arapahoe Peak, 11500-13000 ft. (Daniels, 1010).

MONTANA to OREGON; COLORADO to UTAH.

123. **P. Pattersonii** Vasey. PATTERSON'S MEADOW-GRASS.

Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 895).

COLORADO to ARIZONA.

124. **P. alpina** L. ALPINE MEADOW-GRASS.

Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 935). Long's Peak (Holm).

GREENLAND to ALASKA; QUEBEC to UTAH.

124½. **P. Wheeleri** Vasey. [*P. cuspidata* Vasey]. WHEELER'S MEADOW-GRASS.

Redrock lake, 10100 ft. (Ramaley and Robbins).

MONTANA to IDAHO; COLORADO to OREGON.

125. **P. Vaseyana** Scribn. VASEY'S MEADOW-GRASS.

Subalpine meadows at Eldora, 8600-10000 ft. (Daniels, 868).

COLORADO.

126. **P. longiligula** Scribn. & Will. LONG-LIGULATE MEADOW-GRASS.

Boulder (E. Bethel), determined by P. L. Ricker of U. S. Dept. of Agric., and recorded (as host of a fungus) by Arthur in Journal of Mycology, Jan. 1908, p. 13.

SOUTH DAKOTA to OREGON; NEW MEXICO to CALIFORNIA.

127. **P. pseudopratensis** Scribn. & Rydb. FALSE KENTUCKY BLUE-GRASS.

About swales and streams in tne plains and mesas, 5100-6000 ft. (Daniels, 953).

SOUTH DAKOTA to NEBRASKA and COLORADO.

128. **P. longipedunculata** Scribn. LONG-PEDUNCULATE MEADOW-GRASS.

Plains and mountain-cañons, 5100-12500 ft. (Daniels, 503).

WYOMING to NEW MEXICO.

129. **P. juncifolia** Scribn. RUSH-LEAVED MEADOW-GRASS.

Common on the plains and mesas, 5100-6000 ft. (Daniels, 905).

WYOMING to COLORADO and UTAH.

130. **P. confusa** Rydb. BUNCH MEADOW-GRASS.

Dry plains, mesas, and mountainsides, 5100-10000 ft. (Daniels, 924).

NEBRASKA to MONTANA and COLORADO.

131. **P. pratericola** Rydb. & Nash [*P. andina* Nutt.]. PRAIRIE MEADOW-GRASS.

Near Long's Peak (Porter & Coulter).

NEBRASKA to WYOMING and COLORADO.

68. PANICULARIA Fabr. MANNA-GRASS.

132. **P. nervata** (Willd.) Kuntze [*Glyceria nervata* (Willd.) Trin.]. NERVED MANNA-GRASS.

About streams and ditches, in swales and at the margins of lakes and ponds, 5100-9000 ft. (Daniels, 264).

LABRADOR to BRITISH COLUMBIA; FLORIDA to MEXICO and CALIFORNIA.

133. **P. Americana** (Torr.) Mac M. [*Glyceria grandis* Wats.]. REED MEADOW-GRASS.

In swales and along streams, less common than the preceding, 5100-8600 ft. (Daniels, 969).

NEW BRUNSWICK to ALASKA; TENNESSEE to NEVADA.

134. **P. Holmii** Beal. HOLM'S MANNA-GRASS.

Deep cañons on north slope of Green Mountain, 7000-8100 ft. (Daniels, 464). Lamb's Ranch, Long's Peak, 9100 ft. (Beal).

COLORADO.

135. **P. borealis** Nash. NORTHERN FLOATING MANNA.

In irrigation ditches about Boulder; also floating in Glacier lake, 5100-9000 ft. (Daniels, 739).

MAINE to ALASKA; NEW YORK to CALIFORNIA.

69. PUCCINELLIA Parl. SALT MEADOW-GRASS.

136. **P. airoides** (Nutt.) Wats. & Coult. SLENDER SALT MEADOW-GRASS.

Along water-courses in the mesas, and in alkaline soil on the plains, 5100-6000 ft. (Daniels, 383). Also at Longmont (Rydberg).

MANITOBA to MACKENZIE and BRITISH COLUMBIA; KANSAS to NEVADA.

70. FESTUCA L. FESCUE-GRASS.

137. **F. octoflora** Walt. [*F. tenella* Willd.]. SLENDER FESCUE-GRASS.

Abundant on the plains and arid open mountain slopes, 5100-9000 ft. (Daniels, 181).

QUEBEC to BRITISH COLUMBIA; FLORIDA to CALIFORNIA.

138. **F. elatior** L. [*F. elatior pratensis* (Huds.) Gray]. MEADOW FESCUE.

Common throughout the irrigated area, especially along ditches, 5100-6000 ft. (Daniels, 785).

EUROPE, thence to temperate NORTH AMERICA.

139. **F. rubra** L. RED FESCUE.

Subalpine meadows at Glacier Lake, 9000 ft. (Daniels, 699).

LABRADOR to ALASKA; NORTH CAROLINA to CALIFORNIA: EUROPE: ASIA.

140. **F. brachyphylla** Schultes [*F. ovina brevifolia* S. Watson]. SHORT-LEAVED FESCUE.

Bald ridges in the mountain region, 7000 (Green Mt.) -14500 ft. (Daniels, 364).

GREENLAND to ALASKA; VERMONT to CALIFORNIA.

141. **F. minutiflora** Rydb. SMALL-FLOWERED FESCUE.

Mountainsides at Eldora, and on Arapahoe Peak above timberline, 8600-12000 ft. (Daniels, 1001).

COLORADO to CALIFORNIA.

141½. **F. ovina** L. SHEEP FESCUE.

Redrock lake, 10100 ft. (Ramaley and Robbins). Long's Peak (Holm).

NORTH AMERICA: EUROPE.

141½a. **F. ovina supina** (Schur). Hack. PROSTRATE FESCUE.

Long's Peak (Holm).

GREENLAND and BRITISH COLUMBIA to NEW HAMPSHIRE, ARIZONA, and CALIFORNIA.

142. **F. ingrata nudata** (Vasey) Rydb. [*F. ovina nudata* Vasey]. NAKED-STEMMED FESCUE. BLUE BUNCH-GRASS.

Common throughout the mountain region and the mesas, 5700-12000 ft. (Daniels, 174). The type doubtless occurs, but all the material preserved belongs to the variety.

MONTANA to BRITISH COLUMBIA; COLORADO to UTAH.

143. **F. Kingii** (S. Watson) Scribn. [*F. confinis* Vasey]. KING'S FESCUE.

Boulder Cañon, 6500-10000 ft. (Rydberg); Boulder (E. Bethel).

MONTANA to COLORADO and CALIFORNIA.

71. BROMUS L. BROME-GRASS.

144. **B. marginatus latior** Shear. LARGE MARGINATE BROME.

Vicinity of Boulder, 5100-6000 ft. (Rydberg).

ALBERTA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

145. **B. brizaeformis** F. & M. QUAKE-GRASS BROME.

The commonest ruderal grass about Boulder, and fast spreading throughout the plains district, 5100-6000 ft. (Daniels, 257).

EUROPE and ASIA, thence to the UNITED STATES.

146. **B. secalinus** L. COMMON CHESS, or CHEAT.

In fields and waste places, 5100-6000 ft. (Daniels, 388).

EUROPE and ASIA, thence to all temperate lands.

147. **B. hordeaceus** L. [*B. mollis* L.]. SOFT CHESS.

Along the railroad between Boulder and Marshall, 5400 ft. (Daniels, 524).

EUROPE, thence to the UNITED STATES.

148. **B. lanatipes** (Shear) Rydb. [*B. Porteri lanatipes* Shear]. LANATE BROME.

Common on the mesas, foothills, and mountain slopes, less frequent in the plains, 5100-9000 ft. (Daniels, 346). Also at Lafayette (Rydberg).

COLORADO.

149. **B. Richardsonii** Link. RICHARDSON'S BROME.

Common on the mesas, foothills, and mountains, 6000-11000 ft. (Daniels, 454).

SASKATCHEWAN to BRITISH COLUMBIA; COLORADO to ARIZONA and OREGON.

150. **B. Pumpellianus** Scribn. PUMPELLY'S BROME.

Frequent throughout, 5100-10000 ft. (Daniels, 382).

SASKATCHEWAN to ALASKA and NEW MEXICO.

151. **B. tectorum** L. THATCH CHEAT.

Waste places about Boulder, 5100-6000 ft. (Daniels, 496). Also at Longmont (Rydberg).

EUROPE, thence to the UNITED STATES.

72. LOLIUM L. DARNEL.

152. **L. Italicum** A. Br. ITALIAN RYE GRASS.

About irrigation ditches in the city of Boulder, 5300-5600 ft. (Daniels, 839). Not in Rydberg's Flora.

EUROPE, thence to the UNITED STATES.

73. **AGROPYRON** Gaertn. WHEAT GRASS.

153. **A. Scribneri** Vasey. SCRIBNER'S WHEAT GRASS.
Long's Peak (Holm).
MONTANA to COLORADO and ARIZONA.

153½. **A. spicatum inerme** (Scribn. & Sm.) Heller [*A. Vaseyi* S. & S.]. VASEY'S WHEAT GRASS.
Frequent on the mesas and foothills, 5700-7000 ft. (Daniels, 171).
MONTANA to OREGON; COLORADO to UTAH.

154. **A. Arizonicum** S. & S. ARIZONA WHEAT GRASS.
Mountains between Sunshine and Ward, 8000-11000 ft. (Rydberg).
COLORADO to ARIZONA and MEXICO.

155. **A. Richardsonii** (Trin.) Schrad. [*A. unilaterale* Cassidy]. RICHARDSON'S WHEAT GRASS.
Mountain meadows, rather local, 7000 (Bear Cañon)-10000 ft. (Daniels, 830).
MINNESOTA to BRITISH COLUMBIA; IOWA to COLORADO.

156. **A. andinum** (S. & S.) Rydb. [*A. violaceum andinum* S. & S.]. MOUNTAIN WHEAT GRASS.
Mountainsides at Eldora 8600-9000 ft. (Daniels, 640).
MONTANA to COLORADO.

157. **A. violaceum** (Hornem.) Vasey. VIOLET WHEAT GRASS.
Common on the foothills and mountains, 6300 (Green Mt.)—12000 ft. (Daniels, 362).
GREENLAND to ALASKA; NEW HAMPSHIRE to UTAH.

158. **A. tenerum** Vasey. SLENDER WHEAT GRASS.
Common on the plains, foothills, and lower mountain slopes, 5100-7500 ft. (Daniels, 395).
LABRADOR to ALASKA; NEW HAMPSHIRE to COLORADO.

159. **A. pseudorepens** S. & S. FALSE QUACK GRASS.
Common on the plains and in mountain meadows, 5100-10000 ft. (Daniels, 511).
IOWA to ALBERTA; NEW MEXICO to UTAH.

160. **A. riparium** S. & S. RIPARIAN WHEAT GRASS.

About ditches in the plains, 5400-5700 ft. (Daniels, 398).

MONTANA to COLORADO.

161. **A. occidentale** Scribn. WESTERN WHEAT GRASS.

On the plains, where it is very abundant; also sparingly in mountain meadows, 5100-9500 ft. (Daniels, 402). Also at Longmont (Rydberg).

MANITOBA to SASKATCHEWAN and OREGON; MISSOURI to ARIZONA.

162. **A. molle** (S. & S.) Rydb. SOFT WHEAT GRASS.

On the plains, where it is especially characteristic of alkaline flats, and in the drier mountain valleys, 5100-9000 ft. (Daniels, 978).

SASKATCHEWAN to WASHINGTON and NEW MEXICO.

74. TRITICUM L. WHEAT.

163. **T. sativum vulgare** (Vill.) Hack. [*T. vulgare* Vill.]. WHEAT.

Adventitious along the railroad between Boulder and Marshall, 5400 ft. (Daniels, 514).

OLD WORLD, thence to the NEW.

75. HORDEUM L. BARLEY.

164. **H. jubatum** L. SQUIRREL-TAIL GRASS.

Common on the plains and in mountain cañons; a frequent weed in waste places, 5100-11000 ft. (Daniels, 380).

ONTARIO to ALASKA; MISSOURI to CALIFORNIA, thence naturalized eastward.

165. **H. pusillum** Nutt. LITTLE BARLEY.

Abundant on the plains and mesas, and following the roads into the mountain district, 5100-7000 ft. (Daniels, 203).

ONTARIO to BRITISH COLUMBIA; FLORIDA to CALIFORNIA.

166. **H. sativum hexastichon** (L.) Hack. SIX-ROWED BARLEY.

Adventitious along the railroad between Boulder and Mrshall, 5400 ft. (Daniels, 480).

OLD WORLD, thence to the NEW.

76. **SITANION** Raf. Bristle grass.

167. **S. longifolium** J. G. Smith. Long-leaved bristle grass.

Common on the foothills and mountain slopes, 6000-9000 ft. (Daniels, 363).

Nebraska to Nevada; Texas to Arizona.

168. **S. brevifolium** J. G. Smith. Short-leaved bristle grass.

Abundant on the plains, and frequent on open mountain slopes, 5100-10000 ft. (Daniels, 202). Also on the mountains between Sunshine and Ward (Rydberg).

Wyoming to Utah; Colorado to Arizona.

77. **ELYMUS** L. Lyme grass.

169. **E. Canadensis** L. Canadian wild rye.

Common along ditches and streams both in and out of shade, 5100-7000 ft. (Daniels, 357).

Nova Scotia to Washington; Georgia to New Mexico.

170. **E. robustus** S. & S. Stout wild rye.

In swales along railroads and on stream-banks, 5100-6000 ft. (Daniels, 489).

South Dakota to Idaho; Missouri to Colorado.

171. **E. brachystachys** Scribn. & Ball. Slender wild rye.

Plains south of Boulder, 5400-5700 ft. (Daniels, 396).

Michigan to South Dakota; Texas to Utah and Mexico.

172. **E. Macounii** Vasey. Macoun's wild rye.

On the plains and in meadows on the foot-hills, 5100-7000 ft. (Daniels, 417).

Manitoba and Saskatchewan to Alberta; New Mexico to Utah.

173. **E. condensatus** Presl. Smooth lyme grass.

Dry meadows throughout, 5100-10000 ft. (Daniels, 961).

Alberta to British Columbia; New Mexico to California.

174. **E. ambiguus** Vasey & Scribn. AMBIGUOUS LYME GRASS.

Common on the foothills and mountainsides, 5900-9000 ft. (Daniels, 158).

COLORADO.

175. **E. strigosus** Rydb. STRIGOSE LYME GRASS.

Common on the foothills and mountain ridges, 6000-8600 ft. (Daniels, 962). Boulder is the type locality.

WYOMING to COLORADO.

176. **E. villiflorus** Rydb. VILLOUS LYME GRASS.

Common on the foothills; occasional on the plains and mesas, 5100-8000 ft. (Daniels, 963). Boulder is the type locality.

SOUTH DAKOTA and the CANADIAN ROCKIES to COLORADO.

Family 13. CYPERACEAE J. St. Hil. Galingale family.

78. CYPERUS L. GALINGALE.

177. **C. inflexus** Muhl. [*C. aristatus* Boeckl.]. AWNED CYPER GRASS.

Scarce on the plains and foothills in moist sands, 5100-6500 ft. (Daniels, 253).

VERMONT to BRITISH COLUMBIA; FLORIDA to CALIFORNIA and MEXICO.

178. **C. Bushii** Britt. BUSH'S CYPER GRASS.

In sandy soil at Meadow Park, 6500 ft. (Rydberg).

WISCONSIN to OREGON; KANSAS to COLORADO.

79. SCIRPUS L. BULRUSH.

179. **S. Americanus** Pers. [*S. pungens* Vahl.]. THREE SQUARE.

In swales, along ditches and streams, and at the margins of ponds and lakes, but apparently not following the streams very far into the foothills, 5100-6500 ft. (Daniels, 668).

NORTH AMERICA: CHILI: EUROPE.

180. **S. lacustris** L. Great bulrush.

With the preceding but often in water of greater depth, and penetrating farther back into the mountains, 5100-8600 ft. (Daniels, 414).

Throughout the North Temperate Zone.

181. **S. atrovirens pallidus** Britton. Pale bulrush.

Swales, ditches and streams in the plains and mesas, and ascending but slightly into the foot-hills, 5100-6000 ft. (Daniels, 490).

Minnesota to the Northwest Territory and Colorado.

80. ELEOCHARIS R. Br. Spike rush.

182. **E. palustris** (L.) R. & S. Swamp spike rush.

Common in swamps, swales, and stagnant pools throughout, 5100-10000 ft. (Daniels, 492).

North America: Europe: Asia.

183. **E. glaucescens** (Willd.) Schultes [*E. palustris glaucescens* (Willd.) Gray]. Pale swamp spike rush.

Common with the above, but in shallower water, 5100-9000 (Glacier Lake, Eldora) ft. (Daniels, 733).

Ontario and the United States.

184. **E. acicularis** (L.) R. & S. Needle rush.

Common in limose places throughout, 5100-10000 ft. (Daniels, 254).

Europe: Asia: North America: Central America.

184½. **E. tenuis** (Willd.) Schult. Slender spike rush.

Redrock lake, 10100 ft. (Ramaley and Robbins).

Newfoundland to Manitoba; Florida to Colorado.

185. **E. acuminata** (Muhl.) Nees. Flat-stemmed spike rush.

Ditches and swales in the plains, 5100-5600 ft. (Daniels, 734).

Anticosti to Alberta; Georgia to Louisiana and Colorado.

31. **CAREX** L. SEDGE.

186. **C. canescens** L. SILVERY SEDGE.

Subalpine bogs at Eldora, 8500-11500 ft. (Daniels, 852). Redrock lake, 10100 ft. (Ramaley and Robbins).

NEWFOUNDLAND to BRITISH COLUMBIA; VIRGINIA to COLORADO and OREGON: EUROPE and ASIA.

187. **C. tenella** Schkuhr. SOFT-LEAVED SEDGE.

Local in deep mountain cañons in shade, 6000-11500 ft. (Daniels, 610).

NEWFOUNDLAND to BRITISH COLUMBIA; NEW JERSEY to CALIFORNIA: EUROPE.

188. **C. Deweyana** Schwein. DEWEY'S SEDGE.

Only detected in Bear Cañon, where it is very rare, 6000-7000 ft. (Daniels, 762).

NOVA SCOTIA to MANITOBA and OREGON; PENNSYLVANIA to NEW MEXICO and UTAH.

189. **Carex stipata** Muhl. AWL-FRUITED SEDGE.

Irrigation ditches, 5100-5600 ft. (Daniels, 237). Not in Rydberg's Flora.

NEWFOUNDLAND to BRITISH COLUMBIA; FLORIDA to CALIFORNIA.

190. **C. vulpinoidea** Michx. FOX SEDGE.

Irrigation ditches, 5100-5600 ft. (Daniels, 745).

NEW BRUNSWICK to MANITOBA; FLORIDA to TEXAS and COLORADO.

191. **C. occidentalis** Bailey [*C. muricata Americana* Bailey]. WESTERN SEDGE.

Low meadows at Eldora, 8600-11000 ft. (Daniels, 611).

COLORADO to NEW MEXICO and ARIZONA.

192. **C. Hoodii** Boott [*C. muricata confixa* Bailey]. HOOD'S SEDGE.

Grassy meadows, Bluebell cañon, thence to the subalpine zone, 5800-10000 ft. (Daniels, 497).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

193. **C. marcida** Boott. CLUSTERED FIELD SEDGE.

Abundant in dry meadows, 5100-8600 ft. (Daniels, 95).

MANITOBA to BRITISH COLUMBIA; KANSAS to NEW MEXICO and NEVADA.

194. **C. Sartwellii** Dewey. SARTWELL'S SEDGE.

Swales along railroads in the plains, 5100-6000 ft. (Daniels, 971).

ONTARIO to BRITISH COLUMBIA; NEW YORK to UTAH.

195. **C. Douglasii** Boott. DOUGLAS' SEDGE.

Common in dry soil throughout, 5100-11000 ft. (Daniels, 317). Also near Long's Peak (Rydberg; Coulter in Wabash College Herb.).

MANITOBA to BRITISH COLUMBIA; NEBRASKA to NEW MEXICO and CALIFORNIA.

196. **C. scoparia** Schkuhr. BROOM SEDGE.

Wet meadows about ditches and streams, 5100-7000 ft. (Daniels, 266).

NOVA SCOTIA to MANITOBA; FLORIDA to COLORADO.

197. **C. athrostachya** Olney. BRACTED SEDGE.

Shores of a pond south of Boulder, thence to timberline, 5500-11000 ft. (Daniels, 258).

ASSINIBOIA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

198. **C. festiva** Dewey. PRETTY SEDGE.

Abundant throughout the foothills and mountains in cañons and humid meadows, 6000-13000 ft. (Daniels, 103).

ASSINIBOIA and BRITISH COLUMBIA to MEXICO.

199. **C. ebenea** Rydb. [*C. festiva Haydeniana* Bailey]. EBONY SEDGE.

In frozen ground, alpine valley near snow, above Bloomerville, 9000-10000 ft. (Daniels, 324). Also on Long's Peak (Rydberg).

ALBERTA to BRITISH COLUMBIA; COLORADO to UTAH.

200. **C. petasata** Dewey. WESTERN'S HARE'S-FOOT SEDGE.

Deep cañons, north slope of Green Mt., 7000 ft. (Daniels, 469).

ALBERTA to ALASKA; COLORADO to OREGON.

201. **C. pratensis** Drej. MEADOW SEDGE.

Gregory Cañon, 6000-6500 ft. (Daniels, 688). Also on Long's Peak (Rydberg).

ONTARIO to ALASKA; MICHIGAN to COLORADO.

202. **C. siccata** Dewey. DRY-SPIKED SEDGE.

Common in dry meadows throughout, 5100-10000 ft. (Daniels, 972). Also near Long's Peak (Rydberg).

ONTARIO to BRITISH COLUMBIA; NEW YORK to CALIFORNIA.

203. **C. straminea** Willd. STRAW SEDGE.

Common along watercourses and grassy meadows in the plains, mesas, and foothills, 5100-6500 ft. (Daniels, 372).

NEW BRUNSWICK to MANITOBA; NORTH CAROLINA to OKLAHOMA and COLORADO.

204. **C. straminiformis** Bailey. FALSE STRAW SEDGE.

Dry torrents, high mesas at the foot of the Flat-irons, 5700-6000 ft. (Daniels, 381).

COLORADO to WASHINGTON and CALIFORNIA.

205. **C. festucacea** Schkuhr. FESCUE SEDGE.

Meadows and swales, frequent in the plains and mesas, and in meadows on the lower foothills, 5100-6400 (Flagstaff Hill) ft. (Daniels, 185).

NEW BRUNSWICK to MINNESOTA; FLORIDA to COLORADO.

206. **C. stenophylla** Wahl. NARROW-LEAVED SEDGE.

Dry mesas between Marshall and South Boulder Peak, 5700-6000 ft. (Daniels, 438).

MANITOBA to BRITISH COLUMBIA; IOWA to COLORADO.

207. **C. incurva** Lightf. CURVED SEDGE.

Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 916).

GREENLAND to ALASKA; COLORADO to BRITISH COLUMBIA.

208. **C. alpina Stevenii** Holm. STEVEN'S ALPINE SEDGE.

Lamb's ranch, near Long's Peak, 9100 ft. (Rydberg).

COLORADO.

209. **C. atrata** L. BLACK SEDGE.
Long's Peak, 11500-13000 ft. (Rydberg).
LABRADOR to ALASKA; QUEBEC to COLORADO and CALIFORNIA.

210. **C. chalciolepis** Holm. BRONZE-SCALED SEDGE.
Long's Peak, 8500-13000 ft. (Rydberg).
COLORADO.

211. **C. bella** Bailey. BEAUTIFUL SEDGE.
Above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels, 940).
COLORADO to UTAH and ARIZONA.

212. **C. rhomboidea** Holm. RHOMBIC SEDGE.
In swamps near Long's Peak, 8500-9500 ft. (Rydberg).
COLORADO.

213. **C. Goodenovii** J. Gay [*C. vulgaris* Fries]. COMMON SEDGE.
Subalpine bogs, Eldora, 8600-10000 ft. (Daniels, 851).
NEWFOUNDLAND to ALASKA; PENNSYLVANIA to COLORADO: EUROPE.

214. **C. rigida** Good. [*C. vulgaris alpina* Booth]. STIFF SEDGE.
Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 907).
ALASKA to COLORADO.

215. **C. chimaphila** Holm. WINTER-LOVING SEDGE.
Above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels, 923). Also on Long's Peak (Rydberg).
COLORADO.

216. **C. acutina** Bailey. ACUTISH SEDGE.
Boulder Cañon (5400-7000 ft. (Daniels, 556). Also Lamb's ranch, near Long's Peak, 9100 ft. (Rydberg).
MACKENZIE to ALASKA; COLORADO to OREGON.

217. **C. stricta** Lam. ERECT SEDGE.
Swales along railroad between Boulder and Marshall, 5400 ft. (Daniels, 418). Not in Rydberg's Flora.

EASTERN UNITED STATES and CANADA to COLORADO and TEXAS.

217½. **C. variabilis** Bailey. VARIABLE SEDGE.
Redrock lake, 10100 ft. (Ramaley and Robbins).
MONTANA to COLORADO.

218. **C. aurea** Nutt. GOLDEN SEDGE.
About springs in deep cañons, 6700-11000 ft. (Daniels, 354).
NEWFOUNDLAND to BRITISH COLUMBIA; PENNSYLVANIA to UTAH and WASHINGTON.

219. **C. Geyeri** Boott. GEYER'S SEDGE.
At edge of snow in alpine valley above Bloomerville, 9000-10000 ft. (Daniels, 311).
MONTANA to BRITISH COLUMBIA; COLORADO to OREGON.

220. **C. nigricans** C. A. Mey. BLACKISH SEDGE.
Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 926). Also Thompson's Cañon, Long's Peak (Rydberg).
ALBERTA to ALASKA; COLORADO to CALIFORNIA: ASIA.

221. **C. Pyrenaica** Wahl. PYRENAIC SEDGE.
Above timberline, Arapahoe Peak, 11000-14000 ft. (Daniels, 925). Also on Long's Peak (Rydberg).
ALBERTA to ALASKA; COLORADO to OREGON: EUROPE.

222. **C. rupestris** All. CRAG SEDGE.
Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 930). Also on Long's Peak (Rydberg).
GREENLAND to ALASKA and COLORADO: EUROPE: ASIA.

223. **C. obtusata** Lilj. OBTUSISH SEDGE.
Above timberline on Arapahoe Peak, 11000-12000 ft. (Daniels, 931). Also on Long's Peak (Rydberg).
NEWFOUNDLAND to BRITISH COLUMBIA and COLORADO.

224. **C. oreocharis** Holm. MOUNTAIN-GRACE SEDGE.
Lamb's ranch, near Long's Peak, 9100 ft. (Rydberg).
COLORADO.

225. **C. Pennsylvanica vespertina** Bailey [*C. vespertina* (Bailey) Howell]. WESTERN PENNSYLVANIA SEDGE.

Common on the plains and foothills, 5100-8500 ft. (Daniels, 11).

COLORADO to OREGON and BRITISH COLUMBIA.

226. **C. umbellata brachyrhina** Piper [*C. umbellata brevirostris* Boott]. SHORT-BEAKED UMBELLATE SEDGE.

Dry rocky mesa fronting Flagstaff Hill, 5700-6000 ft. (Daniels, 125).

MAINE to BRITISH COLUMBIA; NEW MEXICO to CALIFORNIA.

227. **C. Beckii** Boott [*C. durifolia* Bailey]. BECK'S SEDGE.

Cañon at base of Flagstaff Hill, 5700-6000 ft. (Daniels, 463).

ONTARIO to MANITOBA; NEW YORK to COLORADO.

228. **C. capillaris** L. HAIR SEDGE.

Above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels, 915). Also Thompson's Cañon on Long's Peak (Rydberg).

GREENLAND to ALASKA; NEW HAMPSHIRE to UTAH: EUROPE: ASIA.

229. **C. utriculata** Boott. BOTTLE SEDGE.

Swales and limose banks of streams, local (Boulder creek half way to Falls; subalpine bogs at Eldora, etc.), 5100-10000 ft. (Daniels, 563).

LABRADOR to BRITISH COLUMBIA; DELAWARE to CALIFORNIA.

229½. **C. saxatilis** L. [*C. pulla* Gooden.]. ROCK SEDGE.

Redrock lake, 10100 ft. (Ramaley & Robbins).

GREENLAND and ALASKA to COLORADO.

230. **C. lanuginosa** Michx. WOOLLY SEDGE.

Subalpine bogs at Eldora, 8600 ft. (Daniels, 652).

NOVA SCOTIA to BRITISH COLUMBIA; NEW JERSEY to CALIFORNIA.

Order 10. ARALES.

Family 14. **ARACEAE** Neck. **Arum family.**

82. ACORUS L. CALAMUS.

231. **A. Calamus** L. SWEET FLAG.

Swales along railroad in the city of Boulder, 5300-5400 ft. (Daniels).

NOVA SCOTIA to MINNESOTA; FLORIDA to TEXAS and COLORADO: EUROPE: ASIA.

Family 15. **LEMNACEAE** Dumort. **Duckweed family.**

83. LEMNA L. DUCKWEED.

232. **L. gibba** L. GIBBOUS DUCKWEED.

Ponds near Boulder, 5100-6000 ft. (Rydberg).

NEBRASKA to CALIFORNIA; TEXAS to MEXICO: OLD WORLD and AUSTRALIA.

233. **L. minor** L. LESSER DUCKWEED.

Springy swales in the city of Boulder, 5400 ft. (Daniels 748).

Cosmopolitan.

Order 11. XYRIDALES.

Family 16. **COMMELINACEAE** Reichenb. **Dayflower family.**

84. TRADESCANTIA L. SPIDERWORT.

234. **T. Universitatis** Cockerell [*T. occidentalis* Rydb., not Britton]. UNIVERSITY SPIDERWORT.

Common on the plains, mesas, and foothills, and following the deeper cañons several miles into the mountain region, 5100-7000 ft. (Daniels, 44). The vicinity about Boulder is the type locality. Both *T. scopulorum* Rose and *T. occidentalis* Britton, according to Rydberg's Flora, occur about Boulder, but the former is a New Mexico plant, while the latter is from Wisconsin.

COLORADO.

Family 17. PONTEDERIACEAE Dumort. Pickerel-weed family.

85. HETERANTHERA Willd. MUD PLANTAIN.

235. **H. limosa** (Sw.) Willd. LIMOSE MUD PLANTAIN.
Between Longmont and Loveland, 5100-5500 ft. (Rydberg), in shallow water or mud.
VIRGINIA to NEBRASKA and COLORADO; FLORIDA to MEXICO, the WEST INDIES, and CENTRAL AMERICA.

Order 12. LILIALES.

Family 18. MELANTHACEAE R.Br. Bunch-flower family.

86. ANTICLEA Kunth. ZYGADENUS.

235½. **A. elegans** (Pursh) Rydb. [*Zygadenus elegans* Pursh]. SHOWY ZYGADENUS.
Redrock lake, 10100 ft. (Ramaley).
SASKATCHEWAN to ALASKA; COLORADO to NEVADA.

236. **A. Coloradensis** Rydb. COLORADO ZYGADENUS.
In cañons and subalpine meadows, locally abundant, 7000 (Bear Cañon) -12000 ft. (Daniels, 651).
COLORADO and NEW MEXICO to UTAH.

87. TOXICOSCORDION Rydb. POISON CAMASS.

237. **T. gramineum** Rydb. DEATH CAMASS.
Mesas and foothills; blossoming in June, 5800-7000 ft. (Daniels, 106).
SASKATCHEWAN to IDAHO and COLORADO.

238. **T. falcatum** Rydb. FALCATE POISON CAMASS.
Spruce forests along Bear Cañon, 6000-7500 ft. (Daniels 759).
COLORADO.

Family 19. JUNCACEAE Vent. Rush family.

88. JUNCUS L. RUSH.

239. **J. Balticus montanus** Engelm. MOUNTAIN BALTIC RUSH.
Along ditches and in swales and wet meadows, 5100-11000 ft. (Daniels, 379).
LABRADOR to WASHINGTON, COLORADO, and UTAH.

240. **J. Drummondii** Mey. DRUMMOND'S RUSH.
Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 922).
MONTANA to ALASKA; COLORADO to CALIFORNIA.

241. **J. interior** Wiegand. INLAND RUSH.
Common in swales and meadows on the plains, mesas, and foothills, and following the main streams some distance into the mountains, 5100-6500 ft. (Daniels, 152).
ILLINOIS to WYOMING; MISSOURI to COLORADO.

242. **J. Arizonicus** Wiegand. ARIZONA RUSH.
Dry beds of torrents, mesas at foot of the Flat-irons 5700-6000 ft. (Daniels, 964).
TEXAS to COLORADO and ARIZONA.

243. **J. confusus** Coville. CONFUSED RUSH.
Swales along the railroad between Boulder and Marshall, 5400 ft. (Daniels, 421).
MONTANA to WASHINGTON and COLORADO.

244. **J. Dudleyi** Wiegand. DUDLEY'S RUSH.
Swales, meadows, and mountain cañons, 5100-8600 ft. (Daniels, 965). Replaces *J. interior* Wiegand in the mountain region.
MAINE to WASHINGTON; NEW YORK to MEXICO.

245. **J. bufonius** L. TOAD RUSH.
Wet sandy soil throughout except at the higher elevations, 5100-9000 ft. (Daniels, 251).
Cosmopolitan.

246. **J. marginatus** Rostk. GRASS-LEAVED RUSH.
Irrigation ditches along the Arapahoe Road, 5300 ft. (Daniels, 740). Not in Rydberg's Flora.
MAINE to ONTARIO; FLORIDA to COLORADO.

247. **J. longistylis** Torr. LONG-STYLED RUSH.
Common in swales, about ditches and ponds, and in wet meadows throughout, 5100-10000 ft. (Daniels, 249).
ALBERTA to IDAHO; NEBRASKA to MEXICO and CALIFORNIA.

248. **J. triglumis** L. THREE-FLOWERED RUSH.
Above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels, 1007).
LABRADOR to ALASKA; NEW YORK to COLORADO.

249. **J. castaneus** Smith. CHESTNUT RUSH.
Above timberline, Arapahoe Peak, 11000-12500 ft. (Daniels, 639).
GREENLAND to ALASKA and COLORADO.

250. **J. nodosus** L. KNOTTED RUSH.
In swales and along ditches and streams, 5100-6500 ft. (Daniels, 735).
NOVA SCOTIA to MACKENZIE and BRITISH COLUMBIA: VIRGINIA to NEVADA.

251. **J. Torreyi** Coville. TORREY'S RUSH.
With the preceding, but more abundant, 5100-6500 ft. (Daniels, 495).
NEW YORK to MONTANA; TEXAS to ARIZONA.

251½. **J. Mertensianus** Bong. MERTENS' RUSH.
Redrock lake, 10100 ft. (Ramaley and Robbins).
MONTANA to ALASKA; COLORADO to CALIFORNIA.

252. **J. parous** Rydb. REDDISH BROWN RUSH.
Dry beds of torrents, mesas fronting the Flat-irons, 5700-6000 ft. (Daniels, 373).
COLORADO to NEW MEXICO.

253. **J. Saximontanus** A. Nelson [*J. xiphioides montanus* Engelm.]. ROCKY MOUNTAIN RUSH.
Aspen bogs at Glacier Lake and Eldora; also a dwarf form on Arapahoe Peak above timberline, 8500-12000 ft. (Daniels, 703).

89. **JUNCOIDES** Adans. WOOD RUSH.

254. **J. parviflorum melanocarpum** (Michx.) Cockerell. Nov. comb. [*Luzula melanocarpus* Michx.]. SMALL-FLOWERED WOOD RUSH.
Cañons on the north slope of Green Mt., 7000-8100 ft.

(Daniels, 332). A similar form was gathered above Bloomerville, 9000-10000 ft. Also at Caribou (Rydberg).

GREENLAND to ALASKA; COLORADO to CALIFORNIA: EUROPE: ASIA.

254a. **J. parviflorum subcongestum** (S. Wats.) Daniels. Nov. comb. [*Luzula spadicea subcongesta* S. Wats.]. DENSE-CYMED WOOD RUSH.

Alpine valley near edge of snow, Bloomerville, 8500-11500 ft. (Daniels, 328).

COLORADO to CALIFORNIA.

255. **J. spicatum** (L.) Kuntze [*Luzula spicata* (L.) Desv.]. SPIKED WOOD RUSH.

Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 896).

GREENLAND to BRITISH COLUMBIA; NEW HAMPSHIRE to CALIFORNIA.

Family 20. ALLIACEAE Batch. Onion family.

90. ALLIUM L. ONION.

256. **A. recurvatum** Rydb. [*A. cernuum obtusum* Cockerell]. RECURVED WILD ONION.

Common throughout the mesas, foothills and the mountain plateau, 5700-8600 ft. (Daniels, 452). Also in the mountains between Sunshine and Ward (Rydberg).

SOUTH DAKOTA to BRITISH COLUMBIA and NEW MEXICO.

257. **A. Nuttallii** S. Wats. NUTTALL'S WILD ONION.

Aspen bog at Glacier Lake, 9000 ft. (Daniels, 336). Also southwest of Ward (Rydberg).

SOUTH DAKOTA to WYOMING; KANSAS to COLORADO.

258. **A. Geyeri** S. Wats. [*A. dictyotum* Greene; *A. reticulatum deserticola* Jones]. GEYER'S WILD ONION.

Common throughout in both dry and moist soils, 5100-11500 ft. (Daniels, 54).

NORTH DAKOTA to WASHINGTON and NEW MEXICO.

259. **A. reticulatum** Fraser. FRASER'S WILD ONION.
Springy cañons in the foothills and the mountain plateau, 6000-8500 ft. (Daniels, 292).
SASKATCHEWAN to IDAHO; SOUTH DAKOTA to ARIZONA.

260. **A. Pikeanum** Rydb. PIKE'S PEAK WILD ONION.
Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 1002).
COLORADO.

Family 21. LILIACEAE Adans. Lily family.

91. LEUCOCRINUM Nutt. SAND LILY.

261. **L. montanum** Nutt. MOUNTAIN SAND LILY.
Along the railroad between Boulder and Marshall, 5400 ft. (Daniels). Very abundant at Boulder (Cockerell).
SOUTH DAKOTA to MONTANA and COLORADO.

92. LILIUM L. LILY.

262. **L. Philadelphicum montanum** (A. Nelson) Cockerell. Nov. comb. MOUNTAIN LILY.
Springy cañon on north slope of Green Mt., 6500-8000 ft. (Daniels, 355). Occasionally bearing two or more flowers.
MONTANA to COLORADO.

93. ERYTHRONIUM L. ADDER'S-TONGUE. DOG-TOOTH VIOLET.

263. **E. parviflorum** (S. Wats.) Goodding [*E. grandiflorum parviflorum* S. Wats.]. SMALL-FLOWERED ADDER'S TONGUE.
Above timberline, Arapahoe Peak, 11000-11500 ft. (Daniels, 888).
WYOMING to COLORADO and UTAH.

94. LLOYDIA Salisb.

264. **L. serotina** (L.) Sweet. LATE LLOYDIA.
Arapahoe Peak, 10000-14000 ft. (Rydberg).
MONTANA to ALASKA and COLORADO.

Family 22. CONVALLARIACEAE Link. Lily-of-the-valley family.

95. VAGNERA Adans. FALSE SOLOMON'S SEAL.

265. **V. racemosa** (L.) Morong [*Smilacina racemosa* (L.) Desf.]. WILD SPIKENARD.

Boulder Cañon, 6500-8500 ft. (Rydberg).

NOVA SCOTIA to WASHINGTON; GEORGIA to CALIFORNIA.

266. **V. amplexicaulis** (Nutt.) Greene [*Smilacina amplexicaulis* Nutt.] CLASPING-LEAVED FALSE SOLOMON'S SEAL.

Common in shady cañons throughout; at the edge of the wasting snows in a high alpine valley above Bloomerville July 7, 1906, 5700-10000 ft. (Daniels, 143).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

267. **V. stellata** (L.) Morong [*Smilacina stellata* (L.) Desf.] STARRY FALSE SOLOMON'S SEAL.

Common throughout; along ditches and streams in the plains, and in cañons and wooded valleys in the mesas and mountains, 5100-12000 ft. (Daniels, 111). St. Vrain creek (Coulter in Wabash College Herb.).

NEWFOUNDLAND to SASKATCHEWAN and MONTANA; VIRGINIA to COLORADO.

96. STREPTOPUS Michx. TWISTED STALK.

268. **S. amplexifolius** (L.) DC. CLASPING-LEAVED TWISTED STALK.

Local in deep cañons in the foothills and mountains, 6500-10000 ft. (Daniels, 456).

GREENLAND to ALASKA; NORTH CAROLINA to COLORADO and OREGON.

97. DISPORUM Salisb.

269. **D. majus** (Hook.) Britton [*D. trachycarpum* (S. Wats.) B. & H.; *Prosartes trachycarpa* S. Wats.]. ROUGH-FRUITED DISPORUM.

Local in company with the preceeding, 6500 (Green Mt.; Bear Cañon) -11000 ft. (Daniels, 455). Also at Eldora (Rydberg).

MANITOBA to BRITISH COLUMBIA; NEBRASKA to ARIZONA.

98. **ASPARAGUS** L.

270. **A. officinalis** L. COMMON ASPARAGUS.

A common escape throughout the cultivated district, 5100-6000 ft. (Daniels, 114).

EUROPE, thence to NORTH AMERICA.

Family 23. **DRACAENACEAE** Link. **Dragon-tree family.**

99. **YUCCA** L. SPANISH BAYONET.

271. **Y. glauca** Nutt. [*Y. angustifolia* Pursh]. NARROW-LEAVED SPANISH BAYONET.

Common in the plains, mesas, and foothills; just north of the entrance to Bear Cañon it forms the main facies of the vegetation, 5100-6500 (Green Mt.) ft. (Even higher I think on the first line of hills). (Daniels, 39).

NEBRASKA to MONTANA; MISSOURI to TEXAS and ARIZONA.

Family 24. **CALOCHORTACEAE** Rydb. **Mariposa lily family.**

100. **CALOCHORTUS** Pursh. MARIPOSA LILY.

272. **C. Gunnisonii** S. Wats. GUNNISON'S MARIPOSA LILY.

Common in the mesas and mountain meadows, 5600-10000 ft. (Daniels, 53). At Ward occurs the forma *immaculatus* Cockerell (Cockerell).

MONTANA to COLORADO and ARIZONA.

Family 25. **SMILACEAE** Vent. **Greenbrier family.**

101. **NEMEXIA** Raf. CARRION FLOWER.

273. **N. lasioneuron** (Hook.) Rydb. [*Smilax lasioneuron* Hook.; *N. herbacea melica* A. Nelson]. WESTERN CARRION FLOWER.

Cañons in the mesas and foothills; especially frequent in gulches on the east slope of Flagstaff Hill, 5700-7000 ft. (Daniels, 224). The type locality of *N. herbacea melica* A. Nelson.

SASKATCHEWAN to NEBRASKA and COLORADO.

Order 13. AMARYLLIDALES.

Family 26. IXIACEAE Ecklon. Ixia family.

102. SISYRINCHIUM L. Blue-eyed grass.

274. **S. alpestre** Bickn. Alpine blue-eyed grass.
Mountain meadows at Eldora, 8600 ft. (Daniels, 648).
Colorado.

275. **S. angustifolium** Miller. Narrow-leaved blue-eyed grass.
Common in meadows and about streams throughout except at the higher elevations, 5100-9000 ft. (Daniels, 72). Also at North Boulder Peak (Rydberg).
Newfoundland to Mackenzie and British Columbia; Virginia to Colorado.

103. IRIS L. Fleur-de-lis.

276. **I. Missouriensis** Nutt. Missouri blue flag.
In swales and wet meadows about Boulder, 5100-6000 ft. (Daniels). Common at 8000-9000 ft. at Eldora, Hesse, Miller's Ranch (Ramaley). Near Long's Peak (Coulter in Wabash College Herb.)
North Dakota to Idaho; Colorado to California.

Order 14. ORCHIDALES.

Family 27. ORCHIDACEAE Lindl. Orchis family.

104. LIMNORCHIS Rydb. Bog orchis.

277. **L. stricta** (Lindl.) Rydb. Narrow-spiked bog orchis.
Subalpine bogs and springy mountainsides at Eldora, 8600-10000 ft. (Daniels, 993).
Montana to Alaska; Colorado to Washington.

278. **L. viridiflora** (Cham.) Rydb. Green-flowered bog orchis.
Common in deep cañons and about springs throughout the mesas, foothills, and mountains, 5800-10000 ft. (Daniels, 69).
Alberta to Alaska and Colorado.

279. **L. borealis** (Cham.) Rydb. NORTHERN BOG ORCHIS.

Springs on mountainside at Eldora, 8600-10000 ft. (Daniels, 842).

MONTANA to ALASKA; COLORADO to WASHINGTON.

280. **L. laxiflora** Rydb. LOOSE-FLOWERED BOG ORCHIS.

Common in deep mountain cañons, 6500-10000 ft. (Daniels, 602).

OREGON to COLORADO and UTAH.

105. PIPERIA Rydb. PIPER'S ORCHIS.

281. **P. Unalaschensis** (Spreng.) Rydb. [*Habenaria Unalaschensis* S. Wats.] ALASKAN PIPER'S ORCHIS.

Under pines on north slope of Green Mt., very rare, 6000-8100 ft. (Daniels, 470). Also on South Boulder Peak, 8500 ft. (Rydberg).

MONTANA to ALASKA; COLORADO to CALIFORNIA.

106. IBIDIUM Salisb. LADIES' TRESSES.

282. **I. Romanzoffianum strictum** (Rydb.) Daniels. Nov. comb. [*Gyrostachys stricta* Rydb.] NARROW - SPIKED LADIES' TRESSES.

One plant in a deep cañon on the north slope of Green Mt.; common in springy bogs at Eldora, 7000-10000 ft. (Daniels, 769).

NEWFOUNDLAND to ALASKA; PENNSYLVANIA to COLORADO.

107. OPHRYS (Tourn.) L. TWAYBLADE.

283. **O. borealis** (Morong) Rydb. [*Listera borealis* Morong]. NORTHERN TWAYBLADE.

Deep cañons on north slope of Green Mt., very rare, 6500-8100 ft (Daniels, 607).

HUDSON BAY to MACKENZIE; COLORADO to MONTANA.

283½. **O. nephrophylla** Rydb. [*Listera nephrophylla* Rydb.] KIDNEY-LEAVED TWAYBLADE.

Redrock lake 10100 ft. (Ramaley and Robbins).

ALASKA to COLORADO and OREGON.

108. **PERAMIUM** Salisb. RATTLESNAKE PLANTAIN.

284. **P. ophioides** (Fernald) Rydb. SNAKE-MOUTH RATTLE-SNAKE PLANTAIN.

Densely wooded cañons on north slope of Green Mt., very rare, 7000-8100 ft. (Daniels, 827).

PRINCE EDWARD'S ISLAND to SOUTH DAKOTA; NORTH CAROLINA to COLORADO.

109. **ACROANTHES** Raf. ADDER'S MOUTH.

285. **A. monophylla** (L.) Greene [*Microstylis monophylla* (L.) Lindl.]. ONE-LEAVED ADDER'S MOUTH.

Deep cañons on north slope of Green Mt., very scarce, 6500-8100 ft. (Daniels, 342).

QUEBEC to MINNESOTA; PENNSYLVANIA to COLORADO.

110. **CYTHEREA** Salisb. CALYPSO.

286. **C. bulbosa** (L.) House. [*Calypso borealis* Salisb.]. NORTHERN CALYPSO.

Nederland, Boulder County, 8263 ft. (Miss Zora Phillips).

LABRADOR to ALASKA; MAINE to CALIFORNIA: EUROPE.

111. **CORALLORHIZA** R. Br. CORALROOT.

286½. **C. ochroleuca** Rydb. YELLOW CORALROOT.

Redrock lake, 10100 ft. (Ramaley and Robbins).

NEBRASKA to COLORADO.

287. **C. Corallorhiza** (L.) Karst. [*C. innata* R. Br.]. EARLY CORALROOT.

Cañon in mesa at foot of Flagstaff Hill, only two plants, 5700-5800 ft. (Daniels, 122). Also at Caribou, 10000 ft. (Rydberg).

NOVA SCOTIA to ALASKA; GEORGIA to COLORADO and WASHINGTON.

288. **C. multiflora** Nutt. LARGE CORALROOT.

A solitary cluster of plants under conifers at the Royal Arch at base of the Flat-irons, 6200 ft. (Daniels, 229). Also on North Boulder Peak (Rydberg).

NOVA SCOTIA to ALASKA; FLORIDA to CALIFORNIA.

Sub-class 2. **DICOTYLEDONES.**

Series 1. **CHORIPETALAE.**

Order 15. SALICALES.

Family 28. SALICACEAE Lindl. Willow family.

112. POPULUS L. POPLAR. ASPEN. COTTONWOOD.

289. **P. tremuloides aurea** (Tidestrom) Daniels, Nov. comb.* AMERICAN ASPEN.

Throughout the foothills and mountain region except at the higher elevations, 5800-10000 ft. (Daniels, 314).

NEWFOUNDLAND to HUDSON BAY and ALASKA; NEW JERSEY and TENNESSEE to MEXICO and LOWER CALIFORNIA.

290. **P. Sargentii** Dode. [*P. occidentalis* (Rydb.) Britton; *P. deltoides occidentalis* Rydb.]. WESTERN COTTONWOOD.

Common along streams, ascending Boulder creek as far as Eldora, 5100-8600 ft. (Daniels, 820). Also at Lyons (Rydberg).

SASKATCHEWAN to MONTANA; KANSAS to ARIZONA.

291. **P. acuminata** Rydb. BLACK COTTONWOOD.

A solitary tree near a stream about half way between Boulder and Marshall, 5400 ft. (Daniels, 819). Common in all gulches; there are large trees in Sunshine Cañon, 6500 ft. (Ramaley).

SOUTH DAKOTA to IDAHO; NEW MEXICO to NEVADA.

292. **P. angustifolia** James. NARROW-LEAVED COTTONWOOD.

Along streams and in cañons on the mesas and in the foothills and mountains, 5400-9000 ft. (Daniels, 52).

NORTH DAKOTA to WASHINGTON; NEW MEXICO to CALIFORNIA.

293. **P. balsamifera** L. BALSAM POPLAR.

Fourth of July mine; Eldora; Allenspark, 8000-10000 ft. (Ramaley).

LABRADOR to ALASKA; NEW ENGLAND to COLORADO.

*See Appendix A.

113. SALIX L. Willow.

294. **S. amygdaloides** Anders. Peach willow.

Common along streams; the only willow, except the next, of tree size about Boulder, 5100-7000 ft. (Daniels, 90).

Quebec to Washington; New York to Missouri and Arizona.

295. **S. caudata** (Nutt.) Piper [*S. Fendleriana* Anders. ; *S. pentandra caudata* Nutt.; *S. lasiandra Fendleriana* Bebb]. Fendler's willow.

Along streams in mountain cañons, 5500 (Boulder creek)-10000 ft. (Daniels, 807).

Alberta to British Columbia; New Mexico to California.

296. **S. exigua** Nutt. Narrowleaf willow.

Marshall; Valmont; Boulder; South Boulder Cañon; near junction of Fourmile and Boulder creeks, 5000-9000 ft. (Ramaley).

Mackenzie to Washington; Colorado to California.

297. **S. luteosericea** Rydb. Silky sandbar willow.

Sandy stream flats in the plains and mesas, 5100-7000 ft. (Daniels, 134).

Nebraska to Idaho and Colorado.

297½. **S. lutea** Nutt. Yellow willow.

Redrock lake, 10100 ft. (Ramaley and Robbins).

Canada to Colorado and California.

298. **S. Wolfii** Bebb. Wolf's willow.

Eldora to Baltimore, 8000-10000 ft. (Rydberg).

Wyoming to Colorado.

299. **S. irrorata** Anders. Bloom-branched willow.

Gregory Cañon (E. Bethel).

Colorado to New Mexico.

300. **S. perrostrata** Rydb. Long-beaked willow.

Common in mountain cañons, 5500-8600 ft. (Daniels, 811).

Hudson Bay to Alaska and Colorado.

301. **S. Bebbiana** Sarg. [*S. rostrata* Richardson]. BEBB'S WILLOW.

Cañons and mountain valleys, frequent, 5700-10000 ft. (Daniels, 824). St. Vrain Cañon (Coulter in Wabash College Herb.).

ANTICOSTI to ALASKA; NEW JERSEY to CALIFORNIA.

302. **S. Scouleriana** Barratt [*S. Nuttallii* Sarg.; *S. flavescens* Nutt.]. NUTTALL'S WILLOW.

High alpine valley next to snow, above Bloomerville, Boulder Cañon, 5700-10000 ft. (Daniels, 321). Also from Eldora to Baltimore (Rydberg).

ASSINIBOIA to BRITISH COLUMBIA; NEW MEXICO to CALIFORNIA.

303. **S. brachycarpa** Nutt. DWARF WILLOW.

Silver lake, 7000-11000 ft. (Ramaley).

QUEBEC to ALBERTA and COLORADO.

304. **S. pseudolapponicum** Seem. FALSE LAPLAND WILLOW.

Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 883). Also between Eldora and Baltimore (Rydberg).

COLORADO.

305. **S. glaucops** Anderson. GLAUCOUS WILLOW.

Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 937). Also mountains south of Ward, and between Sunshine and Ward, (Rydberg).

ALBERTA to YUKON; COLORADO to CALIFORNIA.

306. **S. chlorophylla** Anders. GREEN-LEAF WILLOW.

Near Fourth of July mine, (Ramaley).

LABRADOR and NEW HAMPSHIRE to ALASKA and COLORADO.

307. **S. petrophila** Rydb. [*S. arctica petraea* Anderson]. ROCK-LOVING WILLOW.

Above timberline, Arapahoe Peak, 11000-14000 ft. (Daniels, 951).

NEW HAMPSHIRE to BRITISH COLUMBIA; COLORADO to UTAH.

308. **S. Saximontana** Rydb. ROCKY MOUNTAIN WILLOW.

Above timberline, Arapahoe Peak, 11000-14000 ft. (Daniels, 901).

WYOMING and COLORADO to WASHINGTON and CALIFORNIA.

Order 16. FAGALES.

Family 29. BETULACEAE Agardh. Birch family.

114. BETULA L. BIRCH.

309. **B. papyrifera Andrewsii** (A. Nels.) Daniels [*B. Andrewsii* A. Nels.] ANDREWS'S CANOE BIRCH.

A few patches in valleys on the north slope of Green Mountain (Daniels, 1018). The type locality.

COLORADO, as above.

310. **B. fontinalis** Sarg. [*B. occidentalis* S. Wats.]. FOUNTAIN BIRCH. WESTERN RED BIRCH.

Everywhere along streams except at high altitudes, where the next takes its place, 5100-9000 ft. (Daniels, 149). Also Eldora to Baltimore (Rydberg). Near Long's Peak (Coulter in Wabash College Herb.).

ALBERTA to YUKON; SOUTH DAKOTA to NEW MEXICO and OREGON.

311. **B. glandulosa** Michx. GLANDULAR BIRCH. SCRUB BIRCH.

In bogs, Eldora to Baltimore, 9000-11000 ft. (Rydberg): Ward (Cockerell).

GREENLAND to ALASKA; MAINE to COLORADO and OREGON: ASIA.

115. ALNUS Gaertn. ALDER.

312. **A. tenuifolia** Nutt. [*A. incana virescens* S. Wats.]. THIN-LEAVED ALDER.

Along streams throughout, 5400 (Boulder creek) -10000 ft. (Daniels, 571). Also mountains between Sunshine and Ward (Rydberg).

MONTANA to ALASKA; NEW MEXICO to CALIFORNIA.

Family 30. **CORYLACEAE** Mirbel. **Hazel family.**

116. CORYLUS L. HAZEL.

313. **C. rostrata** Ait. BEAKED HAZEL NUT.
Abundant in cañons in the mesas, foothills, and the mountain plateau, 5600-8000 ft. (Daniels, 116).
NOVA SCOTIA to NORTH DAKOTA; GEORGIA to COLORADO.

Order 17. URTICALES.

Family 31. **URTICACEAE** Reichenb. **Nettle family.**

117. URTICA L. NETTLE.

314. **U. gracilis** Ait. SLENDER NETTLE.
Common in stream-flats both in and out of shade, 5100-9000 ft. (Daniels, 583). Also mountains between Sunshine and Ward (Rydberg).
NOVA SCOTIA to ALASKA; NORTH CAROLINA to NEW MEXICO

118. PARIETARIA L. PELLITORY.

315. **P. Pennsylvanica** Muhl. PENNSYLVANIA PELLITORY.
Moist places under rocks and in cañons and on shady banks of streams, 5100-7000 ft. (Daniels, 498).
ONTARIO to BRITISH COLUMBIA; FLORIDA to MEXICO.

316. **P. obtusa** Rydb. OBTUSE-LEAVED PELLITORY.
Sunset Cañon, 6000 ft. (Rydberg).
COLORADO to UTAH; TEXAS to CALIFORNIA.

Family 32. **CANNABINACEAE** Lindl. **Hemp family.**

119. HUMULUS L. HOP.

317. **H. Lupulus Neo-Mexicanus** A. Nels. & Cockerell. NEW MEXICO HOP.
Rocky banks of cañons and along streams and in waste places as along fences, 5100-8000 ft. (Daniels, 573).
WYOMING to UTAH; NEW MEXICO to ARIZONA.

Family 33. **ULMACEAE** Mirbel. **Elm family.**

120. ULMUS L. ELM.

318. **U. Americana** L. AMERICAN ELM.

A tree of considerable size occurs in a wild place near the entrance to Boulder Cañon, doubtless self-sown from trees planted for shade, 5500 ft. (Daniels).

NEWFOUNDLAND to MANITOBA; FLORIDA to TEXAS.

121. CELTIS L. HACKBERRY.

319. **C. reticulata** Torr. VEINY-LEAVED HACKBERRY.

Rocky ridges on the mesas and foothills, scarce, 5700-6500 ft. (Daniels, 796).

TEXAS to COLORADO and ARIZONA.

Order 18. SANTALALES.

Family 34. **LORANTHACEAE** D. Don. **Mistletoe family.**

122. RAZOUMOFSKYA Hoffm. SMALL MISTLETOE.

320. **R. Americana** (Nutt.) Kuntze [*Arceuthobium Americanum* Nutt.]. AMERICAN SMALL MISTLETOE.

On *Pinus contorta Murrayana* (Oreg. Com.) Engelm. at Sunset, 7700 ft. (Rydberg).

BRITISH COLUMBIA to COLORADO and OREGON.

321. **R. cryptopoda** (Engelm.) Coville [*Arceuthobium cryptopodum* Engelm; *A. robustum* Engelm]. HIDDEN-FOOTED SMALL MISTLETOE.

On *Pinus scopulorum* (Engelm.) Lemmon upon high ridge well toward eastern summit of Green Mt., 7500-8000 ft. (Daniels, 770). Also between Sunshine and Ward (Rydberg).

TEXAS and COLORADO to ARIZONA and MEXICO.

Family 35. **SANTALACEAE** R. Br. **Sandalwood family.**

123. COMANDRA Nutt. BASTARD TOAD-FLAX.

322. **C. pallida** A. DC. PALE BASTARD TOAD-FLAX.

Frequent on the plains, mesas, and foothills, 5100-8000 ft. (Daniels, 49). St. Vrain Cañon (Coulter in Wabash College Herb.).

MANITOBA to BRITISH COLUMBIA; TEXAS to CALIFORNIA.

Order 19. POLYGONALES.

Family 36. **POLYGONACEAE** Lindl. **Knotweed family.**

124. **ERIOGONUM** Michx. Wool-joint.

323. **E. alatum** Torr. Winged wool-joint.

Common on the plains, mesas, foothills, and open mountainsides, 5100-10000 ft. (Daniels, 170).

Nebraska to Wyoming; Texas to Arizona.

324. **E. vegetius** (T. & G.) A. Nels. [*E. flavum vegetius* T. & G.; *E. Jamesii flavescens* S. Wats.; *E. Bakeri* Greene]. Baker's wool-joint.

Mountains between Sunshine and Ward, and at Meadow Park, 9000-10000 ft. (Rydberg).

Wyoming to Utah; New Mexico to Arizona.

325. **E. flavum** Nutt. [*E. crassifolium* Dougl.]. Yellow wool-joint.

Common in open places throughout, 5100-12000 ft. (Daniels, 368).

Saskatchewan to Alberta; Nebraska to Colorado.

326. **E. umbellatum** Torr. Umbellate wool-joint.

Very abundant in open places throughout, 5100-12000 ft. (Daniels, 55).

Wyoming to Idaho; Colorado to Utah.

327. **E. subalpinum** Greene. Subalpine wool-joint.

Along the Arapahoe Trail from Eldora to Arapahoe Peak and ascending to the timberline, but not above it, 8600-11000 ft. (Daniels, 950).

Alberta to British Columbia; Colorado to Nevada.

328. **E. effusum** Nutt. Effuse wool-joint.

Plains and mesas between Marshall and South Boulder Peaks, and along the railroad between Boulder and Marshall, 5400-6000 ft. (Daniels, 439).

Nebraska to Montana and Colorado.

125. RUMEX L. Dock.

329. **R. Acetosella** L. Sheep sorrel.

Along railroads and roadsides, and in fields and waste places, in 1906 still somewhat scarce, 5100-6000 ft. (Daniels, 589). Very common now (1910), along railways up to 9000 ft. and higher (Ramaley).

Europe: Asia, thence to North America.

330. **R. occidentalis** S. Wats. Western dock.

In Bear Cañon, 6000-7000 ft. (Daniels, 710).

Labrador to Alaska; Texas to California.

331. **R. densiflorus** Osterh. [*R. Bakeri* Greene]. Dense-flowered dock.

Subalpine bogs at Eldora, 8600-10000 ft. (Daniels, 908).

Wyoming to Colorado.

332. **R. crispus** L. Curly dock.

Fields and waste places and becoming common in ditches and swales, 5100-5700 ft. (Daniels, 491).

Europe and Asia, thence to North America.

333. **R. salicifolius** Weinm. Willow-leaved dock.

Common in ditches, shallow streams, and in swales and low meadows, 5100-10000 ft. (Daniels, 234).

Labrador to Alaska; Texas to Lower California: Europe.

334. **R. obtusifolius** L. Bitter dock.

Waste places and fields, 5100-6000 ft. (Daniels).

Europe and Asia, thence to North America.

126. OXYRIA Hill.

335. **O. digyna** (L.) Hill. Mountain sorrel.

Creek-banks at Eldora; above timberline, Arapahoe Peak, 8600-12000 ft. (Daniels, 844).

Greenland to Alaska; New Hampshire to Arizona and California: Europe: Asia.

127. POLYGONUM L. Knotweed.

336. **P. erectum** L. Erect knotweed.

Along the railroad in Boulder Cañon, 5500 ft. (Daniels, 580).

Maine to Alberta; Georgia to Arkansas and Colorado.

337. **P. buxiforme** Small. Box-like knotweed.

Bear Cañon, and all waste places, 5100-10000 ft. (Daniels, 698).

Ontario to Washington; Virginia to Texas and Nevada.

338. **P. aviculare** L. Doorweed.

Common about houses, along railroads, and in all waste places, 5100-8000 ft. (Daniels, 582).

Asia: Europe: North America.

339. **P. ramosissimum** Michx. Bushy knotweed.

Common along railroads and roads, and in low weedy grounds, 5100-10000 ft. (Daniels, 519).

Minnesota to Washington; Illinois to New Mexico and Nevada; Maine to New Jersey along the coast.

340. **P. Sawatchense** Small. Saguache knotweed.

High mesas at foot of the Flat-irons, 5700-6000 ft. (Daniels, 178).

South Dakota to Washington; Colorado to Arizona and California.

341. **P. confertiflorum** Nuttall [*P. Watsonii* Small]. Watson's knotweed.

About the quarries at foot of the Flat-irons, 5700-6000 ft. (Daniels, 660).

Montana to Washington; Colorado to California.

342. **P. unifolium** Small. One-leaved knotweed.

Aspen bogs at Glacier Lake, 9000 ft (Daniels, 672).

Montana to Colorado.

343. **P. Engelmannii** Greene [*P. tenue microspermum* Engelm.]. Engelmann's knotweed.

Sandy stream-flats, especially common along the railroad in Boulder Cañon, 5100-10000 ft. (Daniels, 568).

Montana and Colorado to British Columbia.

344. **P. Douglasii** Greene. DOUGLAS'S KNOTWEED.

Common in open, especially sandy places throughout, 5100-10000 ft. (Daniels, 958).

VERMONT to BRITISH COLUMBIA; NEW YORK to NEW MEXICO and CALIFORNIA.

344a. **P. Douglasii consimile** (Greene) Small [*P. consimile* Greene]. BRANCHED DOUGLAS'S KNOTWEED.

Gregory Cañon, 6000-6300 ft. (Daniels, 546). Lower Boulder Cañon (Rydberg).

Range of the type?

128. PERSICARIA Adans. SMARTWEED. LADY'S THUMB.

345. **P. emersa** (Michx.) Cockerell. Nov. comb. [*Polygonum Muhlenbergii* S. Wats; *Polygonum emersum* (Michx.) Britton]. MUHLENBERG'S LADY'S THUMB.

Along ditches and in swales in the plains, 5100-6000 ft. (Daniels).

MAINE to BRITISH COLUMBIA; VIRGINIA to CALIFORNIA and MEXICO.

346. **P. lapathifolia** (L.) S. F. Gray [*Polygonum lapathifolium* L.]. DOCK-LEAVED LADY'S THUMB.

Swales and ditches in the plains, 5100-6000 ft. (Daniels, 506).

EUROPE: ASIA: NORTH AMERICA.

347. **P. Persicaria** (L.) Small. [*Polygonum Persicaria* L.]. COMMON LADY'S THUMB.

Common in waste places, and along ditches and in swales, 5100-6000 ft. (Daniels, 517).

EUROPE, thence to NORTH AMERICA.

348. **P. punctata** (Ell.) Small [*Polygonum punctatum* Ell.; *Polygonum acre* H. B. K.]. WATER SMARTWEED. DOTTED WATER PEPPER.

Margins of ponds, in swales and springy grounds, 5100-6000 ft. (Daniels, 798).

NORTH AMERICA: CENTRAL AMERICA: SOUTH AMERICA.

129. BISTORTA Tourn. BISTORT.

349. **B. bistortoides** (Pursh) Small [*Polygonum Bistorta oblongifolium* Meisn.]. OBLONG-LEAVED BISTORT.

Along Arapahoe Trail and above timberline on Arapahoe Peak, 8600-13000 ft. (Daniels, 890).

MONTANA to WASHINGTON; NEW MEXICO to CALIFORNIA.

350. **B. vivipara** (L.) S. F. Gray [*Polygonum viviparum* L.]. ALPINE BISTORT.

Above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels, 894). Also Eldora to Baltimore (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

GREENLAND to ALASKA; NEW HAMPSHIRE to COLORADO: EUROPE: ASIA.

130. TINIARIA Reichenb. FALSE BUCKWHEAT.

351. **T. Convolvulus** (L.) Webb. & Moq. [*Polygonum Convolvulus* L.]. BLACK BINDWEED. COMMON FALSE BUCKWHEAT.

Along railroads and roads; throughout the cultivated area as a weed in fields, 5100-9000 ft. (Daniels, 484).

EUROPE and ASIA, thence to NORTH AMERICA.

Order 20. CHENOPODIALES.

Family 37. CHENOPODIACEAE Dumort. Goosefoot family.

131. CHENOPODIUM L. GOOSEFOOT. LAMB'S QUARTERS. PIGWEED.

352. **C. leptophyllum** Nutt. NARROW-LEAVED GOOSEFOOT.

Common in the plains, mesas, and gullies of the foothills and mountains, 5100-8000 ft. (Daniels, 604).

NEBRASKA to MONTANA; MISSOURI to ARIZONA.

353. **C. oblongifolium** (S. Wats.) Rydb. [*C. leptophyllum oblongifolium* S. Wats.]. OBLONG-LEAVED GOOSEFOOT.

Common in dry places on the plains and mesas, 5100-7000 ft. (Daniels, 994).

NORTH DAKOTA to WYOMING; MISSOURI and TEXAS to ARIZONA.

354. **C. incanum** (S. Wats.) Heller [*C. Fremontii incanum* S. Wats.]. Hoary goosefoot.

Frequent on the plains and in waste places, 5100-6000 ft. (Daniels, 411).

Nebraska to Colorado; New Mexico to Nevada.

355. **C. Fremontii** S. Wats. Fremont's goosefoot.

Bear Cañon in shade, 6000-7000 ft. (Daniels, 829).

South Dakota to Montana; New Mexico to Arizona and Mexico.

356. **C. album** L. White goosefoot. Common pigweed.

Common in fields, yards, and waste places, 5100-8600 ft. (Daniels, 806).

Europe and Asia, thence a cosmopolitan weed.

357. **C. hybridum** L. Maple-leaved goosefoot.

Common in shady cañons, and as a weed in gardens and waste places, 5100-8600 ft. (Daniels, 601).

Temperate North America: Europe.

358. **C. rubrum** L. [*Blitum rubrum* (L.) Reichenb.]. Red goosefoot.

Along Boulder Cañon near Falls, 6500-8000 ft. (Daniels, 549).

Newfoundland to British Columbia; New Jersey to Colorado: Europe: Asia.

359. **C. Botrys** L. Feather geranium. Jerusalem oak.

Common in waste places and along railroads in coal ashes. 5100-8000 ft. (Daniels, 598).

Europe and Asia, thence to North America.

132. BLITUM L. Blite.

360. **B. capitatum** L. Strawberry blite.

Frequent in cañons and along mountain roads, 6000-10000 ft. (Daniels, 545). Also mountains between Sunshine and Ward (Rydberg).

Nova Scotia to Alaska; New Jersey to California: Europe.

133. CYCLOLOMA Moq.

361. **C. atriplicifolium** (Spreng.) Coult. [*C. platyphyllum* Moq.] WINGED PIGWEED.

Along the railroad between Boulder and Marshall; also along the railroad in Sunset Cañon, 5400-7700 ft. (Daniels, 485). Marshall (W. W. Robbins).

ONTARIO to MONTANA; ARKANSAS to ARIZONA.

134. MONOLEPIS Schrad.

362. **M. Nuttalliana** (R. & S.) Greene [*M. chenopodioides* Moq.]. NUTTALL'S MONOLEPIS.

Above timberline, Arapahoe Peak, the only ruderal observed there, 11000-15000 ft. (Daniels, 918).

MINNESOTA to WASHINGTON; TEXAS to CALIFORNIA.

135. ATRIPLEX L. ORACHE.

363. **A. carnosa** A. Nels. FLESHY ORACHE.

Alkaline flats at Boulder lake, 5300 ft. (Daniels, 729).

NEBRASKA to MONTANA; KANSAS to COLORADO.

364. **A. argentea** Nutt. SILVERY ORACHE.

Alkaline flats at Boulder lake, 5300 ft. (Daniels, 730).

NORTH DAKOTA to BRITISH COLUMBIA; KANSAS to COLORADO.

365. **A. occidentalis** Torr & Fremont. WESTERN ORACHE.

Dry mesas at Boulder (Rydberg).

COLORADO to UTAH; TEXAS to ARIZONA.

366. **A. hortensis** L. GARDEN ORACHE.

Along railroads and in yards, 5100-7000 ft. (Daniels, 679).

EUROPE, thence to NORTH AMERICA.

136. EUROTIA Adans. WHITE SAGE.

367. **E. lanata** (Pursh) Moq. WOOLLY WHITE SAGE.

Plains at Boulder (Rydberg).

SOUTH DAKOTA to WASHINGTON; KANSAS to CALIFORNIA.

137. CORISPERMUM L. BUGSEED.

368. **C. marginale** Rydb. MARGINAL-FRUITED BUGSEED.

Valleys near Boulder (Rydberg).

WYOMING to COLORADO.

138. DONDIA Adans. SEA BLITE.

369. **D. depressa** (Pursh) Britton [*Suaeda depressa* S. Wats.]. LOW SEA BLITE.

About the shores of Boulder lake, and other brackish lakes and pools, 5100-6000 ft. (Daniels, 778). Near Boulder (W. W. Robbins).

SASKATCHEWAN to MONTANA; COLORADO to NEVADA.

369½. **D. erecta** (S. Wats.) A. Nels. [*Suaeda depressa erecta* S. Wats.]. ERECT SEA BLITE.

Calkins lake (W. W. Robbins).

NORTH DAKOTA to MONTANA; COLORADO to NEVADA.

139. SALSOLA L. SALTWORT. SEA KALE.

370. **S. Tragus** L. RUSSIAN THISTLE.

Very common in waste places and along railroads, 5100-7000 ft. (Daniels, 419).

EUROPE and ASIA, thence to NORTH AMERICA.

Family 38. AMARANTHACEAE J. St. Hil. Amaranth family.

140. AMARANTHUS L. AMARANTH. PIGWEED.

371. **A. Powellii** S. Wats. POWELL'S PIGWEED.

Sandy valleys at Boulder (Rydberg).

TEXAS to COLORADO and CALIFORNIA.

372. **A. retroflexus** L. ROUGH PIGWEED.

Abounding in fields and waste places, 5100-7000 (clearings in Bear Cañon, perhaps even higher in the mountains) ft. (Daniels, 812).

TROPICAL AMERICA, thence a cosmopolitan weed.

373. **A. blitoides** S. Wats. PROSTRATE PIGWEED.

Along thoroughfares, and in fields, waste places, and creek-sands throughout, very common, 5100-10000 ft. (Daniels, 814).

COLORADO to UTAH and MEXICO, thence to the rest of the UNITED STATES and SOUTHERN CANADA.

374. **A. graecizans** L. [*A. albus* L.]. WHITE PIGWEED. TUMBLE WEED.

Common in waste places, especially on the plains, 5100-6000 ft. (Daniels, 813).

TROPICAL AMERICA, thence throughout NORTH AMERICA.

141. FROELICHIA Moench.

375. **F. gracilis** Moq. SLENDER FROELICHIA.

Along the railroad between Boulder and Marshall; also along the railroad in Boulder Cañon, 5400-6000 ft. (Daniels, 476).

NEBRASKA to COLORADO; ARKANSAS to TEXAS.

Family 39. CORRIGIOLACEAE Reichenb. Corrigiola family.

142. PARONYCHIA Adans. WHITLOWWORT.

376. **P. pulvinata** Gray. PULVINATE WHITLOWWORT.

Massif de l' Arapahoe, 1100-13500 ft. (Rydberg).

WYOMING and COLORADO to UTAH.

377. **P. Jamesii** T. & G. JAMES'S WHITLOW-WORT.

Common in open situations throughout, 5100-10000 ft. (Daniels, 136). Also mountains between Sunshine and Ward, and at Meadow Park and Lyons (Rydberg).

NEBRASKA to WYOMING; TEXAS to NEW MEXICO and MEXICO.

Family 40. ALLIONIACEAE Reichenb. Umbrella-wort family.

143. ABRONIA Juss.

378. **A. fragrans** Nutt. FRAGRANT ABRONIA.

Near Boulder (Tweedy). Valmont Butte, not getting to Boulder (Ramaley).

SOUTH DAKOTA to IDAHO; KANSAS to NEW MEXICO.

144. ALLIONIA Loeffl. UMBRELLA-WORT.

379. **A. nyctaginea** Michx. [*Oxybaphus nyctagineus* Sweet]. HEART-LEAVED UMBRELLA-WORT.

Plains and mesas, especially about streams, 5100-6000 ft. (Daniels, 113).

ILLINOIS to SASKATCHEWAN; MISSOURI to COLORADO.

380. **A. hirsuta** Pursh. HAIRY UMBRELLA-WORT.

Common on the plains, mesas, and foothills, 5100-7000 ft. (Daniels, 353).

WISCONSIN and MINNESOTA to SOUTH DAKOTA; MISSOURI to COLORADO.

381. **A. diffusa** Heller. DIFFUSE UMBRELLA-WORT.

On the plains and mesas and rich mountain slopes, 5100-9000 ft. (Daniels, 167).

NORTH DAKOTA to WYOMING; KANSAS to ARIZONA.

382. **A. lanceolata** Rydb. LANCE-LEAVED UMBRELLA-WORT.

Between Sunshine and Ward (Tweedy).

MINNESOTA to WYOMING; TENNESSEE to TEXAS and COLORADO.

383. **A. linearis** Pursh [*Oxybaphus angustifolius* Sweet]. NARROW-LEAVED UMBRELLA-WORT.

On the plains, 5100-6000 ft. (Daniels, 960).

MINNESOTA to MONTANA; LOUISIANA to ARIZONA and MEXICO.

Family 41. TETRAGONIACEAE Reichenb. New Zealand spinach family.

145. MOLLUGO L. CARPET-WEED.

384. **M. verticillata** L. COMMON CARPET-WEED.

Common on shales with thin soil between Marshall and South Boulder Peaks, 5400-6000 ft. (Daniels, 427). Not in Rydberg's Flora.

TROPICAL AMERICA, thence to NORTH AMERICA.

Family 42. PORTULACACEAE Reichenb. Purslane family.

146. TALINUM Adans. FAME-FLOWER.

385. **T. parviflorum** Nutt. SMALL-FLOWERED FAME-FLOWER.

Common on shales with thin soil between Marshall and South Boulder Peaks; also on rocks in Gregory Cañon, 5400-7000 ft. (Daniels, 437).

MINNESOTA to SOUTH DAKOTA; TEXAS to ARIZONA and MEXICO.

147. **CLAYTONIA** L. Spring beauty.

386. **C. rosea** Rydb. Rosy spring beauty.

Common at Boulder (Cockerell).

Saskatchewan to British Columbia; Colorado to California.

387. **C. megarrhiza** Parry. Large-rooted spring beauty.

Arapahoe Peak, towards summit, 12000-13500 ft. (Daniels, 889, collected by Mrs. T. D. A. Cockerell).

Montana and Colorado to Utah.

148. **CRUNOCALLIS** Rydb. Water spring beauty.

388. **C. Chamissoi** (Ledeb.) Cockerell. Nov. comb. [*Claytonia Chamissonis* Esch.]. Chamisso's water spring beauty.

Along ditches in the plains, and in deep cañons in the foothills and mountains; along streams at Ward and Bloomerville; in subalpine bogs at Eldora; and in wet tundras on Arapahoe Peak, 5100-11000 ft. (Daniels, 239). Arapahoe Pass (Rydberg).

Minnesota to British Columbia; New Mexico to California.

149. **OREOBROMA** Howell. Bitter root.

389. **O. pygmaea** (Gray) Howell. [*Calandrinia pygmaea* Gray; *Lewisia pygmaea* (Gray) Robinson]. Pygmy bitter root.

Arapahoe Peak, 12000 ft. (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

Montana and Colorado to California.

150. **PORTULACA** L. Purslane. Pussley.

390. **P. oleracea** L. Common purslane.

Campus of the University of Colorado at Boulder (Cockerell).

Tropical America, now cosmopolitan.

391. **P. retusa** Engelm. Retuse-leaved purslane.

Along the railroad in Sunset Cañon, 5700-7700 ft. (Daniels, 722).

Arkansas to Nevada; Texas to New Mexico.

Family 43. ALSINACEAE Wahl. Chickweed Family.

151. ALSINE L. Chickweed. Starwort.

392. **A. media** L. [*Stellaria media* (L.) Cyr.]. Common chickweed.

Streets in the city of Boulder, 5300-5600 ft. (Daniels, 803).

Europe and Asia, thence a cosmopolitan weed.

393. **A. Baicalensis** Coville [*Stellaria umbellata* Turcz.]. Lake Baical starwort.

Arapahoe Peak above timberline in wet tundras, 11000-13500 ft. (Daniels, 929). Also along mountain streams from Eldora to Baltimore (Rydberg).

Montana to Oregon; Colorado to California: Siberia.

394. **A. longifolia** (Muhl.) Britton [*Stellaria longifolia* Muhl.]. Long-leaved stitchwort.

In high alpine valley near snow above Bloomerville, 9000-11000 ft. (Daniels, 326).

Newfoundland to Alaska; Maryland to Colorado: Europe: Asia.

395. **A. longipes** (Goldie) Coville [*Stellaria longipes* Goldie]. Long-pedicelled stitchwort.

Wet meadows at Caribou, 8000-10000 ft. (Rydberg).

Labrador to Alaska and Colorado: Siberia.

395a. **A. longipes stricta** (Richardson) Rydb. [*Stellaria stricta* Richardson]. Strict long-pedicelled stitchwort.

Eldora to Baltimore, 8000-11000 ft. (Rydberg).

Range of the type, but extending to California.

396. **A. Jamesiana** (Torr.) Heller [*Stellaria Jamesiana* Torr.]. James's starwort.

Along a stream in the mesa fronting Flagstaff Hill, 5700-6000 ft. (Daniels, 26). The plants have fimbriate petals!

Wyoming to New Mexico and California.

152 CERASTIUM L. Mouse-ear chickweed.

397. **C. occidentale** Greene. Western mouse-ear chickweed.

Common on the mesas, foothills, and mountainsides in sheltered places and about streams and springs, 5700 (stream in mesa fronting Flagstaff Hill)—12000 ft. (Daniels, 24). St. Vrain Cañon, 7000 ft. (Coulter in Wabash College Herb.).

MONTANA to COLORADO and UTAH.

153. **ARENARIA** L. SANDWORT.

398. **A. Tweedyi** Rydb. TWEEDY'S SANDWORT.

Above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels, 1003).

WYOMING to NEW MEXICO and ARIZONA.

399. **A. Fendleri** Gray. FENDLER'S SANDWORT.

High mesas between Marshall and South Boulder Peaks, thence throughout the mountain region, 5700-12000 ft. (Daniels, 425). Also mountains between Sunshine and Ward, and at Caribou (Rydberg).

WYOMING to NEW MEXICO and ARIZONA.

399a. **A. Fendleri diffusa** Porter & Coulter. DIFFUSE FENDLER'S SANDWORT.

Plains and mesas about Boulder and Marshall, and in the foothills and mountains, 5100-10000 ft. (Daniels, 423).

COLORADO.

154. **ALSINOPSIS** Small.

400. **A. propinqua** (Richardson) Rydb. [*Arenaria propinqua* Richardson; *A. verna aequicaulis* A. Nels.]. GLANDULAR SANDWORT.

Arapahoe Peak in dry tundras, 11000-13000 ft. (Daniels, 754). Also Eldora to Baltimore (Rydberg).

HUDSON BAY to BRITISH COLUMBIA; COLORADO to UTAH.

401. **A. obtusiloba** Rydb. [*Arenaria obtusa* Torr.]. OBTUSE-LEAVED SANDWORT.

Very common in dry tundras, forming often the main part of the turf, Arapahoe Peak, 11000-13500 ft. (Daniels, 913). Also at Caribou, 10000 ft. (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

ALBERTA to BRITISH COLUMBIA; NEW MEXICO to UTAH.

Family 44. CARYOPHYLLACEAE Reichenb. Pink family.

155. SILENE L. CAMPION. CATCHFLY.

402. **S. antirrhina** L. SLEEPY CATCHFLY.

Common on the plains and mesas, and in deep cañons for some distance in the mountains, 5100-6500 (Boulder Cañon), ft. (Daniels, 477).

NEWFOUNDLAND to BRITISH COLUMBIA; FLORIDA to CALIFORNIA and MEXICO.

402a. **S. antirrhina depauperata** Rydb. DEPAUPERATE SLEEPY CATCHFLY.

Bear Cañon, 7000 ft. (Daniels, 974).

SASKATCHEWAN to BRITISH COLUMBIA; COLORADO to ARIZONA.

403. **S. noctiflora** L. NIGHT-BLOOMING CATCHFLY.

Along streets and in waste places in the city of Boulder, 5300-5600 ft. (Daniels, 815). Campus of the University of Colorado (Cockerell).

EUROPE, thence to NORTH AMERICA.

404. **S. acaulis** L. MOSS CAMPION.

Dry tundras, Arapahoe Peak, where it is abundant and characteristic, 11000-13500 ft. (Daniels, 902).

GREENLAND to ALASKA; NEW HAMPSHIRE to ARIZONA: arctic-alpine in the OLD WORLD.

156. LYCHNIS L.

405. **L. Drummondii** (Hook.) S. Wats. DRUMMOND'S PINK.

Common in open places throughout, 5100-10000 ft. (Daniels, 173). Also mountains between Sunshine and Ward (Rydberg).

MANITOBA to BRITISH COLUMBIA; NEW MEXICO to ARIZONA.

157. VACCARIA Medic.

406. **V. Vaccaria** (L.) Britton [*V. vulgaris* Host; *Saponaria Vaccaria* L.]. COW HERB.

Common in waste places about Boulder, 5300-5700 ft. (Daniels, 135).

EUROPE, thence to NORTH AMERICA.

158. SAPONARIA L. Soapwort.

407. **S. officinalis** L. Bouncing Bet.

Roadsides and along railroads, 5300-5600 ft. (Daniels, 725). Not in Rydberg's Flora.

Europe, thence to North America.

Order 21. RANALES.

Family 45. CERATOPHYLLACEAE Gray. Hornwort family.

159. CERATOPHYLLUM L. Hornwort.

408. **C. demersum** L. Common hornwort.

Owen's lake; Boulder lake, 5200-5300 ft. (Daniels, 614).

North America: Europe: Asia.

Family 46. RANUNCULACEAE Juss. Crowfoot family.

160. CALTHA L. Marsh marigold.

409. **C. leptosepala** DC. [*C. rotundifolia* (Huth) Greene; *C. chionophila* Greene]. White marsh marigold.

Along brooks crossing the Arapahoe Trail from Eldora to Arapahoe Peak, where in the wet tundras it ascends above timberline, 8600-12000 ft. (Daniels, 880). Long's Peak (Coulter in Wabash College Herb.).

Mackenzie to Yukon and Alaska; Colorado to Nevada and Oregon.

161. TROLLIUS L. Globe flower.

410. **T. albiflorus** (Gray) Rydb. [*T. laxus albiflorus* Gray]. White globe flower.

Along brooks crossing the Arapahoe Trail from Eldora to Arapahoe Peak, where in the wet tundras it ascends above timberline, 9000-12000 ft. (Daniels, 919). Long's Peak (Coulter in Wabash College Herb.).

Montana to Washington; Colorado to Utah.

162. ACTAEA L. Baneberry.

411. **A. arguta** Nutt. Western red baneberry.

Frequent in deep cañons throughout, 6000 (Bear Cañon at entrance)—10000 ft. (Daniels, 970).

Montana to Alaska; New Mexico to California: Northern Asia.

411a. **A. arguta eburnea** (Rydb.) Cockerell. Nov. comb. [*Actaea eburnea* Rydb.]. Ivory baneberry.

Mountain cañons throughout, 6500 (Bear Cañon)—10000 ft. (Daniels, 468).

Newfoundland to Alberta; Vermont to Utah.

163. AQUILEGIA L. Columbine.

412. **A. coerulea** James. Azure columbine.

North slope of Green Mt.; Bear Cañon; common on the mountains between Sunset and Ward; above timberline, Arapahoe Peak, 6500-12000 ft. (Daniels, 350). Nearly exterminated in the immediate region about Boulder. Also North Boulder Peak (Rydberg). The State flower of Colorado.

Montana to Colorado and Utah.

164. DELPHINIUM L. Larkspur.

413. **D. Penardii** Huth. Penard's larkspur.

Common on the plains, mesas, and foothills, 5100-8000 ft. (Daniels, 66).

Colorado.

414. **D. camporum** Greene. Plains larkspur.

Plains and foothills near Boulder, 5100-8000 ft. (Rydberg).

Texas to Colorado and Arizona.

415. **D. Nelsonii** Greene. Nelson's larkspur.

Along streams in mesa fronting Flagstaff Hill, 5700-6000 ft. (Daniels, 112). Sugarloaf Mountain, 8000 ft. (Ramaley).

Alberta to Washington; Nebraska to Utah.

416. **D. occidentale** S. Wats. [*D. quercetorum* Greene]. Western larkspur.

Rich mountainsides between Glacier Lake and Eldora, 8000-10000 ft. (Daniels, 628).

Wyoming and Colorado to Utah.

416½. **D. Barbeyi** Huth [*D. scopulorum subalpinum* Gray; *D. subalpinum* (Gray) A. Nels.]. BARBEY'S LARKSPUR.
Boulder Cañon (Coulter in Wabash College Herb.).
WYOMING and COLORADO.

417. **D. Ajacis** L. GARDEN LARKSPUR.
Escaped into streets in the city of Boulder, 5300-5600 ft. (Daniels, 191).
EUROPE, thence to CANADA and the UNITED STATES.

165. ACONITUM L. MONKSHOOD.

418. **A. porrectum** Rydb. PORRECT MONKSHOOD.
Arapahoe Pass, 10000 ft. (Rydberg).
WYOMING to COLORADO.

419. **A. Columbianum** Nutt. COLUMBIA MONKSHOOD.
Boulder Cañon above the Falls near the Perfect Tree, 7500-8000 ft. (Daniels, 540). Also Redrock lake, 10100 ft. (Ramaley & Robbins).
MONTANA to BRITISH COLUMBIA; NEW MEXICO to CALIFORNIA.

420. **A. insigne** Greene. SHOWY MONKSHOOD.
Subalpine meadows near Eldora, 8600-11000 ft. (Daniels, 979).
COLORADO.

421. **A. ochroleucum** A. Nels. OCHROLEUCOUS MONKSHOOD.
Aspen bogs at Eldora, 8600-9000 ft. (Daniels, 980).
WYOMING to COLORADO.

166. ANEMONE L. WIND FLOWER.

422. **A. globosa** Nutt. GLOBOSE ANEMONE.
Bear Cañon, scarce; common in aspen bogs at Eldora and Glacier Lake, 7000-11000 ft. (Daniels, 446). Also at Caribou (Rydberg).
SOUTH DAKOTA to MACKENZIE and ALASKA; COLORADO to CALIFORNIA.

423. **A. cylindrica** Gray. LONG-FRUITED ANEMONE.

Common in the mesas, thence following the streams in the plains, and on the foothills, 5100-8000 ft. (Daniels, 186).

NEW BRUNSWICK to BRITISH COLUMBIA; NEW JERSEY to ARIZONA.

424. **A. Canadensis** L. [*A. Pennsylvanica* L.] CANADA ANEMONE. PENNSYLVANIA ANEMONE.

Common in cañons and along streams throughout, except in the higher elevations, 5100-9000 ft. (Daniels, 443).

LABRADOR to ALBERTA; MARYLAND to NEW MEXICO.

167. PULSATILLA Adans. PASQUE FLOWER.

425. **P. hirsutissima** (Pursh) Britton [*Anemone patens Nuttalliana* Gray]. AMERICAN PASQUE FLOWER.

Common in open places throughout, 5100-10000 ft. (Daniels, 219). Also Sugarloaf, 8500 ft. (Cockerell), and North Boulder Peak, and Eldora to Baltimore (Rydberg). Long's Peak (Coulter in Wabash College Herb.).

ILLINOIS to MACKENZIE; TEXAS to WASHINGTON.

425a. **P. hirsutissima rosea** (Cockerell) Daniels. Nov. comb. PINK PASQUE FLOWER.

Boulder (Miss Marie Gill). This rose-colored form is due to some unusual acidity of the sap, not to a difference in the character of the pigment.

168. CLEMATIS L. VIRGIN'S BOWER.

426. **C. ligusticifolia** Nutt. WESTERN VIRGIN'S BOWER.

Common among bushes in cañons and along streams, ascending for a considerable distance into the mountains along the principal streams, 5100-8000 ft. (Daniels, 155).

NORTH DAKOTA to BRITISH COLUMBIA; MISSOURI to CALIFORNIA.

169. VIORNA Reichenb. LEATHER FLOWER.

427. **V. Jonesii** (Kuntze) Rydb. [*Clematis Douglasii Jonesii* Kuntze]. JONES'S LEATHER FLOWER.

Scarce in the foothills at Orodell along Boulder Cañon, 6000-7000 ft. (Daniels, 723). Near Boulder (Patterson).

COLORADO to NEVADA.

428. **V. eriophora** Rydb. [*Clematis eriophora* Rydb.]. WOOLLY LEATHER FLOWER.

Foothills along Boulder Cañon, 6000-7000 ft. (Daniels, 998). Puzzling intermediates between this species and the preceding were found at Orodell.

WYOMING to COLORADO and UTAH.

170. **ATRAGENE** L. BELL RUE.

429. **A. occidentalis** Hornem. [*A. Columbiana* Nutt.]. WESTERN BELL RUE.

Very scarce in Bear Cañon, 6000-7000 ft. (Daniels, 761). Redrock lake 10100 ft. (Ramaley & Robbins).

MONTANA to BRITISH COLUMBIA; COLORADO to UTAH.

171. **MYOSURUS** L. MOUSE TAIL.

430. **M. apetalus** Gay [*M. aristatus* Benth.]. BEAKED MOUSE TAIL.

In muddy places, Long's Peak, 9000 ft. (Rydberg).

MONTANA to WASHINGTON; COLORADO to CALIFORNIA: CHILI: NEW ZEALAND.

172. **BATRACHIUM** S. F. Gray. WHITE WATER CROWFOOT.

431. **B. aquatile flaccidum** (Pers.) Cockerell. Nov. comb. [*B. flaccidum* (Pers.) Rupr.]. FLACCID-LEAVED WHITE WATER CROWFOOT.

Aquatic in a pond at Glacier Lake, 9000 ft. (Daniels, 618). Also at Boulder (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

LABRADOR to WASHINGTON; NORTH CAROLINA to LOWER CALIFORNIA.

173. **RANUNCULUS** L. CROWFOOT. BUTTERCUP.

432. **R. reptans** L. [*R. Flammula reptans* (L.) E. Meyer]. CREEPING CROWFOOT.

Common in limose places about Boulder; at Marshall; in Sunset Cañon; aspen and subalpine bogs at Glacier Lake and

Eldora, 5100-10000 ft. (Daniels, 619). Also at Ward (Rydberg).

LABRADOR to ALASKA; NEW JERSEY to UTAH and OREGON: EUROPE: ASIA.

433. **R. ellipticus** Greene. ELLIPTIC-LEAVED CROW-FOOT.

Long's Peak (Porter and Coulter).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

434. **R. cardiophyllus** Hook. [*R. affinis cardiophyllus* Gray]. HEART-LEAVED CROWFOOT.

Wet meadows and bogs from Eldora to Baltimore, 8000-10000 ft. (Rydberg).

SASKATCHEWAN to COLORADO.

435. **R. inamoenus** Greene. UGLY CROWFOOT.

Bear Cañon, 7000 ft. (Daniels, 449). Also in meadows and along streams at Caribou, and from Eldora to Baltimore, 7000-10000 ft. (Rydberg).

MONTANA to NEW MEXICO and UTAH.

436. **R. micropetalus** (Greene) Rydb. [*R. affinis micropetalus* Greene]. SMALL-PETALLED CROWFOOT.

Aspen bogs at Glacier Lake, 9000 ft. (Daniels, 715).

COLORADO to UTAH and ARIZONA.

437. **R. pedatifidus** J. G. Smith [*R. affinis* R. Br.]. NORTHERN BUTTERCUP.

Alpine bogs and meadows, Eldora to Baltimore, 7000-12000 ft. (Rydberg). Near Long's Peak (Coulter in Wabash College Herb.).

LABRADOR to ALASKA; COLORADO to ARIZONA: SIBERIA.

438. **R. alpeophilus** A. Nels. ALPINE CROWFOOT.

In wet places near the snow at Caribou, 9000-12000 ft. (Rydberg).

MONTANA to COLORADO.

439. **R. adoneus** Gray. ADONIS-LIKE BUTTERCUP.

Alpine peaks at Ward (Rydberg).

WYOMING and COLORADO to UTAH.

440. **R. abortivus** L. KIDNEY-LEAVED CROWFOOT.

Common in low grounds, 5100-9000 (streams at Bloomerville) ft. (Daniels, 322).

LABRADOR to SASKATCHEWAN; FLORIDA to COLORADO.

441. **R. micranthus** Nutt. SMALL-FLOWERED CROWFOOT.

In Bear Cañon, 6000-7000 ft. (Daniels, 828).

MASSACHUSETTS to SASKATCHEWAN; FLORIDA to COLORADO.

442. **R. sceleratus eremogenes** (Greene) Cockerell. Nov. comb. [*R. eremogenes* Greene]. WESTERN SWAMP CROWFOOT.

Along ditches and in swales about Boulder and Marshall; along Four-mile creek in Sunset Cañon, 5100-8000 ft. (Daniels, 429).

SASKATCHEWAN to ALBERTA; NEW MEXICO to CALIFORNIA.

443. **R. Macounii** Britton. MACOUN'S BUTTERCUP.

About irrigation ditches in the plains, 5100-5600 ft. (Daniels, 236).

ONTARIO to ALBERTA: IOWA to COLORADO.

174. HALERPESTES Greene.

444. **H. Cymbalaria** (Pursh) Greene [*Ranunculus Cymbalaria* Pursh; *Oxygraphis Cymbalaria* (Pursh) Prantl; *Cyrtorrhyncha Cymbalaria* (Pursh) Britton]. SEASIDE CROWFOOT.

Around ponds and irrigation ditches about Boulder and Marshall on the plains, 5100-5700 ft. (Daniels, 255). Also at Ward (Cockerell). Valmont (Coulter in Wabash College Herb.).

NORTH AMERICA: SOUTH AMERICA: ASIA.

175. CYRTORRHYNCHA Nutt.

445. **C. ranunculina** Nutt. [*Ranunculus Nuttallii* Gray]. NUTTALL'S BUTTERCUP.

Rare on the north slope of Green Mt., 6500-7000 ft. (Daniels, 369). Near Long's Peak (Porter & Coulter; also Coulter in Wabash College Herb.).

WYOMING to COLORADO.

176. THALICTRUM L. MEADOW-RUE.

446. **T. purpurascens** L. PURPLISH MEADOW-RUE.

Springy cañon at the foot of Flagstaff Hill; wet meadows between Marshall and South Boulder Peaks, 5400-6000 ft. (Daniels, 434).

NOVA SCOTIA to SASKATCHEWAN; FLORIDA to COLORADO.

447. **T. Fendleri** Engelm. FENDLER'S MEADOW-RUE.

Cañons on the north slope of Green Mt., 6000-8100 ft. (Daniels, 532). Also in the mountains from Eldora to Baltimore (Rydberg).

WYOMING and NEW MEXICO to ARIZONA.

Family 47. NYMPHAEACEAE DC. Water-lily family.

177. NYMPHAEA L. YELLOW POND LILY.

448. **N. polysepala** (Engelm.) Greene [*Nuphar polysepalum* Engelm.]. MANY-SEPALLED YELLOW POND LILY. WESTERN SPATTER DOCK.

Alpine lakes at Ward, 9000-11000 ft. (Daniels). A portion of Engelmann's type material came from the vicinity of Long's Peak, lat. 40°.

MONTANA to ALASKA; COLORADO to CALIFORNIA.

Family 48. BERBERIDACEAE T. & G. Barberry family.

178. ODOSTEMON Raf. OREGON GRAPES.

449. **O. repens** (Lindl.) Cockerell [*O. Aquifolium* Rydb., not *Berberis Aquifolium* Pursh; *B. repens* Lindl.]. CREEPING OREGON GRAPES. HOLLY BARBERRY.

Common on the mesas, foothills, and mountain slopes, 5700-10000 ft. (Daniels, 471). Long's Peak (Coulter in Wabash College Herb.).

MONTANA to IDAHO; NEW MEXICO to CALIFORNIA.

Order 22. PAPAVERALES.

Family 49. PAPAVERACEAE Juss. Poppy family.

179. PAPAVER L. Poppy.

450. **P. Argemone** L. Rough-fruited poppy. Wind rose.

Escaped into streets and plains near dwellings, 5500-5600 ft. (Daniels, 200).

Europe, thence to the United States.

180. ARGEMONE L. Prickly poppy.

451. **A. intermedia** Sweet. White prickly poppy.

Abundant on the plains, mesas, and open meadows in the foothills, 5100-7500 ft. (Daniels, 85).

South Dakota to Wyoming; Texas to Mexico.

452. **A. hispida** Gray [*A. bipinnatifida* Greene]. Hairy prickly poppy.

Plains and foothills near Boulder, 5100-9000 ft. (Rydberg).

Wyoming to New Mexico and Utah.

Family 50. FUMARIACEAE DC. Fumitory family.

181. CAPNOIDES Adans. Corydalis.

453. **C. aureum** (Willd.) Kuntze [*Corydalis aurea* Willd.]. Golden corydalis.

Rather frequent in rocky places throughout, 5100-10000 ft. (Daniels, 82). Also in the mountains between Sunshine and Ward, and at Ward (Rydberg). Long's Peak (Coulter in Wabash College Herb.).

Nova Scotia to Alaska; Pennsylvania to California.

454. **C. montanum** (Engelm.) Britton [*C. pachylobum* Greene; *Corydalis aurea occidentalis* Gray]. Mountain corydalis.

Near Boulder, and in the mountains between Sunshine and Ward (Rydberg).

South Dakota to Utah; Missouri to Texas and Arizona.

Family 51. BRASSICACEAE Lindl. Mustard family.

182. CARDARIA Desv.

455. **C. Draba** (L.) Desv. [*Lepidium Draba* L.]. HOARY CRESS.
Near Boulder, (Rydberg).
EUROPE and ASIA, thence to the UNITED STATES.

183. LEPIDIUM L. PEPPER GRASS.

456. **L. medium** Greene. MEDIUM PEPPER GRASS.
Plains and foothills near Boulder, and in Boulder Cañon, 5000-7000 ft. (Daniels, 123).
MISSOURI to TEXAS and CALIFORNIA.

457. **L. divergens** Osterh. DIVERGENT PEPPER GRASS.
Common in creek-sands and along roads and railroads in the foothills and mesas, 5400-8000 ft. (Daniels, 32).
COLORADO.

184. THLASPI L. PENNY GRASS.

458. **T. arvense** L. FIELD PENNY GRASS.
Local in waste places; especially abundant along roadsides at the entrance of Boulder Cañon, 5100-6000 ft. (Daniels, 163).
EUROPE and ASIA, thence to NORTH AMERICA.

459. **T. Nuttallii** Rydb. NUTTALL'S PENNY GRASS.
Rocky cañons on the north slope of Green Mt., 6000-8100 ft. (Daniels, 275).
MONTANA and COLORADO to WASHINGTON.

460. **T. Coloradense** Rydb. COLORADO PENNY GRASS.
Gregory Cañon, 6200 ft. (Daniels, 194). Also in wet places among rocks, Massif de l' Arapahoe, 11000-13500 ft. (Rydberg).
COLORADO.

461. **T. purpurascens** Rydb. PURPLISH PENNY GRASS.
Among rocks on the peaks, Eldora to Baltimore (Rydberg).
COLORADO to ARIZONA.

185. BURSA Weber. SHEPHERD'S PURSE.

462. **B. Bursa-pastoris** (L.) Weber [*Capsella Bursa-pastoris* (L.) Medic.]. COMMON SHEPHERD'S PURSE.

Very common in fields and waste places, 5100-9000 ft. (Daniels, 252).

EUROPE, thence now cosmopolitan.

186. PHYSARIA Gray. DOUBLE BLADDER POD.

463. **P. didymocarpa** (Hook.) Gray. COMMON DOUBLE BLADDER POD.

Common under rocks in the mesas and foothills, 5700-7000 ft. (Daniels, 80). Also Long's Peak (Porter & Coulter; Coulter in Wabash College Herb.).

SASKATCHEWAN to ALBERTA; COLORADO to UTAH.

464. **P. floribunda** Rydb. MANY-FLOWERED DOUBLE BLADDER POD.

Plains and foothills near Boulder; Eldora to Baltimore, (Rydberg). Also Boulder (Mrs. T. D. A. Cockerell).

COLORADO.

187. LESQUERELLA S. Wats. BLADDER POD.

465. **L. Shearis** Rydb. SHEAR'S BLADDER POD.

On shales with thin soil between Marshall and South Boulder Peaks, 5400-6000 ft. (Daniels, 436). Plains and foothills at Boulder (Rydberg).

COLORADO.

188. CAMELINA Crantz. MYAGRUM.

466. **C. sativa** (L.) Crantz [*Myagrum sativum* L.]. FALSE FLAX.

Along streets and in waste places in the city of Boulder, 5300-5700 ft. (Daniels, 281). Not in Rydberg's Flora.

EUROPE, thence to NORTH AMERICA.

189. NASTURTIUM R. Br. CRESS.

467. **N. Nasturtium—aquaticum** (L.) Karst. [*N. officinale* R. Br.; *Roripa Nasturtium* (L.) Rusby.]. WATER CRESS.

Frequent in ditches, streams, and springy swales in and about Boulder, 5100-6000 ft. (Daniels, 590).

EUROPE and ASIA, thence to both NORTH and SOUTH AMERICA.

190. RADICULA Hill. YELLOW CRESS.

468. **R. calycina** (Engelm.) Greene [*Nasturtium calycinum* Engelm.; *Roripa calycina* (Engelm.) Rydb.]. WARTY PODDED YELLOW CRESS.

Along the railroad near Boulder lake, 5200-5300 ft. (Daniels, 774).

MONTANA to WASHINGTON and NEW MEXICO.

469. **R. sinuata** (Nutt.) Greene [*Nasturtium sinuatum* Nutt.; *Roripa sinuata* (Nutt.) A. S. Hitchc.]. SPREADING YELLOW CRESS.

On stream banks and in wet ground near Boulder (Rydberg).

MINNESOTA to WASHINGTON; MISSOURI to ARIZONA.

470. **R. hispida** (Desv.) Moench. [*Nasturtium hispidum* Desv.; *Roripa hispida* (Desv.) Britton]. HAIRY MARSH CRESS.

Along streams, ditches, and in swales, 5100-9000 ft. (Daniels, 581).

NEW BRUNSWICK to BRITISH COLUMBIA; FLORIDA to NEW MEXICO.

471. **R. obtusa** (Nutt.) Greene [*Nasturtium obtusum* Nutt.; *Roripa obtusa* (Nutt.) Britton]. BLUNT-LEAVED MARSH CRESS.

Massif de l' Arapahoe, 10000 ft. (Rydberg).

MICHIGAN to WASHINGTON; TEXAS to UTAH.

472. **R. curvipes** (Greene) Greene [*Roripa curvipes* Greene]. CURVED-PODDED MARSH CRESS.

In Boulder Cañon, 5500-6000 ft. (Daniels, 544).

WYOMING to COLORADO.

190½. **ARMORACIA** Gaertn. HORSE RADISH.

473. **A. Armoracia** (L.) Cockerell. Nov. comb. [*Roripa Armoracia* (L.) A. S. Hitchc.; *Nasturtium Armoracia* (L.) Fries.]. COMMON HORSE RADISH.

Escaped to waysides, Boulder (Daniels).

EUROPE, thence to AMERICA.

191. **SISYMBRIUM** L. HEDGE MUSTARD.

474. **S. officinale** (L.) Scop. COMMON HEDGE MUSTARD.

Common in waste places about Boulder, 5100-6000 ft. (Daniels, 256).

EUROPE and ASIA, thence to NORTH AMERICA.

192. **SOPHIA** Adans. TANSY MUSTARD.

475. **S. leptophylla** Rydb. FINE-LEAVED TANSY MUSTARD.

Along Boulder Cañon, 6000 ft. (Daniels, 284).

WYOMING and IDAHO to COLORADO.

476. **S. incisa** (Engelm.) Greene [*Sisymbrium incisum* Engelm.; *Descurainia incisa* (Engelm.) Britton]. CUT-LEAVED TANSY MUSTARD.

Boulder Cañon at Falls; also in Gregory Cañon on rocky banks, 6000-9000 ft. (Daniels, 981).

WYOMING to NEW MEXICO.

477. **S. intermedia** Rydb. WESTERN TANSY MUSTARD.

Common throughout the lower elevations, 5100-9000 ft. (Daniels, 121).

MICHIGAN to BRITISH COLUMBIA; TENNESSEE to CALIFORNIA.

478. **S. andrenarum** Cockerell. HOARY TANSY MUSTARD.

Rather frequent in Boulder Cañon, 5500-7000 ft. (Daniels, 550).

MONTANA to WASHINGTON and NEW MEXICO.

193. **ERYSIMUM** L. TREACLE MUSTARD.

479. **E. asperum** (Nutt.) DC. WESTERN WALLFLOWER.

Mountains between Sunshine and Ward (Rydberg).

SASKATCHEWAN to ARKANSAS and COLORADO.

480. **E. oblanceolatum** Rydb. OBLANCEOLATE-LEAVED WALLFLOWER.

Plains and foothills near Boulder (Rydberg).

WYOMING to COLORADO.

481. **E. nivale** (Greene) Rydb. [*E. asperum nanum* Cockerell]. SNOW WALLFLOWER.

Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 885).

WYOMING to COLORADO.

482. **E. Cockerellianum** Daniels. Nov. nomen. [*E. asperum alpestre* Cockerell; *E. alpestre* (Cockerell) Rydb., not Kotschy nor Jordan]. COCKERELL'S WALLFLOWER.

Abundant throughout, 5100-12000 ft. (Daniels, 57). Also mountains between Sunshine and Ward (Rydberg). Since *E. alpestre* has been twice used as a specific name (by Kotschy and by Jordan) a new name is necessary for the species.

COLORADO to UTAH; TEXAS to ARIZONA.

194. RAPHANUS L. RADISH.

483. **R. sativus** L. GARDEN RADISH.

Spontaneous along streets in waste places, 5400-5600 ft. (Daniels, 772).

ASIA, thence universal in cultivation.

195. CAMPE Dulac. WINTER CRESS.

484. **C. Americana** (Rydb.) Cockerell. Nov. comb. [*Barbarea Americana*, Rydb.]. AMERICAN WINTER CRESS.

In rich soil, between Eldora and Baltimore, 8500-9000 ft. (Rydberg).

SASKATCHEWAN to MONTANA; COLORADO to NEVADA.

196. BRASSICA L. MUSTARD.

485. **B. juncea** (L.) Coss. INDIAN MUSTARD.

Along Boulder Cañon Road about six miles beyond Boulder, 7000 ft. (Daniels, 283).

ASIA, thence to both NORTH and SOUTH AMERICA.

486. **B. nigra** (L.) Koch. BLACK MUSTARD.

Frequent along roadsides and in waste places, 5100-6000 ft. (Daniels, 747).

EUROPE and ASIA, thence to NORTH AMERICA.

487. **B. campestris** L. RUTA BAGA.

Adventitious along the Arapahoe Road, 5300 ft. (Daniels, 790).

EUROPE, thence universal in cultivation.

197. ALYSSUM L. MADWORT.

488. **A. alyssoides** (L.) Gouan. [*A. calycinum* L.]. YELLOW ALYSSUM.

Boulder, roadside on University Hill, 5300-5600 ft. (Cockerell).

EUROPE, thence to NORTH AMERICA.

198. KONIGA Adans.

489. **K. maritima** (L.) R. Br. [*Alyssum maritimum* (L.) Lam.]. SWEET ALYSSUM.

Spontaneous on the campus of the University of Colorado, Boulder, 5500 ft. (Daniels, 680).

EUROPE, thence universal in cultivation.

199. DRABA L. WHITLOW-GRASS.

490. **D. Coloradensis** Rydb. COLORADO WHITLOW-GRASS.

Plains and hillsides near Boulder, 5100-5500 ft. (Rydberg).

COLORADO.

491. **D. nemorosa** L. WOOD WHITLOW-GRASS.

At Boulder, University Hill, on rise opposite base of Flagstaff Hill, 5500-6000 ft. (Cockerell).

MICHIGAN and ONTARIO to BRITISH COLUMBIA; COLORADO to OREGON: EUROPE: ASIA.

492. **D. crassifolia** Graham. THICK-LEAVED WHITLOW-GRASS.

Above timberline, Arapahoe Peak, 11000-13500 ft. (Daniels, 928).

GREENLAND to BRITISH COLUMBIA; COLORADO to UTAH.

493. **D. Fladnizensis** Wulf. WHITE ARCTIC WHITLOW-GRASS.
Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 1009).
LABRADOR to BRITISH COLUMBIA; COLORADO to UTAH: EUROPE: ASIA.

494. **D. cana** Rydb. HOARY WHITLOW-GRASS.
Massif de l' Arapahoe, 11000-12000 ft. (Rydberg).
LABRADOR to YUKON and COLORADO.

495. **D. streptocarpa** Gray. TWISTED-PODDED WHITLOW-GRASS.
Common in barren, rocky places throughout the mountainous region 6000-13000 ft. (Daniels, 313). Also Eldora to Baltimore (Rydberg). Sugarloaf, 8500 ft. (Cockerell).
COLORADO to NEW MEXICO and ARIZONA.

496. **D. luteola** Greene. YELLOWISH WHITLOWWORT.
In spray of Boulder Falls, a decumbent small-flowered form, 7500 ft. (Daniels, 295). Also Eldora to Baltimore (Rydberg).
COLORADO.

497. **D. aureiformis** Rydb. [*D. Bakeri* Greene]. BAKER'S WHITLOW-GRASS.
Above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels, 1004).
SOUTH DAKOTA to COLORADO.

498. **D. aurea** Wahl. GOLDEN WHITLOWWORT.
Common in the subalpine and alpine district, 8600 (Eldora)-13000 (Arapahoe Peak) ft. (Daniels, 805). Also Eldora to Baltimore (Rydberg).
GREENLAND to BRITISH COLUMBIA; COLORADO to ARIZONA.

499. **D. decumbens** Rydb. DECUMBENT WHITLOWWORT.
At snow-line, Arapahoe Peak, 12000-13000 ft. (Daniels, 914).
COLORADO.

200. CARDAMINE L. BITTERCRESS.

500. **C. cordifolia** Gray. HEART-LEAVED BITTERCRESS.
Wet mossy tundras above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels, 713). Also mountains between Sunshine

and Ward, and at Caribou (Rydberg). Common everywhere above 9000 ft. (Ramaley).

WYOMING to NEW MEXICO and ARIZONA.

501. **C. incana** (Gray) A. Nels. [*C. cardiophylla* Rydb.; *C. infausta* Greene]. HOARY BITTERCRESS.

Along an alpine brook at edge of snow above Bloomerville, 9000-10000 ft. (Daniels, 323).

COLORADO.

502. **C. vallicola** Greene. VALLEY BITTERCRESS.

Dripping rocks under an irrigation sluice, Boulder Cañon, 5500-5600 ft. (Daniels, 578).

WYOMING to COLORADO.

201. ARABIS L. ROCK-CRESS.

503. **A. ovata** (Pursh) Poir. OVATE-LEAVED ROCK-CRESS.

Common among rocks throughout the mountain region and the rougher mesas, 5700-10000 ft. (Daniels, 567). Also from Eldora to Baltimore (Rydberg).

NEW BRUNSWICK to ALBERTA; GEORGIA to CALIFORNIA.

504. **A. philonipha** A. Nelson. SNOW-LOVING ROCK-CRESS.

Mountainsides at Ward, 9000-9500 ft. (Daniels, 954).

MONTANA to WASHINGTON; COLORADO to UTAH.

505. **A. oxyphylla** Greene. SHARP-LEAVED ROCK-CRESS.

Mesas and foothills; common, 5600-8000 ft. (Daniels, 199). University Hill near base of Flagstaff Hill (Cockerell).

WYOMING to COLORADO and UTAH.

506. **A. connexa** Greene. RELATED ROCK-CRESS.

Ward 9200 ft. (Daniels, 207). Also from Eldora to Baltimore (Rydberg).

MONTANA to COLORADO and UTAH.

507. **A. Fendleri** (S. Wats.) Greene [*A. Hoelboellii Fendleri* S. Wats.]. FENDLER'S ROCK-CRESS.

High alpine slope near snow above Bloomerville, 9000-10000 ft. (Daniels, 318).

COLORADO to NEW MEXICO.

508. **A. divaricarpa.** A. Nels. DIVERGENTLY PODDED ROCK-CRESS.

North slope of Green Mt., Gregory Cañon, 6400 ft. (Daniels, 528). Mountains between Sunshine and Ward (Rydberg).

ASSINIBOIA to COLORADO and UTAH.

202. THELYPODIUM Endl.

509. **T. paniculatum** A. Nels. [*T. sagittatum* Endl.; *T. torulosum* Heller]. PANICLED THELYPODIUM.

Near the summit of Flagstaff Hill, 6500-7000 ft. (Daniels, 223).

MONTANA to COLORADO and UTAH.

203. STANLEYA Nutt.

510. **S. glauca** Rydb. GLAUCOUS STANLEY'S CRESS.

Along the railroad between Boulder and Valmont, 5200-5300 ft. (Daniels, 415).

NORTH DAKOTA to WYOMING; COLORADO to UTAH.

Family 52. CAPPARIDACEAE Lindl. Caper family.

204. POLANISIA Raf. CLAMMY-WEED.

511. **P. trachysperma** T. & G. LARGE-FLOWERED CLAMMY WEED.

Along railroads and in creek-sands, 5100-7000 ft. (Daniels, 483).

ASSINIBOIA to TEXAS and NEVADA.

205. PERITOMA DC. CLEOME.

512. **P. serrulatum** (Pursh) DC. [*Cleome serrulata* Pursh]. PINK CLEOME. ROCKY MOUNTAIN BEE PLANT.

Sands and waste places, 5100-9000 ft. (Daniels, 286).

SASKATCHEWAN to IDAHO; MISSOURI to ARIZONA.

512a. **P. serrulatum albiflorum** Cockerell. WHITE CLEOME.

Sunset Cañon, 7000 ft. (Daniels, 603).

Order 23. ROSALES.

Family 53. CRASSULACEAE DC. Orpine family.

206. CLEMENTSIA Rose.

513. **C. rhodantha** (Gray) Rose [*Sedum rhodanthum* Gray]. RED ORPINE.

Alpine and subalpine in bogs and along streams, 8600 (Eldora)—13000 (Arapahoe Peak) ft. (Daniels, 848). Also at Caribou (Rydberg).

MONTANA to COLORADO and ARIZONA.

206½. RHODIOLA L. ROSE-ROOT.

513½. **R. integrifolia** Raf. ENTIRE-LEAVED ROSE-ROOT.

Common at high altitudes (Ramaley). Arapahoe Peak (Rydberg).

ALBERTA to ALASKA; COLORADO to CALIFORNIA.

207. SEDUM L. ORPINE. STONE-CROP.

514. **S. stenopetalum** Pursh. NARROW-PETALLED ORPINE.

Abundant throughout the mountainous regions in rocky places, 5600-12000 ft. (Daniels, 104). Also in the mountains between Sunshine and Ward (Rydberg).

ALBERTA to BRITISH COLUMBIA; NEW MEXICO to CALIFORNIA.

514a. **S. stenopetalum rubrolineatum** Cockerell.

With the type, but in the higher altitude (Cockerell).

ROCKY MOUNTAINS.

Family 54. SAXIFRAGACEAE Dumort. Saxifrage family.

208. PECTIANTHIA Raf. BISHOP'S CAP.

515. **P. pentandra** (Hook.) Rydb. [*Mitella pentandra* Hook.]. WESTERN BISHOP'S CAP.

Springy places and along streams, Caribou (Rydberg).

ALBERTA to ALASKA; COLORADO to CALIFORNIA.

209. OZOMELIS Raf. MITRE-WORT.

516. **O. stenopetala** (Piper) Rydb. [*Mitella stenopetala* Piper]. NARROW-PETALLED MITRE-WORT.

Springy places, Eldora to Baltimore (Rydberg).
Redrock lake, 10100 ft. (Ramaley & Robbins).
COLORADO to UTAH.

210. HEUCHERA L. ALUM-ROOT.

517. **H. bracteata** (Torr.) Ser. BRACTED ALUM-ROOT.

Common in the crevices of rocks, 5800-10000 ft. (Daniels, 139). Also in the mountains between Sunshine and Ward, and from Eldora to Baltimore (Rydberg).

WYOMING to COLORADO.

518. **H. Hallii** Gray. HALL'S ALUM-ROOT.

Rocky places, Arapahoe Peak, 11500-12000 ft. (Daniels, 881).

COLORADO.

519. **H. parvifolia** Nutt. SMALL-LEAVED ALUM-ROOT.

Common on banks in the mesas, foothills, and mountains throughout, 5700-12000 ft. (Daniels, 98). Also at Ward and Caribou (Rydberg).

ALBERTA to OREGON; NEW MEXICO to ARIZONA.

211. SAXIFRAGA L. SAXIFRAGE.

520. **S. debilis** Engelm. WEAK SAXIFRAGE.

Wet rocks, Massif de l' Arapahoe, 9000-13000 ft. (Rydberg).

MONTANA to COLORADO and UTAH.

212. MICRANTHES Haw.

521. **M. rhomboidea** (Greene) Small [*Saxifraga rhomboidea* Greene]. RHOMBOID-LEAVED SAXIFRAGE.

Among rocks in the foothills and mountains, Flagstaff Hill, 6000 ft. (Daniels). Also Massif de l' Arapahoe, 12000 ft., and Eldora to Baltimore (Rydberg). Near Long's Peak (Coulter in Wabash College Herb.). *Saxifraga nivalis* L., reported by Ramaley & Robbins from Redrock lake, 10100 ft., is probably this plant (cf. Coulter-Nelson's New Manual of Rocky Mountain Botany, p. 240).

MONTANA and IDAHO to COLORADO.

522. **M. arguta** (D. Don) Small [*Saxifraga arguta* D. Don; *S. denudata* Nutt.; *S. punctata* Hook., in part; not L.]. SMOOTH SAXIFRAGE.

In springy places and along streams; mountains between Sunshine and Ward; Massif de l' Arapahoe (Rydberg). Streams near Bloomerville, and on Arapahoe Peak, 9000-12000 ft. (Daniels, 308).

MONTANA to BRITISH COLUMBIA; NEW MEXICO to CALIFORNIA.

213. LEPTASEA Haw.

523. **L. chrysantha** (Gray) Small [*Saxifraga chrysantha* Gray]. GOLDEN SAXIFRAGE.

Toward summit of Arapahoe Peak, 13000-13500 ft. (Daniels, 949, collected by Mrs. T. D. A. Cockerell).

COLORADO and NEW MEXICO.

524. **L. Hirculus** (L.) Small [*Saxifraga Hirculus* L.]. ARCTIC SAXIFRAGE.

In wet places at Caribou (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

GREENLAND to ALASKA; COLORADO to BRITISH COLUMBIA: EUROPE: ASIA.

525. **L. austromontana** (Wieg.) Small [*Saxifraga bronchiales* Torr.; not L.; *S. austromontana* Wieg.]. WESTERN MOUNTAIN SAXIFRAGE.

On rocky ledges, Boulder Cañon above the Falls; at Sunset; and above timberline, Arapahoe Peak, 7000-13000 ft. (Daniels, 542). Also at Caribou; South Boulder Peak; mountains between Sunshine and Ward (Rydberg).

ALBERTA to BRITISH COLUMBIA; NEW MEXICO to WASHINGTON.

526. **L. flagellaris** (Willd.) Small [*Saxifraga flagellaris* Willd.]. FLAGELLATE SAXIFRAGE.

Massif de l' Arapahoe, 10000-13500 ft. (Rydberg).

GREENLAND to ALASKA; COLORADO to ARIZONA.

Family 55. PARNASSIACEAE Dumort. Grass of Parnassus family.

214. PARNASSIA L. GRASS OF PARNASSUS.

527. **P. fimbriata** Banks. FIMBRIATE GRASS OF PARNASSUS.

Springs and springy places, Caribou (Rydberg).

ALBERTA to ALASKA; COLORADO to CALIFORNIA.

Family 56. HYDRANGEACEAE Dumort. Hydrangea family.

215. EDWINIA Heller. JAMESIA.

528. **E. Americana** (T. & G.) Heller [*Jamesia Americana* T. & G.]. AMERICAN JAMESIA.

Abundant in the foothills and mountains in rocky and clivose places, 5700-10000 ft. (Daniels, 138). Also at Ward; in the mountains between Sunshine and Ward; and from Eldora to Baltimore (Rydberg).

WYOMING and UTAH to NEW MEXICO.

Family 57. GROSSULARIACEAE Dumort. Gooseberry family.

216. RIBES L. GOOSEBERRY. CURRANT.

529. **R. Purpusi** Koehne. PURPUS'S GOOSEBERRY.

Common in mountain cañons, 6000-10000 ft. (Daniels, 290). Also in the mountains between Sunshine and Ward (Rydberg).

WYOMING to NEW MEXICO.

530. **R. vallicola** Greene. VALLEY GOOSEBERRY.

Along streams and in gulches, 5000-9000 ft., St. Vrain creek below Lyons; Pine Glade School (Ramaley).

MONTANA to WASHINGTON; COLORADO to CALIFORNIA.

531. **R. lentum** (Jones) Coville & Rose [*R. lacustre molle* Gray]. WESTERN RED CURRANT.

Eldora to Baltimore (Rydberg).

WYOMING and COLORADO to CALIFORNIA.

532. **R. parvulum** (Gray) Rydb. [*R. lacustre parvulum* Gray]. SMALL BLACK CURRANT.

Moist places, 8000 to 11500 ft.; Redrock lake, west of Ward; Fourth of July mine (Ramaley).

ALBERTA and YUKON to COLORADO and UTAH.

533. **R. pumilum** Nutt. [*R. cereum* Coulter, in part]. SMALL WAX-CURRANT.

Abundant on the mesas, foothills, and mountains, 5500-10000 ft. (Daniels, 84). Long's Peak (Coulter in Wabash College Herb.).

MONTANA to NEW MEXICO and ARIZONA.

534. **R. longiflorum** Nutt. [*R. aureum* T. & G.; not Pursh]. LONG-FLOWERED GOLDEN CURRANT.

Along stream in mesa at the foot of Flagstaff Hill, 5700 ft. (Daniels, 600).

SOUTH DAKOTA to WYOMING; KANSAS to ARIZONA.

535. **R. vulgare** Lam. RED CURRANT.

Escaped into a thicket about a pond near Boulder, 5400 ft. (Daniels, 265).

LABRADOR to ALASKA; NEW JERSEY to INDIANA and MINNESOTA: EUROPE: ASIA. Frequently escaped from cultivation in all temperate regions.

Family 58. ROSACEAE Juss. Rose family.

217. OPULASTER Medic. NINE-BARKS.

536. **O. intermedius** Rydb. [*O. Missouriensis* Daniels]. INTERMEDIATE NINE-BARKS.

Cañons in the foothills, 5700-6500 ft. (Daniels, 74). Lower Boulder Cañon, 5600-7000 ft. (Rydberg).

ILLINOIS to SOUTH DAKOTA; MISSOURI to COLORADO.

537. **O. Ramaleyi** Aven Nelson [*O. bracteatus* Rydb.]. RAMALEY'S NINE-BARKS.

Cañons in the foothills, 5600-6500 ft. (Daniels, 693).

COLORADO.

538. **O. glabratus** Rydb. GLABROUS NINE-BARKS.

Boulder, along streams, 5000-11000 ft. (Rydberg).

COLORADO.

539. **O. monogynus** (Torr.) Kuntze [*Physocarpus Torreyi* Max.]. TORREY'S NINE-BARKS.

Rocky cañons in the foothills, 6000-7000 ft. (Daniels, 450).

SOUTH DAKOTA to WYOMING; NEW MEXICO to NEVADA.

218. BOSSEKIA Necker. SALMON-BERRY.

540. **B. parviflora** (Nutt.) Greene [*Rubus Nutkanus* Moç.; *Rubacer parviflorus* (Nutt.) Rydb.]. NUTKA SOUND SALMON-BERRY.

Local in deep wooded cañons in the foothills and mountains, 6500-9000 ft. (Daniels, 533). Near Long's Peak (Porter & Coulter).

ONTARIO to ALASKA; NEW MEXICO to CALIFORNIA and MEXICO.

219. OREOBATUS Rydb. FLOWERING RASPBERRY.

541. **O. deliciosus** (James) Rydb. [*Rubus deliciosus* James]. SAVORY FLOWERING RASPBERRY.

Abundant throughout the higher mesas, the foothills and the mountains, 5500-10000 ft. (Daniels, 29).

COLORADO.

220. RUBUS L. BRAMBLE.

542. **R. Americanus** (Pers.) Britton [*R. triflorus* Richardson]. DWARF RASPBERRY.

Deep cañons on north slope of Green Mt., 6400-8000 ft. (Daniels, 345). Not in Rydberg's Flora.

NEWFOUNDLAND to MANITOBA; NEW JERSEY to COLORADO.

221. BATIDAEA Dumort. RED RASPBERRY.

543. **B. laetissima** Greene. WILD RED RASPBERRY.

Common in gulches in the mesas and foothills, 5500-8000 ft. (Daniels, 212).

LABRADOR to MACKENZIE; NEW JERSEY to COLORADO.

222. TRIDOPHYLLUM Necker. FIVE-FINGER. CINQUEFOIL.

544. **T. paradoxum** (Nutt.) Greene [*Potentilla paradoxa* Nutt.]. BUSHY CINQUEFOIL.

Wet places and along streams, ascending in Sunset Cañon to about 7000 ft., 5100-7000 ft. (Daniels, 241).

PENNSYLVANIA and ONTARIO to WASHINGTON; MISSOURI to NEW MEXICO and MEXICO: EASTERN ASIA.

545. **T. leucocarpum** (Rydb.) Cockerell. Nov. comb. [*Potentilla leucocarpa* Rydb.]. WHITE-SEEDED CINQUEFOIL.

Wet places in the plains and ascending in the cañons to a considerable distance into the mountain region, 5100-7000 (Bear Cañon) ft. (Daniels, 826).

ILLINOIS to WASHINGTON; NEW MEXICO to CALIFORNIA.

546. **T. lateriflorum** (Rydb.) Cockerell. Nov. comb. [*Potentilla lateriflora* Rydb.]. LATERAL-FLOWERED CINQUEFOIL.

Foothills at Boulder, 6000-8000 ft. (Daniels, 238).

ASSINIBOIA to BRITISH COLUMBIA; COLORADO to ARIZONA.

547. **T. Monspeliense** (L.) Greene [*P. Norvegica hirsuta* T. & G.; *P. Monspeliensis* L.]. ROUGH CINQUEFOIL.

Common in meadows in the plains, mesas, and foothills, and in aspen bogs in the mountains, 5100-8600 (Eldora) ft. (Daniels, 117).

LABRADOR to ALASKA; SOUTH CAROLINA to ARIZONA and MEXICO: EUROPE: ASIA.

223. **POTENTILLA** L. FIVE-FINGER. CINQUEFOIL.

548. **P. concinna** Richardson [*P. humifusa* Nutt.]. GROUND CINQUEFOIL.

Mountainsides at Eldora, and bald ridges at Glacier Lake, 8600-10000 ft. (Daniels, 989). Also Long's Peak (Porter & Coulter; and Coulter in Wabash College Herb.). Redrock lake, 10100 ft. (Ramaley & Robbins).

SASKATCHEWAN to ALBERTA; COLORADO to UTAH.

549. **P. dissecta** Pursh [*P. diversifolia* Lehm.]. CUT-LEAVED CINQUEFOIL.

Above timberline, Arapahoe Peak, 11500-13000 ft. (Daniels, 933). Also at Caribou (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

SASKATCHEWAN to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

550. **P. glaucopyhylla** Lehm. [*P. dissecta glaucophylla* (Lehm.) S. Wats.]. GLAUCOUS CUT-LEAVED CINQUEFOIL.

At Caribou, 9900 ft. (Rydberg).

ROCKY MOUNTAINS.

551. **P. pulcherrima** Lehm. FAIREST CINQUEFOIL.

Aspen bogs and subalpine meadows at Eldora and Glacier Lake, 8000-10000 ft. (Daniels, 630).

SASKATCHEWAN to ALBERTA; NEW MEXICO to NEVADA.

552. **P. Pennsylvanica strigosa** Pursh. VILLOUS PENNSYLVANIA CINQUEFOIL.

Common on the plains and in mountain meadows, 5100-8000 ft. (Daniels, 31).

HUDSON BAY to ALBERTA; KANSAS to NEW MEXICO: SIBERIA

552a. **P. Pennsylvanica arachnoidea** Lehm. ARACHNOID PENNSYLVANIA CINQUEFOIL.

Near Boulder, 5000-8000 ft. (Rydberg).

MONTANA to UTAH; NEW MEXICO to ARIZONA.

553. **P. minutifolia** Rydb. MINUTE-LEAVED CINQUEFOIL.

High peaks, Eldora to Baltimore, 9000-13000 ft. (Rydberg).

COLORADO.

554. **P. Hippiana** Lehm. WOOLLY CINQUEFOIL.

Plains, mesas, and mountain meadows, 5100-10000 ft. (Daniels, 433).

MINNESOTA to SASKATCHEWAN and ALBERTA; NEW MEXICO to ARIZONA.

555. **P. propinqua** Rydb. [*P. Hippiana diffusa* Lehm.]. DIFFUSE CINQUEFOIL.

Plains, mesas, and mountain meadows, 5700-10000 ft. (Daniels, 206). Redrock lake, 10100 ft. (Ramaley & Robbins).

COLORADO to NEW MEXICO and ARIZONA.

556. **P. effusa** Dougl. BRANCHED CINQUEFOIL.

Plains, mesas, and mountain ridges, 5100-10000 ft. (Daniels, 287).

ASSINIBOIA to MONTANA; thence to NEW MEXICO.

224. FRAGARIA L. STRAWBERRY.

557. **F. bracteata** Heller. BRACTED STRAWBERRY.

Common in cañons in the foothills and mountains, 6300-11000 ft. (Daniels, 291).

MONTANA to BRITISH COLUMBIA; NEW MEXICO to CALIFORNIA.

558. **F. Americana** (Porter) Britton [*F. vesca Americana* Porter]. AMERICAN STRAWBERRY.

At Boulder, 5400 ft. (Rydberg).

NEWFOUNDLAND to MANITOBA; VIRGINIA to NEW MEXICO and OREGON.

558½. **F. prolifica** Baker & Rydb. PROLIFIC STRAWBERRY.

Boulder Cañon, 8500 ft. (Coulter in Wabash College Herb.).

COLORADO.

559. **F. glauca** (S. Wats.) Rydb. GLAUCOUS STRAWBERRY.

Mountainsides at Eldora, 8600 ft. (Daniels, 850). Redrock lake, 10100 ft. (Ramaley & Robbins).

MACKENZIE to MONTANA; SOUTH DAKOTA to COLORADO and NEVADA.

560. **F. pauciflora** Rydb. SMALL-FLOWERED STRAWBERRY.

North Boulder Peak (Rydberg). Boulder Cañon, 8500 ft. (Coulter in Wabash College Herb.).

HUDSON BAY to ALBERTA; COLORADO to UTAH.

225. SIBBALDIA L.

561. **S. procumbens** L. PROCUMBENT SIBBALDIA.

Above timberline in dry tundras near the snow, 11500-13500 ft., Arapahoe Peak (Daniels, 912). Redrock lake, 10100 ft. (Ramaley & Robbins).

Arctic-alpine around the world.

226. DASIPHORA Raf.

562. **D. fruticosa** (L.) Rydb. [*Potentilla fruticosa* L.]. SHRUBBY CINQUEFOIL.

Subalpine bogs, mostly in aspen zone; but also in bogs in the plains and mesas, 5600-10000 ft. (Daniels, 541).

LABRADOR to ALASKA; NEW JERSEY to CALIFORNIA: EUROPE: ASIA.

227. DRYMOCALLIS Fourr.

563. **D. arguta** (Pursh) Rydb. [*Potentilla arguta* Pursh]. TALL CINQUEFOIL.

On the plains and mesas, the flowers yellow as well as white, 5100-6000 ft. (Daniels, 432). St. Vrain Cañon (Porter & Coulter).

NEW BRUNSWICK to MACKENZIE; DISTRICT OF COLUMBIA to COLORADO.

564. **D. fissa** (Nutt.) Rydb. [*Potentilla fissa* Nutt.]. LARGE-FLOWERED GLANDULAR CINQUEFOIL.

Common in the mesas, foothills, and mountains throughout, 5700-12000 ft. (Daniels, 30). St. Vrain Cañon 7000 ft., and Boulder Cañon (Coulter in Wabash College Herb.).

MONTANA to COLORADO.

228. GEUM L. AVENS.

565. **G. strictum** Ait. YELLOW AVENS.

In Bear Cañon, 7000 ft. (Daniels, 637).

NEWFOUNDLAND to BRITISH COLUMBIA; PENNSYLVANIA to ARIZONA and MEXICO: EUROPE: ASIA.

566. **G. Oregonense** (Scheutz) Rydb. [*G. urbanum Oregonense* Scheutz]. OREGON AVENS.

Mountain meadows and cañons, 6000-10000 ft. (Daniels, 634). Also at Arapahoe Pass and Eldora (Rydberg).

MACKENZIE to BRITISH COLUMBIA; NEW MEXICO to CALIFORNIA.

567. **G. scopulorum** Greene. ROCKY MOUNTAIN AVENS.

In cañons and gulches about springs, 5700-9000 ft. (Daniels, 68).

ROCKY MOUNTAINS.

229. ERYTHROCOMA Greene. PURPLE MOUNTAIN AVENS.

568. **E. ciliata** (Pursh) Greene [*Geum ciliatum* Pursh; *Sieversia ciliata* (Pursh) Don; *G. triflorum* Pursh]. THREE-FLOWERED MOUNTAIN AVENS.

Subalpine and alpine meadows at Eldora, 8000-12000 ft. (Daniels, 627). Also at Arapahoe Pass (Rydberg). Near Long's Peak (Porter & Coulter).

LABRADOR to BRITISH COLUMBIA; NEW YORK to CALIFORNIA and MEXICO.

230. **ACOMASTYLIS** Greene. YELLOW MOUNTAIN AVENS.

569. **A. turbinata** (Rydb.) Greene [*Geum turbinatum* (Rydb); *Sieversia turbinata* (Rydb.) Greene]. TURBINATE MOUNTAIN AVENS.

Above timberline, Arapahoe Peak, 11500-13500 ft. (Daniels, 877).

WYOMING to NEW MEXICO and ARIZONA.

570. **A. Arapahoensis** Daniels. Nov. spec. ARAPAHOE YELLOW MOUNTAIN AVENS.

Plant 20- 30 cm. high, the stems (about three in number) puberulent, becoming softly hairy or villous above; basal leaves ascending, about 1 dm. long and 3 cm. wide, pinnate, the lower pinnae narrowly falcate, entire, the others mainly ovate in outline, deeply cut into 2- 7 cuneate lobes, but with occasional little, simple pinnae interspersed with the larger ones; leaves puberulent or glabrate, the margins softly ciliate with white hairs; rhachis about 3 mm. broad, the base of the petiole about 1 cm. broad, becoming chaffy and sheathing the stems; lower half of stem leafless, the upper half bearing two leaves, 2½- 3 cm. long, pinnately parted into about 10 narrow lobes, the lowermost broad, stipule-like, and sheathing the stem; peduncles softly hairy, 3-4 in number, subtended by leaves closely resembling the two stem leaves, but smaller, the peduncles themselves occasionally bearing 1 or 2 bracts, simple or 2-5 pinnately incised; flowers 2-2½ cm. wide, bright yellow, the petals broadly obovate, five in number; sepals and bractlets villous at base, 5 each, spreading, becoming erect in fruit or the tips reflexed in age; sepals broadly triangular, about twice as high as the narrower bractlets; stamens numerous; styles included in fruit, glabrate; achenes softly villous with white hairs. Foliage, stems, sepals and bractlets purple-tinged.

The plant differs from *A. turbinata* (Rydb.) Greene, in its larger size, its softly hairy upper portion, its 3- 4 flowered stems, its broader sepals, which are much longer than the bractlets, and in its larger flowers. This is probably the

Geum Rossii humilis of Coulter's Manual, but genuine *G. Rossii humilis* T. & G. comes no nearer than Unalaska, the type locality. *A. turbinata* (Rydb.) Greene is a low plant, 7-15 cm. high, usually 1- flowered.

At timberline, Arapahoe Peak, 11500 ft. (Daniels, 906).

231. **HOLODISCUS** Max. MEADOWSWEET.

571. **H. dumosus** (Nutt.) Heller. [*Spiraea dumosa* Nutt.]. BUSHY MEADOWSWEET.

Boulder County (McFarland).

WYOMING and UTAH to COLORADO and ARIZONA.

232. **KUNZIA** Spreng. PURSHIA.

572. **K. tridentata** (Pursh) Spreng. [*Purshia tridentata* (Pursh) DC.]. THREE-TOOTHED PURSHIA.

Rocky hillsides, 6500-8500 ft.; head of Gregory Cañon; north of Nederland (Ramaley). Boulder Cañon, 9000 ft. (Coulter in Wabash College Herb.).

MONTANA to WASHINGTON; NEW MEXICO to CALIFORNIA.

233. **CERCOCARPUS** H. B. K. MOUNTAIN MAHOGANY.

573. **C. parvifolius** Nutt. SMALL-LEAVED MOUNTAIN MAHOGANY.

High mesas fronting the Flat-irons, 5700-6000 ft. (Daniels, 172). Also from Eldora to Baltimore (Rydberg).

SOUTH DAKOTA to MONTANA; NEW MEXICO to UTAH.

234. **DRYAS** L.

574. **D. octopetala** L. WHITE MOUNTAIN AVENS.

Above timberline, Arapahoe Peak, 11500-13500 ft. (Daniels, 939). Also mountains south of Ward (Rydberg).

Arctic-alpine around the world.

235. **AGRIMONIA** L. AGRIMONY.

575. **A. Brittoniana occidentalis** Bickn. WESTERN AGRIMONY.

Plains, and cañons among the foothills, 5100-7500 (Bear Cañon) ft. (Daniels, 259).

SOUTH DAKOTA to WYOMING; NEW MEXICO to ARIZONA.

236. ROSA L. Rose. Brier.

576. **R. pratincola** Greene. Prairie rose.

Common on the plains and mesas, 5100-6000 ft. (Daniels, 58).

Minnesota to Alberta; Kansas to Colorado.

576a. **R. pratincola angustiarum** Cockerell, n. var. Castle Rock rose.

Boulder Cañon, 7340 ft. (near Castle Rock), Sept. 22, 1907, growing close to *R. Engelmanni* Wats.

Low bush. *Flowers* corymbose, often four together.

Sepals foliolar-tipped, narrow tomentose, with scattered large dark marginal stalked glands, these last present or absent on same branch. No lateral lobes. Length of sepals prox. 17 mm. Sepals in fruit erect.

Fruit depressed globose, very shiny, with no sign of a neck.

Five fruits { Long. (mm.) 11. 9½. 11. 10. 10. Measured while fresh.
Lat. (mm.) 13. 11. 12. 10 ⅛. 10½.

Twigs and *peduncles* deep crimson. Penduncles minutely hairy.

Branches with straw colored, fairly numerous, straight slender prickles, the larger ones about 7 mm., long; infrastipular prickles normally absent.

Stipules broad, to 8½ mm., margins dentate, more or less glandular.

Leaflets: a series of leaves counted showed leaflets: 11. 9. 9. 10. 9. 9. 7. 5. 11. 9. 11. 9. 9. 11. 9. 9. 11. 11. 9. 3,

Leaflets; cuneate basally, simply and strongly toothed, very finely but closely pubescent beneath. Terminal leaflet long. 26., lat. 13½ mm.

Frequently one or two leaflets from between auricles of stipules, as in *R. suffulta.* Stipules convolute as in *R. Woodsii,* but leaves not shining. (Cockerell, MS., Oct. 1907.)

576b. **R. pratincola setulosa** Cockerell. N. var.

Fruit bristly. Bluebell Cañon (Cockerell), 1910.

577. **R. Sayi** Schweinitz. SAY'S ROSE.

Common throughout the mesas, foothills and lower mountainsides, 5500-10000 ft. (Daniels, 47). Also Eldora to Baltimore (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

QUEBEC to ALBERTA; MICHIGAN to COLORADO and NEW MEXICO.

578. **R. Engelmannii** S. Wats. ENGELMANN'S ROSE.

High ridges of Green Mt., 7000-8100 ft. (Daniels, 535). Also Boulder Cañon above Falls (Cockerell). Eldora; foot of Long's Peak (Ramaley).

MICHIGAN to NORTH DAKOTA; TEXAS to COLORADO.

579. **R. melina** Greene. ASHEN ROSE.

Cañons and gulches at foot of Flagstaff Hill, 5700-6000 ft. (Daniels, 102). *R. Nutkana* Presl., reported by Ramaley from Marshall; Bluebell Cañon; Gregory Cañon; and Pine Glade School, is probably *R. Melina* Greene.

WYOMING to COLORADO.

580. **R. Macounii** Greene. MACOUN'S ROSE.

Along the railroad between Boulder and Marshall, 5400 ft. (Daniels, 968). *R. Woodsii* Lindl., reported by Ramaley from Sugarloaf Mt., Bluebird Mine.; and Spencer Mt. at Eldora, is probably *R. Macounii* Greene.

SOUTH DAKOTA to ALBERTA; KANSAS to COLORADO.

581. **R. Fendleri** Crepin. FENDLER'S ROSE.

Bear Cañon, 7000 ft. (Daniels, 205). Also mountains between Sunshine and Ward (Rydberg). Marshall; above Magnolia (Ramaley).

SOUTH DAKOTA to MONTANA; NEW MEXICO to ARIZONA.

582. **R. aciculata** (Cockerell) Cockerell [*R. blanda aciculata* Cockerell]. PRICKLY ROSE..

Gulches at the foot of the Flat-irons, 5700-6000 ft. (Daniels, 462). Also mountains between Sunshine and Ward (Rydberg).

COLORADO to NEW MEXICO.

583. **R. Maximiliani** Nees. MAXIMILIAN'S ROSE.
Gregory Cañon, 5800-6500 ft. (Daniels, 190).
SASKATCHEWAN to WASHINGTON; COLORADO to UTAH.

Family 59. MALACEAE Small. Apple family.

237. AMELANCHIER L. SHADBUSH.

584. **A. polycarpa** Greene. MANY-FRUITED JUNEBERRY.
Mountainsides from Eldora to Arapahoe Peak, where it occurs at timberline, 8600-11500 ft. (Daniels, 909).
WYOMING to COLORADO.

585. **A. elliptica** A. Nels. ELLIPTICAL-LEAVED JUNEBERRY.
Sugarloaf Mountain (Ramaley).
SOUTH DAKOTA to COLORADO.

586. **A. alnifolia** Nutt. ALDER-LEAVED SHADBUSH.
Sunshine Cañon and Eldora (Ramaley).
NORTH DAKOTA to MONTANA; COLORADO to UTAH.

587. **A. oreophila** A. Nels. MOUNTAIN SHADBUSH.
Mesas and foothills, common, 5700-8100 ft. (Daniels, 501).
WYOMING to COLORADO.

238. CRATAEGUS L. HAWTHORN.

588. **C. occidentalis** Britton [*C. Colorado* Ashe]. WESTERN HAW.
Banks of gulches in the mesas and lower foothills, 5700-6000 ft. (Daniels, 835).
COLORADO.

589. **C. Coloradensis** A. Nels. COLORADO HAW.
Banks of gulches in the mesas and lower foothills, 5700-6000 ft. (Daniels, 767). A form from the entrance to Gregory Cañon (Daniels, 838) has the petioles not distally widened.
NORTH DAKOTA to MONTANA; NEBRASKA to COLORADO.

590. **C. erythropoda** Ashe, 1900 [*C. Cerronis* A. Nels., 1902]. CERRO HAW.

Banks of gulches in the mesas and lower foothills, 5700-6000 ft. (Daniels, 794).

COLORADO.

591. **C. Doddsii** Ramaley. DODDS'S HAW.

Pole Cañon (the type locality); also various localities in Boulder Co., 5000-8000 ft. (Ramaley).

COLORADO.

592. **C. Coloradoides** Ramaley. FALSE COLORADO HAW.

Pole Cañon (the type locality); also gulches in the lower foot-hills, 5500-7000 ft. (Ramaley).

COLORADO.

239. SORBUS L. MOUNTAIN ASH.

593. **S. scopulina** Greene. ROCKY MOUNTAIN MOUNTAIN ASH.

At entrance of Bear Cañon and very sparingly throughout the mountainous region, 6000-10000 ft. (Daniels, 764).

ALBERTA to WASHINGTON; COLORADO to UTAH.

Family 60. AMYGDALACEAE Reichenb. Peach family.

240. PRUNUS L. PLUM. CHERRY.

594. **P. Americana** Marsh. AMERICAN WILD PLUM.

Mesas and lower foothills, 5700-7000 ft. (Daniels, 795).

NEW YORK to MONTANA; FLORIDA to COLORADO.

595. **P. prunella** Daniels. Nov. sp. PYGMY PLUM.

Undershrub, thornless, trailing or ascending, 3-6 dm. high with grayish bark, the new twigs reddish; fruits lateral, solitary in the specimens secured, on slender pedicels 1 cm. long; drupes oblong, 1¼-1½ cm. long and 1 cm. wide when dried, black-purple with but slight traces of bloom; pulp red-purple, astringent but sweet and edible; stone oblong 12 mm. long by 7 mm. wide, bean-shaped, flattish, rugose, the margins slightly winged, the ends plainly so; leaves lanceolate, 3-5 cm. long including the petiole, and 12-15 mm. wide in the middle, sharply but not deeply serrate, entire toward the acuminate base; upper surfaces glossy green, under surfaces paler, the midrib white and shining both above and below. Flowers not seen. Mesa at entrance of Gregory Cañon and facing the first Flat-iron, scarce; 5700-6000 ft. (Daniels, 654). A true plum, having perhaps as its nearest ally *P. Watsoni* Sargent. Specific name the diminutive of *Prunus.*

596. **P. Besseyi** Bailey. BESSEY'S SAND CHERRY.

One-fourth mile above Chautauqua grounds, Boulder, (Bethel). Also White Rocks (Ramaley).

NORTH DAKOTA to KANSAS and COLORADO.

597. **P. Pennsylvanica** L. f. WILD RED CHERRY.

Common throughout, 5100-9500 ft. (Daniels, 327). Also mountains between Sunshine and Ward and from Eldora to Baltimore (Rydberg).

NEWFOUNDLAND to NORTH DAKOTA; GEORGIA to COLORADO.

598. **P. melanocarpa** (A. Nels.) Rydb. [*Cerasus demissa melanocarpa* A. Nels.] BLACK-FRUITED WESTERN WILD CHERRY.

Common along cañons throughout the mesas and foothills, 5600-8500 ft. (Daniels, 465).

NORTH DAKOTA to ALBERTA and BRITISH COLUMBIA; NEW MEXICO to CALIFORNIA.

Family 61. FABACEAE Reichenb. Bean family.

241. SOPHORA L.

599. **S. sericea** Nutt. SILKY SOPHORA.

Alkaline flats about Owen's lake, 5200 ft. (Daniels, 664).

SOUTH DAKOTA to WYOMING; TEXAS to ARIZONA.

242. THERMOPSIS R. Br.

600. **T. pinetorum** Greene. PINELAND THERMOPSIS.

Marshall, 5400 ft. (Daniels, 273). Open woodlands and hillsides, Boulder (Rydberg).

COLORADO to NEW MEXICO.

601. **T. divaricarpa** A. Nels. DIVARICATE-PODDED THERMOPSIS.

Abundant throughout the mesas, foothills, and mountains, 5600-11000 ft. (Daniels, 109). Also from Eldora to Baltimore (Rydberg).

WYOMING to COLORADO.

602. **T. arenosa** A. Nels. SAND THERMOPSIS.

In sandy soil, Eldora to Baltimore (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

SASKATCHEWAN and MONTANA to COLORADO.

243. LUPINUS L. LUPINE.

603. **L. Plattensis** S. Wats. PLATTE LUPINE.

Abundant on the plains, mesas, and foothills, 5100-8000 ft. (Daniels, 48).

NEBRASKA and WYOMING to COLORADO.

604. **L. rubricaulis** Greene. RED-STEMMED LUPINE.

Mesas and foothills, 5600-8000 ft. (Daniels, 394).

COLORADO.

604½. **L. alpestris** A. Nels. [*L. alsophilus* Greene]. ALPINE LUPINE.

Redrock lake, 10100 ft. (Ramaley & Robbins).

MONTANA to COLORADO and UTAH.

605. **L. parviflorus** Nutt. SMALL-FLOWERED LUPINE.

Among pines, Gregory Cañon and slopes of Green Mountain, 6000-8000 ft. (Daniels, 344).

SOUTH DAKOTA to MONTANA; COLORADO to UTAH.

606. **L. decumbens** Torr. [*L. argenteus decumbens* (Torr.) Gray; *L. leptostachys* Greene]. DECUMBENT LUPINE.

Common in the plains and foothills, 5100-9000 ft. (Daniels, 704).

NEBRASKA to MONTANA and OREGON; COLORADO to CALIFORNIA.

606a. **L. decumbens argentatus** Rydb. SILVERY DECUMBENT LUPINE.

Plains, foothills, and mountain slopes, 5100-9000 ft. (Daniels, 131). Also between Sunshine and Ward (Rydberg).

WYOMING to COLORADO.

244. TRIFOLIUM L. CLOVER.

607. **T. pratense** L. RED CLOVER.

Throughout the cultivated area, 5100-8500 ft. (Daniels, 744).

EUROPE and ASIA, thence cultivated and naturalized in all temperate lands.

608. **T. hybridum** L. ALSIKE CLOVER.

Roadsides and fields about Boulder, 5100-5700 ft. (Daniels, 244). Not in Rydberg's Flora.

EUROPE, thence to all temperate lands.

609. **T. repens** L. WHITE CLOVER. SHEEP CLOVER.

Common throughout the cultivated area, whence it has penetrated to distant cañons in the foothills, 5100-7500 ft. (Daniels, 500).

EUROPE: SIBERIA: SUB-ARCTIC AMERICA; now in the greater part of NORTH AMERICA.

610. **T. lividum** Rydb. LIVID CLOVER.

Above timberline, Arapahoe Peak, 11500-13000 ft. (Daniels, 1019).

WYOMING to COLORADO.

611. **T. dasyphyllum** Torr. GRAY CLOVER.

Above timberline, Arapahoe Peak, 11500-13000 ft. (Daniels, 874). Also Eldora to Baltimore and in the mountains south of Ward (Rydberg).

MONTANA to COLORADO.

245. MEDICA Hill. LUCERNE.

612. **M. sativa** (L.) Hill [*Medicago sativa* L.]. ALFALFA.

Throughout the cultivated area, and extending into the mountains along the roads and railroads, 5100-7000 ft. (Daniels, 509).

EUROPE, thence to all temperate lands.

246. **MEDICAGO** L. Medic.

613. **M. lupulina** L. Hop medic.

Streets of Boulder, and about the quarries at the base of the Flat-irons, 5300-6000 ft. (Daniels, 658). Not in Rydberg's Flora.

Europe and Asia, becoming cosmopolitan.

247. **MELILOTUS** Juss. Sweet clover. Melilot.

614. **M. alba** Desv. White sweet clover.

Throughout the cultivated area, and abundant along railroads, 5100-7000 ft. (Daniels, 591).

Europe and Asia, thence to North America.

615. **M. officinalis** (L.) Lam. Yellow melilot.

Streets and waste places, and about the quarries at the base of the Flat-irons, 5100-6000 ft. (Daniels, 657).

Europe and Asia, thence to North America.

248. **GEOPRUMNON** Rydb. Ground plum.

616. **G. succulentum** (Richardson) Rydb. [*Astragalus succulentus* Richardson; *A. prunifer* Rydb.]. Succulent ground plum.

Plains and foothills about Boulder, 5100-7000 ft. (Daniels).

Saskatchewan to Montana; South Dakota to Colorado.

249. **ASTRAGALUS** L. Milk vetch.

617. **A. Canadensis** L. [*A. Carolinianus* L.]. Canada milk vetch.

Frequent on the plains, mesas, and along cañons in the foothills, 5100-7000 (Green Mt.) ft. (Daniels, 461).

Quebec to British Columbia; Florida to California.

618. **A. oreophilus** Rydb. Mountain milk vetch.

Plains, mesas, and foothills, local, 5100-8000 ft. (Daniels, 124).

Colorado.

619. **A. nitidus** Dougl. SHINING MILK VETCH.

Cañons, north slope of Green Mt., 7000 ft. (Daniels, 278).

SASKATCHEWAN to ALBERTA and OREGON; MINNESOTA to COLORADO.

620. **A. sulphurescens** Rydb. SULPHUR MILK VETCH.

Gregory Cañon, and cañons on Green Mt., 6000-7500 ft. (Daniels, 613). Also Boulder Cañon and near Boulder (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

COLORADO.

621. **A. virgultatus** Sheld. [*A. hypoglottis bracteosus* Osterh.]. BUSHY MILK VETCH.

At Boulder, 5000-8000 ft. (Rydberg).

WYOMING to COLORADO.

622. **A. goniatus** Nutt. [*A. hypoglottis polyspermus* T. & G.]. PURPLE MILK VETCH.

Abundant on the plains, mesas, and along streams in the foothills, 5100-9000 ft. (Daniels, 5).

SASKATCHEWAN to WASHINGTON; COLORADO to CALIFORNIA.

250. TIUM Medic.

623. **T. Drummondii** (Dougl.) Rydb. [*Astragalus Drummondii* Dougl.]. DRUMMOND'S MILK VETCH.

Mesas and foothills, 5700-8000 ft. (Daniels, 76). Valmont (Coulter in Wabash College Herb.).

SASKATCHEWAN to ALBERTA; NEBRASKA to COLORADO.

624. **T. alpinum** (L.) Rydb. [*Astragalus alpinus* L.]. ALPINE MILK VETCH.

Boulder Cañon above Falls; Eldora and along the Arapahoe Trail to timberline, 7000-11500 ft. (Daniels, 857).

LABRADOR to ALASKA; VERMONT to COLORADO: NORTHERN EUROPE and ASIA.

251. ATELOPHRAGMA Rydb.

625. **A. elegans** (Hook.) Rydb. [*Phaca elegans* Hook.; *Astragalus oroboides Americanus* Gray]. PRETTY MILK VETCH.

About Eldora and along the Arapahoe Trail to timberline and beyond, 8600-13000 ft. (Daniels, 1020).

LABRADOR and QUEBEC to SASKATCHEWAN; IDAHO to COLORADO.

252. XYLOPHACOS Rydb.

626. **X. Parryi** (Gray) Rydb. [*Astragalus Parryi* Gray]. PARRY'S MILK VETCH.

On rocks, Gregory Cañon road and other bare ridges in the foothills, 5900-9000 ft. (Daniels, 638).

WYOMING to COLORADO.

627. **X. Shortianus** (Nutt.) Rydb. [*Astragalus Shortianus* Nutt.]. SHORT'S MILK VETCH.

Dry plains, mesàs, and ridges in the foothills, 5100-9000 ft. (Daniels, 35).

NEBRASKA to WYOMING; COLORADO to ARIZONA.

253. HOMALOBUS Nutt.

628. **H. tenellus** (Pursh) Britton [*Astragalus tenellus* Pursh; *A. multiflorus* (Pursh) Gray]. SLENDER MILK VETCH.

Boulder Cañon above Falls and at Eldora, 7000-10000 ft. (Daniels, 539). Also at Ward, and mountains between Sunshine and Ward (Rydberg).

SASKATCHEWAN to YUKON; MINNESOTA and NEBRASKA to COLORADO and NEVADA.

629. **H. decumbens** Nutt. [*Astragalus decumbens* Gray]. DECUMBENT MILK VETCH.

Valley lying west of South Boulder Peak and Bear Mountain, 7000-7500 ft. (Daniels, 444).

WYOMING to COLORADO.

630. **H. campestris** Nutt. [*Astragalus campestris* Gray; A. *convallarius* Greene]. PLAINS MILK VETCH.

Meadows on Green Mountain, 6500-8100 ft. (Daniels, 316).

MONTANA to BRITISH COLUMBIA; COLORADO to UTAH.

631. **H. flexuosus** (Dougl.) Rydb. [*Phaca flexuosa* (Dougl.) Hook.; *Astragalus flexuosus* Dougl.]. FLEXILE MILK VETCH.

Near Boulder (Rydberg).

SASKATCHEWAN to ALBERTA; MINNESOTA to KANSAS and COLORADO.

632. **H. Salidae** Rydb. SALIDA MILK VETCH.
Plains in Boulder, 5600 ft. (Daniels, 4).
COLORADO.

254. OROPHACA Britton.

633. **O. tridactylica** (Gray) Rydb. [*Astragalus tridactylicus* Gray]. THREE-FINGERED MILK VETCH.
St. Vrain's Cañon (Rydberg; also Coulter in Wabash College Herb.).
COLORADO.

255. ARAGALLUS Necker. LOCO-WEED.

634. **A. deflexus** (Pall.) Heller [*Oxytropis deflexa* (Pall.) DC.]. DEFLEXED LOCO-WEED.
Boulder Cañon; also in subalpine meadows about Eldora and along the Arapahoe Trail, 6000-11000 ft. (Daniels, 808).
SASKATCHEWAN and ALASKA to NEW MEXICO.

634½. **A multiceps** (Nutt) Heller [*Oxytropis multiceps* Nutt.]. CESPITOSE LOCO-WEED.
Boulder Cañon, 9000 ft. (Coulter in Wabash College Herb.). Redrock lake, 10100 ft. (Ramaley & Robbins).
NEBRASKA to WYOMING and COLORADO.

635. **A. minor** (Gray) Cockerell. Nov. comb. [*Oxytropis multiceps minor* Gray; *A. multiceps minor* (Gray) A. Nels.]. LITTLE LOCO-WEED.
Sugarloaf, 8500 ft. (Cockerell). Also mountains between Sunshine and Ward, and at Caribou (Rydberg).
COLORADO.

636. **A. patens** Rydb. BROAD-LEAVED LOCO-WEED.
Plains and foothills near Boulder; below Sunshine and Ward; Eldora to Baltimore (Rydberg). Common throughout, 5500-9000 ft. (Daniels, 333). Boulder is the type locality.
COLORADO.

637. **A. Lamberti** (Pursh) Greene [*Oxytropis Lamberti* Pursh; *Spiesia Lamberti* (Pursh) Kuntze]. LAMBERT'S LOCO-WEED.

Abundant on the plains, mesas, foothills, and in subalpine meadows, 5100-9000 ft. (Daniels, 15). Also on the mountains between Sunshine and Ward, and from Eldora to Baltimore (Rydberg). Saint Vrain creek (Coulter in Wabash College Herb.).

MINNESOTA to MONTANA; MISSOURI to COLORADO.

638. **A. sericeus** (Nutt.) Greene [*Oxytropis sericea* Nutt.; *Spiesia Lamberti sericea* (Nutt.) Rydb.] SILKY LOCO-WEED.

With the preceding, 5100-9000 ft. (Daniels, 43).

NORTH DAKOTA to WYOMING; NEW MEXICO to ARIZONA.

639. **A. Richardsonii** (Hook.) Greene [*Oxytropis splendens Richardsonii* Hook.]. RICHARDSON'S LOCO-WEED.

In mountain valleys from Eldora to Baltimore (Rydberg).

SASKATCHEWAN to YUKON; and in the ROCKY MOUNTAINS to COLORADO.

256. GLYCYRRHIZA L. WILD LIQUORICE.

640. **G. lepidota** Nutt. SCALY WILD LIQUORICE.

Common along roads and railroads, and in the larger cañons, and on the plains throughout, 5100-8000 ft. (Daniels, 160).

ONTARIO to WASHINGTON; NEW YORK to ARIZONA and MEXICO.

257. AMORPHA L. FALSE INDIGO. LEAD PLANT.

641. **A. fruticosa** L. SHRUBBY FALSE INDIGO.

Along streams and in gulches in the mesas and plains, 5100-6000 ft. (Daniels, 50). Not in Rydberg's Flora. Prof. Ramaley reports *A. angustifolia* (Pursh) Boynton from Boulder, but according to Prof. Cockerell the specimen in the Univ. of Colorado Herbarium is *A. fruticosa* L.

OHIO to MANITOBA; FLORIDA to COLORADO and CHIHUAHUA.

642. **A. nana** Nutt. [*A. microphylla* Pursh]. SMALL-LEAVED FALSE INDIGO.

Dry plains between Boulder and Marshall, 5400 ft. (Daniels, 521).

IOWA to MANITOBA; MISSOURI to COLORADO.

258. PSORALEA L. INDIAN BREADROOT. POMME BLANCHE.

643. **P. tenuiflora** Pursh. FEW-FLOWERED INDIAN BREADROOT.

One of the commonest and most characteristic plants of the plains and mesas, and in open meadows on the foothills, 5100-8000 ft. (Daniels, 297). A white-flowered form is occasional (Daniels, 297a).

MINNESOTA to MONTANA; ILLINOIS to ARKANSAS, TEXAS and ARIZONA.

644. **P. argophylla** Pursh. SILVER-LEAF INDIAN BREADROOT.

Local on the plains and mesas, 5100-6000 ft. (Daniels, 189).

WISCONSIN to SASKATCHEWAN; MISSOURI to NEW MEXICO and ARIZONA.

259. PETALOSTEMON Lam. PRAIRIE CLOVER.

645. **P. oligophyllus** (Torr.) Rydb. [*P. gracilis oligophyllus* Torr.; *Kuhnistera oligophylla* (Torr.) Heller]. SLENDER WHITE PRAIRIE CLOVER.

On the plains and mesas, 5100-6000 ft. (Daniels, 161).

IOWA to ASSINIBOIA; TEXAS to ARIZONA and MEXICO.

646. **P. purpureus** (Vent.) Rydb. [*P. violaceus* Michx.; *Kuhnistera purpurea* (Vent.) MacM.]. VIOLET PRAIRIE CLOVER.

Common on the plains and mesas, 5100-7000 ft. (Daniels).

INDIANA to SASKATCHEWAN and ALBERTA; MISSOURI to TEXAS and NEW MEXICO.

647. **P. pubescens** A. Nelson. HAIRY VIOLET PRAIRIE CLOVER.

Plains about Boulder, 5600 ft. (Daniels, 349).

COLORADO.

260. VICIA L. Vetch.

648. **Vicia sparsifolia** Nutt. [*V. linearis* (Nutt.) Greene]. Narrow-leaved vetch.

Mesas and gulches about Boulder, 5600-6000 ft. (Daniels, 334).

Manitoba and Alberta to Idaho; Kansas to California.

649. **V. dissitifolia** (Nutt.) Rydb. [*Lathyrus dissitifolius* Nutt.]. Remote-leaved vetch.

In gulches and cañons in the plains, mesas, and foothills, 5100-9000 ft. (Daniels, 107).

Nebraska to Colorado.

650. **V. oregana** Nutt. Mountain vetch.

Common throughout in cañons and along the banks of streams, 5100-10000 ft. (Daniels, 78).

Minnesota to Saskatchewan and Washington; Kansas to California.

651. **V. producta** Rydb. Small-flowered mountain vetch.

Gulches on east slope of Flagstaff Hill, 6000 ft. (Daniels, 100).

Colorado to Utah; New Mexico to California.

261. LATHYRUS L. Vetchling.

652. **L. leucanthus** Rydb. White-flowered vetchling.

Common in gulches and cañons, 5700-7000 ft. (Daniels, 79).

Colorado to New Mexico.

262. APIOS Moench. Ground nut.

653. **A. Apios Boulderensis** Daniels. Nov. var. Boulder ground nut.

Differing from the typical eastern plant chiefly in the somewhat larger, thinner long-acuminate leaflets, which are nine as well as seven in number, the somewhat smaller brownish deep-violet flowers, which are densely granular under a lens. No pods were secured, nor tubers from the rootstock, only one vine being discovered, which it did not seem wise to uproot for fear of exterminating the plant in the only locality known for the ground nut in the Rocky Mountains.

One vine in a gulch at the foot of Flagstaff Hill, Aug. 18, 1906, 5900-6000 ft. (Daniels, 799).

The species ranges from NEW BRUNSWICK to ONTARIO; FLORIDA to LOUISIANA and EASTERN KANSAS.

Order 24. GERANIALES.

Family 62. GERANIACEAE J. St. Hil. Geranium family.

263. GERANIUM L. CRANESBILL.

654. **G. Richardsonii** Fish. & Traut. [*G. gracilentum* Greene]. RICHARDSON'S CRANESBILL.

Common in springy cañons and damp meadows in the foothills and mountains, 6500-8600 ft. (Daniels, 447).

SASKATCHEWAN to BRITISH COLUMBIA; NEW MEXICO to CALIFORNIA.

655. **G. Parryi** (Engelm.) Heller [*G. Fremontii Parryi* Engelm.]. PARRY'S CRANESBILL.

Meadows and gulches in the high mesas and foothills, 5700-8000 ft. (Daniels, 64). Long's Peak (Coulter in Wabash College Herb.).

WYOMING to COLORADO.

656. **G. Pattersonii** Rydb. PATTERSON'S CRANESBILL.

Eldora to Baltimore (Rydberg).

COLORADO.

657. **G. Fremontii** Torr. in Gray. FREMONT'S CRANESBILL.

Abundant on the plains, mesas, and mountain meadows, 5100-8600 ft. (Daniels, 62). Five miles north of Boulder (Cockerell). St. Vrain Cañon (Coulter in Wabash College Herb.).

COLORADO.

658. **G. longipes** (Wats.) Goodding [*G. Bicknellii* Britton]. BICKNELL'S CRANESBILL.

Waste places, acting like an introduced weed, about Boulder, and along Boulder Cañon road almost to the Falls in the vicinity of houses, 5100-7000 ft. (Daniels, 558).

NOVA SCOTIA to BRITISH COLUMBIA; NEW YORK to CALIFORNIA.

264. ERODIUM L. STORK'S-BILL.

659. **E. cicutarium** (L.) L'Her. HEMLOCK STORK'S-BILL. PIN-CLOVER.

Boulder (Rydberg), where it is very common (Cockerell).

EUROPE, thence to NORTH AMERICA.

Family 63. LINACEAE Dumont. **Flax family.**

265. LINUM L. FLAX.

660. **L. Lewisii** Pursh [*L. perenne Lewisii* (Pursh) Eat. & Wright]. LEWIS'S FLAX.

Abundant on the plains, mesas, and open mountain slopes, 5100-8600 ft. (Daniels, 132).

MACKENZIE to YUKON; TEXAS to CALIFORNIA and MEXICO.

661. **L. pratense** (Norton) Small. MEADOW FLAX.

Abundant in a meadow north of Boulder (Henderson & Cockerell).

Range of the preceding.

Family 64. OXALIDACEAE Lindl. **Wood sorrel family.**

266. XANTHOXALIS Small. YELLOW WOOD SORREL.

662. **X. stricta** (L.) Small [*Oxalis stricta* L.] UPRIGHT YELLOW WOOD SORREL.

Common throughout except at the higher elevations, especially along roads and railroads, and in yards about houses, 5100-8000 ft. (Daniels, 572).

NOVA SCOTIA to SOUTH DAKOTA; FLORIDA to TEXAS and COLORADO: adventitious in EUROPE.

Order 25. EUPHORBIALES.

Family 65. EUPHORBIACEAE St. Hil. **Spurge family.**

267. CROTON L. CROTON.

663. **C. Texensis** (Klotzsch) Muell. Arg. TEXAS CROTON.

Longmont and Boulder (Rydberg).

ILLINOIS to WYOMING; ALABAMA to ARIZONA and MEXICO.

268. **TRAGIA** L. Nettle spurge.

664. **T. ramosa** Torr. Branching nettle spurge.
Dry soil and under rocks, 5100-6000 ft. (Daniels, 86).
Missouri to Colorado; Texas to Arizona and Mexico.

269. **CHAMAESYCE** S. F. Gray. Spurge.

665. **C. petaloidea** (Engelm.) Small [*Euphorbia petaloidea* Engelm.]. White-flowered spurge.
Along the road and railroad in Boulder Cañon, and in creek-sands along Boulder creek, 5400-7000 ft. (Daniels, 775). Also at Longmont (Rydberg).
Iowa to Wyoming; Texas to Colorado.

666. **C. Fendleri** (T. & G.) Small [*Euphorbia Fendleri* T. & G.]. Fendler's spurge.
Foot of Valmont Butte, near Owen's lake, 5300-5400 ft. (Daniels, 666).
Nebraska to Wyoming; Texas to Arizona.

667. **C. glyptosperma** (Engelm.) Small [*Euphorbia glyptosperma* Engelm.]. Ridge-seeded spurge.
Abundant in sandy places and along railroads, 5100-7000 (Sunset Cañon) ft. (Daniels, 576).
Ontario to British Columbia; Texas to Mexico.

668. **C. rugulosa** (Engelm.) Rydb. [*Euphorbia serpyllifolia rugulosa* Engelm.]. Rugulose-seeded spurge.
Mountains between Sunshine and Ward (Rydberg).
Wyoming and New Mexico to California.

669. **C. serpyllifolia** (Pers.) Small [*Euphorbia serpyllifolia* Pers.]. Thyme-leaved spurge.
Very common in waste places, along roadsides and railroads, and on creek-sands, 5100-8000 ft. (Daniels, 420). Also at Lyons (Rydberg).
Michigan to Washington; Texas to California and Mexico.

270. **TITHYMALUS** Adans.

670. **T. marginatus** (Pursh) Cockerell [*Euphorbia marginata* Pursh; *Dichrophyllum marginatum* (Pursh) Kl. & Garcke]. SNOW-ON-THE-MOUNTAIN.

Plains and mesas about Boulder, 5100-6000 ft. (Daniels, 188). My specimens have flowers with five glands.

MINNESOTA to MONTANA; MISSOURI to TEXAS and COLORADO.

670a. **T. marginatus tetramerus** Cockerell. BOULDER SNOW-ON-THE-MOUNTAIN.

Very common about Boulder; although in some plants the central flower of each umbel has five petaloid appendages, the others have but three or four. An occasional form—*forma inornata* has the white margin of the leaves obsolete, or nearly so, but my material is too scant to enable me to determine whether this is characteristic of the variety alone, though a few of my specimens have the central flower with five appendages, 5100-7000 ft. (Daniels, 957).

671. **T. robustus** (Engelm.) Small [*Euphorbia montana robusta* Engelm.]. STOUT SPURGE.

High mesas fronting the Flat-irons, 5700-6000 ft. (Daniels, 187). Also at Longmont (Rydberg).

SOUTH DAKOTA to MONTANA; COLORADO to ARIZONA.

672. **T. philorus** Cockerell [*Euphorbia montana* Engelm.; not Raf.]. MOUNTAIN SPURGE.

Frequent on the plains, mesas and foothills, 5500-8000 ft. (Daniels, 16). Boulder Cañon (Porter & Coulter). A form,—*forma dichotoma* (Daniels, 367) from the high ridges of Green Mt. repeatedly forks into long leafy branches topped by a cluster of two or three flowers, with a few others in the axils of the upper leaves, the central cyme or umbel not being present.

COLORADO to UTAH; TEXAS to ARIZONA.

673. **T. Arkansanus** (Engelm. & Gray) Kl. & Garcke [*Euphorbia Arkansana* Engelm. & Gray]. ARKANSAS SPURGE.

Plains about Boulder, especially on the banks of irrigation ditches, 5100-6000 ft. (Daniels, 391).

MISSOURI to SOUTH DAKOTA and COLORADO; ALABAMA to ARIZONA.

271. **POINSETTIA** Graham.

674. **P. cuphosperma** (Engelm.) Small [*Euphorbia cuphosperma* Boiss.]. WARTY SPURGE.

Plains east of Boulder and along railroads, 5100-6000 ft. (Daniels, 692). Tenth Street, Boulder (Cockerell).

SOUTH DAKOTA to WYOMING; TEXAS to ARIZONA and MEXICO.

675. **P. dentata** (Michx.) Small [*Euphorbia dentata* Michx.]. TOOTHED SPURGE.

On the plains and mesas, frequent, 5100-6000 ft. (Daniels, 431).

PENNSYLVANIA to SOUTH DAKOTA; LOUISIANA to UTAH and MEXICO.

Family 66. CALLITRICHACEAE Lindl. Water starwort family.

272. **CALLITRICHE** L. WATER STARWORT.

676. **C. palustris** L. MARSH WATER STARWORT.

Aspen bog, Glacier Lake; also in streams and ponds about Boulder, 5100-9000 ft. (Daniels, 248). Eldora lake (W. W. Robbins).

NOVA SCOTIA to BRITISH COLUMBIA; FLORIDA to CALIFORNIA: EUROPE: ASIA: SOUTH AMERICA.

677. **C. bifida** (L.) Morong [*C. autumnalis* L.]. AUTUMNAL WATER STARWORT.

South Boulder creek, Arapahoe Road, common; in company with the preceding species, but more abundant, 5200-5400 ft. (Daniels, 738). Not in Rydberg's Flora.

QUEBEC to MANITOBA and OREGON; MICHIGAN to COLORADO.

Order 26. SAPINDALES.

Family 67. SPONDIACEAE Kunth. Cashew family.

273. TOXICODENDRON Miller. Poison ivy.

678. **T. Rydbergii** (Small) Greene [*Rhus Rydbergii* Small]. Rydberg's poison ivy.

Common along streams, roadsides, gulches, and cañons for some distance in the mountainous region, 5100-7000 (Bear Cañon) ft. (Daniels, 42).

Montana to British Columbia; Nebraska to Colorado.

274. RHUS L. Sumach.

679. **R. glabra cismontana** (Greene) Cockerell. Nov. comb. [*R. cismontana* Greene]. Cismontane sumach.

Common on the mesas and foothills, 5400-8000 ft. (Daniels. 221). Magnificently scarlet in the fall.

Dakota and Utah to New Mexico and Arizona.

275. SCHMALTZIA Desv. Fragrant sumac.

680. **S. trilobata** (Nutt.) Small [*Rhus trilobata* Nutt.]. Three-lobed fragrant sumac.

On the dry banks of streams, and on dry hills and ridges, 5400-8000 ft. (Daniels, 599).

Assiniboia to Washington; Missouri to Texas, California, and Mexico.

Family 68. ACERACEAE J. St. Hil. Maple family

276. ACER L. Maple.

681. **A. glabrum** Torr. Smooth maple.

In gulches and cañons and along streams, 5400-8600 ft. (Daniels, 96). Also in the mountains between Sunshine and Ward. and from Eldora to Baltimore (Rydberg).

Nebraska to Wyoming; New Mexico to Utah.

681a. **A. glabrum tripartitum** (Nutt.) Pax [*A. tripartitum* Nutt.]. Three-leaved maple.

Along Boulder Cañon road, 6000-7000 ft. (Daniels, 285).

Range of the type.

277. **RULAC** Adans. Box elder.

682. **R. Negundo** (L.) Hitchc. [*Acer Negundo* L. ; *Negundo Negundo* (L.) Karst.; *Negundo aceroides* Moench]. Common box elder.

Common along streams, 5100-7000 ft. (Daniels, 390). Also St. Vrain creek below Lyons (Ramaley).

Vermont to Idaho; Florida to Texas.

683. **R. Texanum** (Pax) Small [*Acer Texanum* Pax; *Acer Negundo Texanum* Pax]. Texan box elder.

Bear and Bluebell Cañons (Ramaley). Foothills near Boulder (Rydberg).

Saskatchewan to Montana; Missouri to Arizona.

Order 27. RHAMNALES.

Family 69. FRANGULACEAE D C. Buckthorn family.

278. **CEANOTHUS** L. New Jersey tea.

684. **C. velutinus** Dougl. Varnished New Jersey tea.

Common on the foothills, 6000-8000 ft. (Daniels, 272). Also mountains between Sunshine and Ward (Rydberg); Eldora and near foot of Long's Peak (Ramaley).

Montana to British Columbia; Colorado to California.

685. **C. mollissimus** Torr. [*C. ovatus pubescens* T. & G. ; *C. pubescens* (T. & G.) Rydb.] Hairy New Jersey tea.

Common on the mesas and foothills, 5600-8000 ft. (Daniels, 65). Eldora (Ramaley).

Michigan to South Dakota; Missouri to Colorado.

686. **C. subsericeus** Rydb. Silkish New Jersey tea.

Slopes of Green Mt., 6000-7000 ft. (Daniels, 756). Plains north of Marshall, and Boulder Cañon (Ramaley). Appears like a hybrid between the preceding and the next.

Colorado.

687. **C. Fendleri** Gray. Fendler's New Jersey tea.

Common on the mesas, foothills, and mountains, 5600-9000 ft. (Daniels, 91). Also in the mountains between Sunshine and Ward (Rydberg). South Boulder Cañon, and hill north of Nederland (Ramaley).

SOUTH DAKOTA to WYOMING; NEW MEXICO to ARIZONA.

Family 70. VITACEAE Lindl. Grape family.

279. VITIS L. GRAPE.

688. **V. vulpina** L. [*V. riparia* Michx.]. RIVER-BANK GRAPE.

Common along the banks of streams in the plains, mesas, and lower foothills, 5100-6000 ft. (Daniels, 110). Certain forms with strongly lobed leaves simulate *V. palmata* Vahl., and may be a distinct species.

NEW BRUNSWICK to NORTH DAKOTA; WEST VIRGINIA to TEXAS and COLORADO.

689. **V. Boulderensis** Daniels. Nov. sp. BOULDER GRAPE.

Plant weakly climbing, tendrils few, but these stout and little curled, bark reddish brown, the young twigs densely floccose pubescent, leaves small, at most 6 cm. long and wide, exclusive of the petiole, ovate to orbicular, the sinus often deep or sometimes shallow, broad and nearly obsolete; leaves mostly truncate at the top, the apices of the two shallow lateral lobes but little shorter than the main apex, the leaves, however, occasionally sharply acuminate, the margins coarsely dentate, slightly lobed, on slender petioles, which are loosely floccose as well as the veins both above and beneath, but becoming glabrate in age; clusters small, mostly in simple racemes, or with one or two prominent branches, fruit not set on the only vine discovered, and all flowers examined staminate.

Nearest *Vitis Arizonica* Engelm.

Gulch at base of Flagstaff Hill, 5800-6000 ft. (Daniels, 119).

280. PESEDERA Neck. VIRGINIA CREEPER.

690. **P. vitacea** (Hitchc.) Greene [*Ampelopsis quinquefolia vitacea* (Hitchc.) Knerr; *Parthenocissus vitacea* (Hitchc.)]. VINELIKE VIRGINIA CREEPER.

Common about streams and along fences, in the latter case perhaps the plant is *P. quinquefolia* (L.) Planch, introduced; my material which came from cañons in the foothills is, however, all of *P. vitacea* (Hitchc.) Greene, 5100-6500 ft. Daniels, 584).

MICHIGAN to WYOMING; OHIO to ARIZONA.

Order 28. MALVALES.

Family 71. MALVACEAE Neck. Mallow family.

281. MALVA L. MALLOW.

691. **M. rotundifolia** L. ROUND-LEAVED MALLOW. COMMON CHEESES.

Common in waste places, and following the roads and railroads, into the foothills, 5100-7000 ft. (Daniels, 587).

EUROPE, thence to NORTH AMERICA.

282. SIDALCEA Gray. WESTERN MALLOW.

692. **S. candida** Gray. WHITE WESTERN MALLOW.

Along irrigation ditches and streams and in moist mountain meadows, both at Boulder (rare) and at Eldora, 5400-11000 ft. (Daniels, 162).

WYOMING to NEW MEXICO and UTAH.

283. ALTHAEA L. HOLLYHOCK.

693. **A. rosea** Cav. COMMON HOLLYHOCK.

Escaped to roadsides and along streams at Boulder. 5300-5600 ft. (Daniels, 746).

TURKEY, GREECE, and CRETE, thence widely cultivated.

284. MALVASTRUM Gray. FALSE MALLOW.

694. **M. dissectum** (Nutt.) Cockerell. SCARLET FALSE MALLOW.

Common on the plains and mesas, 5100-6000 ft. (Daniels, 204).

SASKATCHEWAN to OREGON; IOWA to TEXAS and UTAH.

Order 29. HYPERICALES.

Family 72. HYPERICACEAE Lindl. St. Johnswort family.

285. HYPERICUM L. St. Johnswort.

694½. **H. formosum** H. B. K. Handsome St. Johnswort.
Common in mountain swamps (Ramaley).
Colorado and Utah to Mexico and Southern California.

695. **H. majus** (Gray) Britton [*H. Canadense majus* Gray]. Larger Canadian St. Johnswort.
Along streams in the plains, a dwarf form only a decimetre high, 5100-5400 ft. (Daniels, 787). Also foothills near Boulder (Rydberg).
Maine to British Columbia; New Jersey to Colorado.

Family 73. VIOLACEAE D C. Violet family.

286. VIOLA L. Violet.

696. **V. palustris** L. Marsh violet.
Eldora to Baltimore (Rydberg).
Labrador to Alaska; New York to Colorado.

697. **V. pallens** (Banks) Brainerd. Pale violet.
Caribou (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).
Newfoundland to British Columbia; North Carolina to Utah.

698. **V. cognata** Greene. Western blue violet.
Plains and foothills near Boulder (Rydberg).
South Dakota to Alberta; New Mexico to California.

699. **V. Nuttallii** Pursh. Nuttall's violet.
Plains and foothills near Boulder (Rydberg). Abundant at Boulder (Cockerell).
Manitoba to Montana; Missouri to New Mexico and Arizona.

700. **V. vallicola** A. Nels. [*V. physalodes* Greene]. VALLEY VIOLET.

Spruce forest, Bear Cañon, 7000 ft. (Daniels, 760). The plant in fruit only.

NORTH DAKOTA to MONTANA; COLORADO to UTAH.

701. **V. biflora** L. TWO-FLOWERED VIOLET.

Eldora to Baltimore (Rydberg).

COLORADO: EUROPE: ASIA.

702. **V. Canadensis Rydbergii** (Greene) House [*V. Rydbergii* Greene]. RYDBERG'S VIOLET.

Common in moist cañons and along streams, 5100-8000 ft. (Daniels, 126). Long's Peak (Coulter in Wabash College Herb.).

ALBERTA to IDAHO; SOUTH DAKOTA to COLORADO.

702a. **V. Canadensis Neo-Mexicana** (Greene) House [*V. Neo-Mexicana* Greene]. NEW MEXICO VIOLET.

Common in moist soil at Glacier Lake, Eldora, and Arapahoe Peak above timberline, 8000-12000 ft. (Daniels, 864). Also Eldora to Baltimore (Rydberg).

COLORADO to NEW MEXICO.

703. **V. bellidifolia** Greene. DAISY-LEAVED VIOLET.

Eldora to Baltimore (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

WYOMING to COLORADO.

287. CALCEOLARIA Loefl. NODDING VIOLET.

704. **C. linearis** (Torr.) Daniels. Nov. comb. [*Ionidium lineare* Torr.]. NARROW-LEAVED NODDING VIOLET.

Banks of stream at foot of Flagstaff Hill, 5700-6000 ft. (Daniels, 108).

KANSAS to COLORADO; TEXAS to ARIZONA and MEXICO.

Order 30. OPUNTIALES.

Family 74. LOASACEAE Reichenb. **Loasa family.**

288. NUTTALLIA Raf. WESTERN STAR.

705. **N. multiflora** (Nutt.) Greene [*Mentzelia multiflora* (Nutt.) Gray; *Touterea multiflora* (Nutt.) Rydb.] MANY-FLOWERED WESTERN STAR.

Common on the plains, mesas, and foothills, 5100-8000 ft. (Daniels, 77).

TEXAS to COLORADO, ARIZONA and MEXICO.

706. **N. speciosa** (Osterh.) Greene [*Mentzelia speciosa* Osterh. ; *Touterea speciosa* Osterh.]. SHOWY WESTERN STAR.

Near Boulder; also between Sunshine and Ward (Rydberg).

WYOMING to COLORADO.

707. **N. sinuata** (Rydb.) Daniels. Nov. comb. [*Touterea sinuata* Rydb.]. WAVY-LEAVED WESTERN STAR.

At Boulder the type-locality (Rydberg).

COLORADO.

708. **N. nuda** (Pursh) Greene [*Mentzelia nuda* (Pursh) T. & G. ; *Touterea nuda* (Pursh) Eat. & Wr.]. NAKED WESTERN STAR.

At Boulder (Rydberg).

NEBRASKA to WYOMING and COLORADO.

709. **N. stricta** (Osterh.) Greene [*Hesperaster strictus* Osterh.]. STRICT WESTERN STAR.

Along the Union Pacific Railroad, the flowers as large as in the next, but the outer filaments dilated, 5200-5400 ft. (Daniels, 678). Also at Lyons (Rydberg).

NEBRASKA to WYOMING; TEXAS to COLORADO.

710. **N. decapetala** (Pursh) Greene [*Bartonia decapetala* Pursh; *Mentzelia decapetala* (Pursh) Urb. & Gilg.; *M.*

ornata Pursh; *Touterea decapetala* (Pursh) Rydb.]. TEN-PETALLED WESTERN STAR.

Near Boulder (Rydberg).

ALBERTA to MONTANA; TEXAS to NEVADA.

289. ACROLASIA Presl. MENTZELIA.

711. **A. latifolia** Rydb. BROAD-LEAVED MENTZELIA.

At Boulder the type locality (Daniels). Between Sunshine and Ward (Rydberg).

COLORADO.

712. **A. albicaulis** (Dougl.) Rydb. [*Mentzelia albicaulis* Dougl.]. WHITE-STEMMED MENTZELIA.

Common in dry, especially sandy soil, 5100-6500 ft. (Daniels, 92).

NEBRASKA to BRITISH COLUMBIA; NEW MEXICO and UTAH.

712a. **A. albicaulis integrifolia** (Wats.) Daniels. Nov. comb. [*Mentzelia albicaulis integrifolia* Wats.; *A. integrifolia* (Wats.) Rydb.; *M. dispersa* Wats.]. ENTIRE-LEAVED MENTZELIA.

With the preceding, into which it apparently passes, 5100-6500 ft. (Daniels, 88).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

Family 75. CACTACEAE H. B. K. Cactus family.

290. CACTUS L. BALL CACTUS.

713. **C. viviparus** Nutt. [*Mamillaria vivipara* (Nutt.) Haw.]. VIVIPAROUS BALL CACTUS.

Near Long's Peak (Porter & Coulter).

NEBRASKA and MONTANA to COLORADO.

291. ECHINOCEREUS Engelm. PRICKLY CEREUS.

714. **E. viridiflorus** Engelm. [*Cereus viridiflorus* Engelm.]. GREEN-FLOWERED PRICKLY CEREUS.

Common on the plains, mesas, and foothills, 5100-8000 ft. (Daniels, 818). Not seen in flower.

KANSAS to WYOMING; TEXAS to NEW MEXICO.

292. **OPUNTIA** Mill. Prickly pear.

715. **O. mesacantha** Raf. [*O. humifusus* Raf.; *O. Rafinesquii* Engelm.]. Western prickly pear.

Abundant on the plains, mesas and foothills, the commonest cactus about Boulder, 5100-7000 ft. (Daniels, 93).

Wisconsin and Minnesota to Colorado; Kentucky and Texas to Arizona.

716. **O. polyacantha** Haw. Many-spined prickly pear.

On the mesas and foothills, apparently ascending higher than the preceding species, 5600-8000 ft. (Daniels, 690).

North Dakota to British Columbia; Oklahoma to New Mexico and Oregon.

717. **O. rhodantha** K. Sch. Red-flowered prickly pear.

On the foothills near the juncture of Sunset and Boulder Cañons, 6500 ft. (Daniels).

Nebraska to Colorado.

718. **O. Greenei** Englm., in Coult. Cont. U. S. Nat. Herb. **3.** 431, [*O. mesacantha Greenii* (Engelm.). Coult.]. Greene's prickly pear.

Vicinity of Boulder (Andrews).

Colorado.

719. **O. fragilis** (Nutt.) Haw. Brittle prickly pear.

Common on the plains, mesas, and lower foothills, 5100-6500 ft. (Daniels, 817). Not seen in flower.

Wisconsin to British Columbia; Kansas to New Mexico and Utah.

Order 31. THYMELIALES.

Family 76. ELAEAGNACEAE Lindl. Silverberry family.

293. **LEPARGYRAEA** Raf. Buffalo berry.

720. **L. Canadensis** (L.) Greene [*Shepherdia Canadensis* (L.) Nutt.]. Canadian buffalo berry.

Valleys in the foothills west of Bear Mountain and South Boulder Peaks, 7000 ft. (Daniels, 445). Also from Eldora to

Baltimore (Rydberg). Near Magnolia; Sugarloaf Mt.; Spencer Mt. (Ramaley).

NEWFOUNDLAND to ALASKA; NEW YORK and MICHIGAN to COLORADO and OREGON.

Order 32. MYRTALES.

Family 77. LYTHRACEAE Lindl. Loosestrife family.

293½. AMMANNIA L.

720½. **A. coccinea** Rottb. SCARLET AMMANNIA.

Marshall lake (W. W. Robbins).

MICHIGAN to SOUTH DAKOTA; FLORIDA to MEXICO: SOUTH AMERICA.

294. LYTHRUM L. LOOSESTRIFE.

721. **L. alatum** Pursh. WINGED LOOSESTRIFE.

Common in swales in the plains, 5100-5600 ft. (Daniels, 413).

MASSACHUSETTS to SOUTH DAKOTA; KENTUCKY to COLORADO.

Family 78. EPILOBIACEAE D C. Willowherb family.

295. CHAMAENERION Adans. FIREWEED.

722. **C. angustifolium** (L.) Scop. [*Epilobium angustifolium* L.]. GREAT WILLOW-HERB. NARROW-LEAVED FIREWEED.

Common throughout, especially in burns and in aspen thickets, 5700-10000 (Arapahoe Trail) ft. (Daniels, 211). Also at Caribou, and in the mountains between Sunshine and Ward (Rydberg). A form from the foothills has white flowers (Daniels, 196).

GREENLAND to ALASKA; NORTH CAROLINA to CALIFORNIA: EUROPE: ASIA.

722a. **C. angustifolium platyphyllum** Daniels. Nov. var.

Leaves remarkably large and broad, some being 17 cm. long and 4 cm. broad, and merely acutish at apex; lateral nerves evident, confluent in loops; flowers few, 2-3 cm. wide, dark purple, subtended by large leaves; style pubescent at base.

Cañons on Green Mt., 6500-7000 ft. (Daniels, 268).

296. **EPILOBIUM** L. WILLOW-HERB.

723. **E. occidentale** (Trelease) Rydb. [*E. adenocaulon occidentale* Trelease]. WESTERN WILLOW-HERB.

In wet ground at Caribou and Boulder (Rydberg).

MONTANA to ALBERTA; SOUTH DAKOTA to COLORADO.

724. **E. adenocaulon** Haussk. NORTHERN WILLOW-HERB.

Common in swales and along streams in the plains, and in mountain cañons and aspen bogs, 5100-8600 ft. (Daniels, 243).

NEW BRUNSWICK to WASHINGTON; PENNSYLVANIA to CALIFORNIA.

725. **E. rubescens** Rydb. REDDISH WILLOW-HERB.

In aspen bogs at Glacier Lake and Eldora, 8600-10000 ft. (Daniels, 707).

COLORADO.

725½. **E. alpinum** L. ALPINE WILLOW-HERB.

Redrock lake, 10100 ft. (Ramaley & Robbins).

GREENLAND and ALASKA to NEW HAMPSHIRE, COLORADO, and CALIFORNIA.

726. **E. anagallidifolium** Lam. PIMPERNEL WILLOW-HERB.

Mountain slopes above Bloomerville near snow, and above timberline on Arapahoe Peak in wet tundras, 10000-12000 ft. (Daniels, 325). Also at Caribou (Rydberg).

LABRADOR and ARCTIC AMERICA to ALASKA; COLORADO to NEVADA: EUROPE: ASIA.

727. **E. paniculatum** Nutt. PANICLED WILLOW-HERB.

Common, especially on creek-sands and along roads and railroads, 5100-8600 ft. (Daniels, 440).

LAKE HURON to ALBERTA and BRITISH COLUMBIA; COLORADO and ARIZONA to CALIFORNIA.

728. **E. adenocladon** (Haussk.) Rydb. [*E. paniculatum adenocladon* Haussk.]. GLANDULAR PANICLED WILLOW-HERB.

At Boulder (Rydberg).

SOUTH DAKOTA to WYOMING; COLORADO to UTAH.

297. GAYOPHYTUM Juss. GAYOPHYTE.

729. **G. intermedium** Rydb. INTERMEDIATE GAYOPHYTE.

Very common throughout except in the high alpine region, 5100-8600 (Eldora) ft. (Daniels, 159). Also at Caribou, Ward, and between Sunshine and Ward (Rydberg).

MONTANA to WASHINGTON; COLORADO to CALIFORNIA.

298. OENOTHERA L. EVENING PRIMROSE.

730. **O. strigosa** (Rydb.) Blankinship [*Onagra strigosa* Rydb.; *Oenothera biennis strigosa* Rydb.]. HAIRY EVENING PRIMROSE.

Common on the plains and foothills, 5100-8000 ft. (Daniels, 137).

MINNESOTA to WASHINGTON; MISSOURI to NEW MEXICO and UTAH.

731. **O. Hookeri** T. & G. [*O. biennis hirsutissima* Gray; *Onagra Hookeri* (T. & G.) Small]. HOOKER'S EVENING PRIMROSE.

Rare on the mesas and foothills, the flowers turning pink in withering, 5700-9000 ft. (Daniels, 562).

IDAHO to CALIFORNIA; NEW MEXICO to MEXICO.

299. ANOGRA Spach. WHITE EVENING PRIMROSE.

732. **A. albicaulis** (Pursh) Britton [*Oenothera albicaulis* Pursh; *O. pinnatifida* Nutt.]. WHITE-STEMMED WHITE EVENING PRIMROSE.

Common on the plains and mesas, and along the shore-sands of Boulder creek, 5100-7000 ft. (Daniels, 141).

NORTH DAKOTA to MONTANA; TEXAS to NEW MEXICO and SONORA.

733. **A rhizomata** A. Nels. RHIZOMATOUS WHITE EVENING PRIMROSE.

Local on the plains, but abundant where found, since it spreads fast with its slender rootstocks, 5600-5400 ft. (Daniels, 393).

WYOMING to COLORADO.

734. **A. Nuttallii** (Sweet) A. Nels. [*Oenothera Nuttallii* Lindl.]. NUTTALL'S WHITE EVENING PRIMROSE.

At Boulder (Rydberg).

MINNESOTA to IDAHO and COLORADO.

735. **A. coronopifolia** (T. & G.) Britton [*Oenothera coronopifolia* T. & G.]. CUT-LEAVED WHITE EVENING PRIMROSE.

At Boulder (Rydberg). Very common from Boulder and Marshall up to about 8000 ft. in dry soil (Ramaley).

SOUTH DAKOTA to WYOMING; KANSAS to NEW MEXICO.

300. PACHYLOPHUS Spach. SCAPOSE EVENING PRIMROSE.

736. **P. montanus** (Nutt.) A. Nels. [*Oenothera montana* Nutt.]. MOUNTAIN SCAPOSE EVENING PRIMROSE.

In eroded soil on Green Mountain and along Boulder Cañon road, 6000-8000 ft. (Daniels, 536).

ASSINIBOIA to IDAHO; COLORADO to NEVADA.

737. **P. macroglottis** Rydb. LARGE-THROATED SCAPOSE EVENING PRIMROSE.

At Boulder (Rydberg).

COLORADO.

738. **P. hirsutus** Rydb. HAIRY SCAPOSE EVENING PRIMROSE.

Mountains between Sunshine and Ward (Rydberg).

WYOMING to NEW MEXICO and UTAH.

301. LAVAUXIA Spach. DELAVAUX' EVENING PRIMROSE.

739. **L. brachycarpa** (Gray) Britton [*Oenothera brachycarpa* Gray]. SHORT-PODDED DELAVAUX' EVENING PRIMROSE.

At Boulder (Rydberg).

KANSAS to MONTANA; TEXAS to NEW MEXICO.

302. **MERIOLIX** Raf.

740. **M. serrulata** (Nutt.) Walp. [*Oenothera serrulata* Nutt.]. TOOTH-LEAVED EVENING PRIMROSE.

Common on the plains and foothills, 5100-8000 ft. (Daniels, 38).

MANITOBA to SASKATCHEWAN; TEXAS to ARIZONA.

303. **GAURA** L. GAURA.*

741. **G. parviflora** Dougl. SMALL-FLOWERED GAURA.

Frequent on the plains, mesas, and lower foothills, 5100-7000 ft. (Daniels, 263).

SOUTH DAKOTA to WASHINGTON; LOUISIANA to ARIZONA and SONORA.

742. **G. coccinea** Pursh. SCARLET GAURA.

Abundant on the plains and mesas, and in meadows on lower hillslopes, 5100-6300 ft. (Daniels, 12).

MANITOBA to MONTANA; TEXAS to ARIZONA and MEXICO.

743. **G. glabra** Lehm. SMOOTH GAURA.

At Boulder (Rydberg).

SOUTH DAKOTA to MONTANA; COLORADO to ARIZONA.

304. **CIRCAEA** L. ENCHANTER'S NIGHTSHADE.

744. **C. alpina** L. ALPINE ENCHANTER'S NIGHTSHADE.

Locally abundant along streams in shady cañons, 5700-8000 ft. (Daniels, 279).

LABRADOR to ALASKA; GEORGIA to COLORADO: EUROPE: ASIA.

*"Gaura and allied evening flowering plants have a special bee-visitor, *Halictus galpinsiae* Cockerell, which has been taken by my wife at Boulder. It flies in the evening, at 7:30 p. m., when the other bees have retired."—Prof. T. D. A. Cockerell, in a letter to the author, Jan. 23, 1908.

Family 79. GUNNERACEAE Endl. Gunnera family.

305. MYRIOPHYLLUM L. Water milfoil.

745. **M. spicatum** L. Spiked water milfoil.

Common in Boulder and Owen's lakes, 5200 ft. (Daniels, 661).

Newfoundland to Saskatchewan and Idaho; Florida to California: Europe: Asia.

Order 33. UMBELLALES.

Family 80. HEDERACEAE L. Ivy family.

306. ARALIA L. Wild sarsaparilla.

746. **A. nudicaulis** L. Common wild sarsaparilla.

Very common in shady cañons, 5700-9000 ft. (Daniels, 341). South Boulder Cañon (Ramaley).

Newfoundland to Manitoba and Idaho; North Carolina to Missouri and Colorado.

Family 81. CORNACEAE Link. Dogwood family.

307. SVIDA Opiz. Dogwood.

747. **S. stolonifera** (Michx.) Rydb. Red-oiser dogwood.

Common along streams throughout, 5100-10000 ft. (Daniels, 289). Sugarloaf Mt.; South Boulder Cañon (Ramaley).

Manitoba to Mackenzie and Alaska; Nebraska to Colorado and Arizona.

Family 82. AMMIACEAE Presl. Parsley family.

308. SANICULA L. Sanicle.

748. **S. Marilandica** L. Maryland sanicle. Black snakeroot.

Common in springy gulches and cañons, 5100-8000 ft. (Daniels, 71).

Newfoundland to Washington; Georgia to Colorado.

309. **OSMORRHIZA** Raf. Sweet cicely.

749. **O. longistylis** (Torr.) DC. [*Washingtonia longistylis* (Torr.) Britton]. Smooth sweet cicely.

Gulches in the mesas at the base of the foothills, rare, 5700-6300 ft. (Daniels, 118).

Nova Scotia to Assiniboia; Georgia to Colorado.

750. **O. obtusa** (C. & R.) Fernald [*Washingtonia obtusa* C. & R.]. Obtuse-fruited sweet cicely.

Common in cañons in the mesas, foothills and mountains, 5700-11000 (Arapahoe Trail) ft. (Daniels, 128).

Alberta to New Mexico and California.

310. **CARUM** L. Caraway.

751. **C. Carvi** L. Common caraway.

Escaped in the mountains between Sunshine and Ward (Rydberg).

Europe and the Mediterranean region to Thibet and Siberia, thence to North America.

311. **CICUTA** L. Water hemlock. Cowbane.

752. **C. occidentalis** Greene. Western cowbane. Western musquash root.

Swales in the plains, 5100-5600 ft. (Daniels, 412).

North Dakota to Idaho; New Mexico to California.

312. **HARBOURIA** C. & R. Harbour's hemlock.

753. **H. trachypleura** (Gray) C. & R. [*Cicuta trachypleura* (Gray) S. Wats.]. Rough-ribbed Harbour's hemlock.

At Boulder, and in the mountains between Sunshine and Ward (Rydberg). In Boulder Cañon (Porter & Coulter). St. Vrain Cañon (Coulter in Wabash College Herb.). Common in the foothills. (Daniels, 157, in part.)

Wyoming to New Mexico.

313. **ALETES** C. & R. Mountain caraway.

754. **A. obovata** Rydb. Obovate-leaved mountain caraway.

Very common on naked mountain slopes, 6000-8100 (summit of Green Mt.) ft. (Daniels, 145).

Colorado.

755. **A. acaulis** (Torr.) C. & R. [*Deweya acaulis* (Torr.); *Carum Hallii* S. Wats.]. STEMLESS MOUNTAIN CARAWAY.

High mesa at entrance to South Boulder Cañon, 5900-6000 ft. (Daniels, 422). Also in gulch south of Boulder (perhaps the same locality as the above), and in the mountains between Sunshine and Ward (Rydberg).

COLORADO to NEW MEXICO.

314. BERULA Hoffm.

756. **B. erecta** (Huds.) Coville [*B. angustifolia* (L.) Mert. & Koch]. CUT-LEAVED WATER PARSNIP.

In a springy puddle in the eastern part of Boulder, 5300-5400 ft. (Daniels, 410).

ONTARIO to BRITISH COLUMBIA; MASSACHUSETTS to TEXAS and CALIFORNIA: EUROPE: ASIA.

315. LIGUSTICUM L. LOVAGE.

757. **L. Porteri** C. & R. PORTER'S LOVAGE.

Common in shady cañons and gulches, 5700-10000 ft. (Daniels, 83). Also in the mountains between Sunshine and Ward (Rydberg). A plant was gathered in a cañon on the north slope of Green Mt., with somewhat differently shaped leaf-segments; it may possibly be *L. affine* A. Nels.

WYOMING to NEW MEXICO and ARIZONA.

316. MUSINEON Raf.

758. **M. divaricatum** (Pursh) C. & R. [*Seseli divaricatum* Pursh; *Adorium divaricatum* (Pursh) Rydb.]. LEAFY MUSINEON.

At Boulder (Rydberg).

ASSINIBOIA to ALBERTA; SOUTH DAKOTA to COLORADO.

317. OXYPOLIS Raf. WATER DROPWORT.

759. **O. Fendleri** (Gray) Heller [*Archemora Fendleri* Gray]. FENDLER'S WATER DROPWORT.

In bogs at Eldora and at Bloomerville, 8600-10000 ft. (Daniels, 310). Also between Sunshine and Ward (Rydberg).

WYOMING to NEW MEXICO.

318. CONIOSELINUM Hoffm. HEMLOCK PARSLEY.

760. **C. scopulorum** (Gray) C. & R. [*Ligusticum scopulorum* Gray]. ROCKY MOUNTAIN HELMLOCK PARSLEY.

In aspen bogs at Eldora, 8600-9000 ft. (Daniels, 721). Redrock lake, 10100 ft. (Ramaley & Robbins).

COLORADO to NEW MEXICO and ARIZONA.

319. HERACLEUM L. COW PARSNIP.

761. **H. lanatum** Michx. WOOLLY COW PARSNIP.

Common in gulches and cañons, 5100-8600 ft. (Daniels, 75). Also between Sunshine and Ward (Rydberg).

LABRADOR and NEWFOUNDLAND to ALASKA; NORTH CAROLINA to CALIFORNIA.

320. ANGELICA L. ANGELICA.

762. **A. Grayi** C. & R. GRAY'S ANGELICA.

In wet tundras, Arapahoe Peak, above timberline, 11500-13000 ft. (Daniels, 891).

WYOMING to COLORADO.

763. **A. ampla** A. Nels. LARGE ANGELICA.

Bear Cañon, 6000-7000 ft. (Daniels, 763).

WYOMING to COLORADO.

321. PASTINACA L. PARSNIP.

764. **P. sativa** L. COMMON PARSNIP.

Very common in waste places about Boulder, and along Boulder Cañon road well towards Falls, 5100-7000 ft. (Daniels, 560).

EUROPE, thence to NORTH AMERICA.

322. COGSWELLIA Sprengel. PARSLEY.

765. **C. orientalis** (C. & R.) Jones [*Lomatium orientale* C. & R.; *Peucedanum nudicaule* Nutt. in part].

Common in the foothills, 4000-8000 ft. (Daniels, 157 in part).

SOUTH DAKOTA, MONTANA and IDAHO to KANSAS, NEW MEXICO and ARIZONA.

323. PSEUDOCYMOPTERUS C. & R. FALSE CYMOPTERUS.

766. **P. sylvaticus** A. Nels. SYLVAN FALSE CYMOPTERUS.
Mountains between Sunshine and Ward (Rydberg).
WYOMING to COLORADO.

767. **P. multifidus** Rydb. [*P. montanus multifidus* Rydb.]. MULTIFID-LEAVED FALSE CYMOPTERUS.
Arapahoe Peak, above timberline, 11500-12000 ft. (Daniels, 899).
COLORADO.

Series 2. SYMPETALAE.

Order 34. ERICALES.

Family 83. MONOTROPACEAE Lindl. Indian pipe family.

324. PTEROSPORA Nutt. PINE DROPS.

768. **P. Andromedea** Nutt. GIANT BIRD'S-NEST.
Rare under pines on the north slopes of Green Mt., 6000-8100 ft. (Daniels, 530). Also on North and South Boulder Peaks (Rydberg).
NOVA SCOTIA to ALASKA; GEORGIA to CALIFORNIA.

Family 84. PYROLACEAE Agardh. Wintergreen family.

325. CHIMAPHILA Pursh. PIPSISSEWA.

769. **C. umbellata** (L.) Nutt. UMBELLATE PIPSISSEWA.
Common in shady cañons on Green Mt., 6500-8100 ft. (Daniels, 751). Also on north and south Boulder Peaks (Rydberg).
NOVA SCOTIA to ALASKA; GEORGIA to CALIFORNIA and MEXICO: EUROPE: ASIA.

326. MONESES Salisb. SINGLE DELIGHT.

770. **M. uniflora** (L.) Gray [*Pyrola uniflora* L.]. ONE-FLOWERED WINTERGREEN.
At Caribou (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).
LABRADOR to ALASKA; PENNSYLVANIA to COLORADO and OREGON: EUROPE: ASIA.

327. PYROLA L. WINTERGREEN. SHINLEAF.

771. **P. secunda** L. ONE-SIDED WINTERGREEN, or SHINLEAF.

Shady banks of cañons on the north slopes of Green Mt., mainly under Douglas spruce, 6500-8100 ft. (Daniels, 531). Also in the mountains between Sunshine and Ward (Rydberg).

LABRADOR to ALASKA; DISTRICT OF COLUMBIA to CALIFORNIA: EUROPE: ASIA.

772. **P. uliginosa** Torr. [*P. rotundifolia uliginosa* Gray]. BOG WINTERGREEN, or SHINLEAF.

With the preceding, 6500-8100 ft. (Daniels, 534). Also on South Boulder Peak (Rydberg).

NOVA SCOTIA to BRITISH COLUMBIA; NEW YORK to COLORADO and CALIFORNIA: JAPAN.

Family 85. ERICACEAE D C. Heath family.

328. ARCTOSTAPHYLOS Adans. BEARBERRY.

773. **A. Uva-ursi** (L.) Spreng. [*Uva-ursi Uva-ursi* (L.) Cockerell. nov. comb.; *U. procumbens* Moench]. RED BEARBERRY.

Common on dry slopes, 5800-8600 ft. (Daniels, 453). Also at Eldora and on the mountains between Sunshine and Ward (Rydberg). South Boulder Cañon; Sugarloaf Mt.; Pine Glade School; Copeland's (Ramaley). *Uva-ursi* (Tourn.) Miller, 1754, has priority over *Arctostaphylos* Adans. 1763, but should such a hyphenated word stand as a generic name?

LABRADOR and ARCTIC AMERICA to ALASKA; NEW JERSEY to COLORADO and OREGON: EUROPE: ASIA.

329. GAULTHERIA L. WINTERGREEN.

774. **G. humifusa** (Graham) Rydb. [*G. Myrsinitis* Hook.]. CREEPING WINTERGREEN.

Fourth of July Mine, 10000-11000 ft. (Andrews).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

330. KALMIA L. LAMBKILL.

775. **K. microphylla** (Hook.) Heller [*K. glauca microphylla* Hook.]. SMALL-LEAVED SWAMP LAUREL.

Above timberline, Arapahoe Peak, 11500-12000 ft. (Daniels, 900). Also at Caribou, and on Long's Peak (Rydberg). Camp Albion; Fourth of July Mine (Ramaley).

ALBERTA to ALASKA; COLORADO to CALIFORNIA.

Family 86. VACCINIACEAE Lindl. Blueberry family.

331. VACCINIUM L. BLUEBERRY. BILBERRY.

776. **V. caespitosum** Michx. DWARF BILBERRY.

From Eldora to Baltimore (Rydberg).

LABRADOR to ALASKA; NEW BRUNSWICK and NEW HAMPSHIRE to COLORADO and WASHINGTON.

777. **V. scoparium** Leiberg. [*V. Myrtillus microphyllum* HOOK; *V. erythrococcum* Rydb.]. RED-BERRIED BILBERRY.

Mountain slopes above Bloomerville near snow and on Arapahoe Peak above timberline, 9000-12000 ft. (Daniels, 331).

ALBERTA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

778. **V. oreophilum** Rydb. MYRTLE BLUEBERRY.

Common in coniferous forests at 10000 ft. (Ramaley), where it has been collected at Bald Mountain near Ward; Redrock lake above Ward; Fourth of July Mine; and at the foot of Long's Peak.

ALBERTA and BRITISH COLUMBIA to NEW MEXICO.

Order 35. PRIMULALES.

Family 87. PRIMULACEAE Vent. Primrose family.

332. PRIMULA L. PRIMROSE.

779. **P. angustifolia** Torr. NARROW-LEAVED PRIMROSE.

Arapahoe Peak above timberline in dry tundras near snow, 12000-13500 ft. (Daniels, 886).

COLORADO.

780. **P. Parryi** Gray. PARRY'S PRIMROSE.

Along cold streams crossing the Arapahoe Trail, and in wet tundras, Arapahoe Peak, above timberline, 9000-13000 ft. (Daniels, 921). Also at Caribou, and in the mountains south of Ward (Rydberg).

MONTANA to COLORADO and ARIZONA.

333. ANDROSACE L. Rock primrose.

781. **A. puberulenta** Rydb. Puberulent rock primrose.

Mountain slopes above Bloomerville near snow, 9200 ft. (Daniels, 338). Plains near Boulder (Rydberg).

Manitoba, Mackenzie and Alberta to New Mexico.

782. **A. pinetorum** Greene. Pine forest rock primrose.

Common under rocks in the foothills and mesas, 5700-8100 ft. (Daniels, 276). Probably Porter and Coulter's *A. septentrionalis* L. from Long's Peak is this plant, as is Coulter's plant from Long's Peak in Wabash College Herb.

Mackenzie to Yukon; Colorado to Arizona.

783. **A. subumbellata** (A. Nelson) Small. Subumbellate rock primrose.

Above timberline, Arapahoe Peak, a diminutive alpine form, 11500-12000 ft. (Daniels, 876).

Montana to Colorado and Arizona.

784. **A. diffusa** Small. Diffuse rock primrose.

At Glacier lake, 8500-9000 ft. (Daniels, 714). Also Massif de l' Arapahoe (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).

Mackenzie to British Columbia; New Mexico to Arizona.

785. **A. subulifera** (Gray) Rydb. [*A. septentrionalis subulifera* Gray]. Subuliferous rock primrose.

Near Boulder (Coulter).

Montana to Colorado.

334. STEIRONEMA Raf. Loosestrife.

786. **S. ciliatum** (L.) Raf. [*Lysimachia ciliata* L.]. Fringed loosestrife.

In springy grounds and moist cañons, 5100-8000 ft. (Daniels, 73).

Nova Scotia to British Columbia; Georgia to Arizona: naturalized in Europe.

335. CENTUNCULUS L. CHAFFWEED.

787. **C. minimus** L. LEAST CHAFFWEED.

Under pines, mesas south of Chautauqua grounds, Boulder, 5800 ft. (Daniels, 180). Not in Rydberg's Flora.

ILLINOIS and MINNESOTA to BRITISH COLUMBIA; FLORIDA to TEXAS and MEXICO: EUROPE: SOUTH AMERICA.

336. DODECATHEON L. SHOOTING STAR.

788. **D. philoscia** A. Nels. SHADE-LOVING SHOOTING STAR.

In the spray of Boulder Falls and along other deep cañons, 6500-8600 ft. (Daniels, 800).

WYOMING to COLORADO.

789. **D. radicatum** Greene. MANY-FLOWERED SHOOTING STAR.

Common in deep cañons, 6200-8000 ft. (Daniels, 274). Also from Eldora to Baltimore (Rydberg). Boulder Cañon (Coulter in Wabash College Herb.).

SOUTH DAKOTA to WYOMING; KANSAS to NEW MEXICO.

790. **D. sinuatum** Rydb. [*D. radicatum sinuatum* Rydb.]. WAVY-LEAVED SHOOTING STAR.

Occasional in cañons with the preceding, of which it seems to be merely a wavy-leaved form, 6200-8000 ft. (Daniels, 854).

COLORADO.

790½. **D. pauciflorum** (Durand) Greene. FEW-FLOWERED SHOOTING STAR.

Redrock lake, 10100 ft. (Ramaley & Robbins).

MACKENZIE and SASKATCHEWAN to COLORADO.

337. DROSACE A. Nels.

791. **D. carinata** (Torr.) A. Nels. [*Douglasia Johnstoni* Aven Nelson]. JOHNSTON'S DOUGLASIA.

Long's Peak (Aven Nelson), the type locality of *Douglasia Johnstoni*.

COLORADO.

Order 36. GENTIANALES.

Family 88. GENTIANACEAE Dumont. **Gentian family.**

338. EUSTOMA Salisb.

792. **E. Andrewsii** A. Nelson. ANDREWS'S EUSTOMA.
Near Boulder, the type locality (Andrews).
COLORADO.

339. ANTHOPOGON Heck. FRINGED GENTIAN.

793. **A. elegans** (A. Nels.) Rydb. [*Gentiana elegans* A. Nels.]. SHOWY FRINGED GENTIAN.
Long's Peak (Rydberg). Redrock lake, 10100 ft. (Ramaley & Robbins).
MACKENZIE to COLORADO and ARIZONA.

794. **A. barbellatus** (Engelm.) Rydb. [*Gentiana barbellata* Engelm.; *G. Moseleyi* A. Nels.]. BEARDED FRINGED GENTIAN.
Aspen bogs at Eldora and along streams crossing Arapahoe Trail, 8600-11000 ft. (Daniels, 863). Redrock lake, 10100 ft. (Ramaley and Robbins). The type of Nelson's *G. Moseleyi* is from Boulder Co.
COLORADO.

340. AMARELLA Gileb. GENTIAN.

795. **A. monantha** (A. Nels.) Rydb. [*Gentiana monantha* A. Nels.]. ONE-FLOWERED GENTIAN.
Above timberline in wet tundras, Arapahoe Peak, 11500-12000 ft. (Daniels, 897). Redrock lake, 10100 ft. (Ramaley & Robbins).
COLORADO.

796. **A. strictiflora** (Rydb.) Greene [*Gentiana amarella stricta* S. Wats.; *G. strictiflora* Rydb.] STRICT-FLOWERED GENTIAN.
Mountains between Sunshine and Ward (Rydberg).
SASKATCHEWAN to ALASKA; COLORADO to CALIFORNIA.

797. **A. scopulorum** Greene [*Gentianella Clementis* Rydb.]. CRAG GENTIAN.

Common in deep cañons and aspen bogs, 6500 (Green Mt.)-9000 ft. (Daniels, 608). Redrock lake, 10100 ft. (Ramaley & Robbins).

SOUTH DAKOTA to MONTANA; COLORADO to ARIZONA.

798. **A. plebeja** (Cham.) Greene [*Gentiana plebeja* Cham.; *G. amarella acuta* Gray, not Hook.]. LOW GENTIAN.

Ward (Cockerell).

MACKENZIE and ALASKA to COLORADO and CALIFORNIA. (?)

798a. **A. plebeja Holmii** (Wettst.) Rydb. [*Gentiana plebeja Holmii* Wettst.; *Amarella nana* Engelm.]. HOLM'S GENTIAN.

Above timberline, Arapahoe Peak, 11500-12000 ft. (Daniels, 944). Also at Caribou (Rydberg).

Range of the type.

341. CHONDROPHYLLA A. Nels.

799. **C. Fremontii** (Torr.) A. Nels. [*Gentiana Fremontii* Torr.]. FREMONT'S GENTIAN.

Long's Peak (Porter & Coulter; also Coulter in Wabash College Herb.).

WYOMING to COLORADO.

799½. **C. Americana** (Engelm.) A. Nels. [*Gentiana prostrata Americana* Engelm.]. AMERICAN GENTIAN.

Redrock lake, 10100 ft. (Ramaley & Robbins).

ALBERTA and ALASKA to COLORADO.

342. DASYSTEPHANA Adans. CLOSED GENTIAN.

800. **D. Romanzovii** (Ledeb.) Rydb. [*Gentiana Romanzovii* Ledeb.]. ROMANZOF'S CLOSED GENTIAN.

Above timberline, Arapahoe Peak, 11500-13000 ft. (Daniels, 892). Redrock lake, 10100 ft. (Ramaley & Robbins).

MONTANA to ALASKA; COLORADO to UTAH: ASIA.

801. **D. Parryi** (Engelm.) Rydb. [*Gentiana Parryi* Engelm.]. PARRY'S CLOSED GENTIAN.

Bogs at Eldora, thence along Arapahoe Trail to Arapahoe Peak, 8600-12000 ft. (Daniels, 847). Redrock lake, 10100 ft. (Ramaley & Robbins). Also mountains between Sunshine and Ward (Rydberg).

WYOMING to COLORADO and UTAH.

802. **D. Bigelovii** (Gray) Rydb. [*Gentiana Bigelovii* Gray]. BIGELOW'S CLOSED GENTIAN.

Dry mesas near entrance to Bear Cañon, 5800-6000 ft. (Daniels, 766).

COLORADO to NEW MEXICO and ARIZONA.

343. PLEUROGYNE Eschsch.

803. **P. fontana** A. Nels. [*P. rotata tenuifolia* Griseb.]. FOUNTAIN PLEUROGYNE.

At Caribou (Rydberg).

HUDSON BAY and ALASKA to COLORADO.

344. SWERTIA L.

804. **S. palustris** A. Nels. MARSH SWERTIA.

Along alpine streams, Arapahoe Trail, and in wet tundras, Arapahoe Peak, above timberline, 9000-12000 ft. (Daniels, 893). Redrock lake, 10100 ft. (Ramaley & Robbins).

MONTANA to COLORADO and UTAH.

804½. **S. congesta** A. Nels. DENSE-FLOWERED SWERTIA.

Long's Peak (Cooper).

MONTANA to COLORADO and UTAH.

345. FRASERA Walt. COLUMBO.

805. **F. stenosepala** Rydb. NARROW-SEPALLED COLUMBO.

On the mesas and foothills, common, 5700-8000 ft. (Daniels, 168). Also at Ward (Rydberg).

WYOMING to NEW MEXICO.

806. **F. speciosa** Dougl. SHOWY COLUMBO.

Redrock lake, 10100 ft. (Ramaley & Robbins).

SOUTH DAKOTA to MONTANA and OREGON; COLORADO to CALIFORNIA.

807. **F. angustifolia** Rydb. NARROW-LEAVED COLUMBO.
Mountains between Sunshine and Ward (Rydberg).
MONTANA to COLORADO.

Order 37. ASCLEPIADALES.

Family 89. APOCYNACEAE Lindl. Dogbane Family.

346. APOCYNUM L. DOGBANE.

808. **A. androsaemifolium** L. SPREADING DOGBANE.
South Boulder Cañon, and north of Nederland, 6500-9000 ft. (Ramaley).
ANTICOSTI to BRITISH COLUMBIA; GEORGIA to ARIZONA.

809. **A. scopulorum** Greene. CRAG DOGBANE.
Common on the foothills, 6000-9000 ft. (Daniels, 231). Sugarloaf (Ramaley).
SASKATCHEWAN and YUKON to COLORADO.

810. **A. lividum** Greene. PALE DOGBANE.
Eldora (Ramaley).
COLORADO.

811. **A. ambigens** Greene. SMOOTH DOGBANE.
In Boulder Cañon, Bear Cañon, and other valleys in the foothills, 5600-8000 ft. (Daniels, 515).
MONTANA to WASHINGTON; COLORADO to CALIFORNIA.

812. **A. cannabinum** L. INDIAN HEMP.
Along railroads and stream banks, and ascending along the cañons and gulches for some distance into the foothills, 5100-6500 ft. (Daniels, 348).
ANTICOSTI to WASHINGTON; FLORIDA to LOWER CALIFORNIA.

813. **A. hypericifolium** Ait. CLASPING-LEAVED DOGBANE.. ST. JOHNSWORT INDIAN HEMP.
Along the railroad between Boulder and Marshall, and along roads in the plains, 5100-6000 ft. (Daniels, 409).
ONTARIO to BRITISH COLUMBIA; OHIO to NEW MEXICO.

Family 90. ASCLEPIADACEAE. Milkweed family.

347. ACERATES Ell. Green milkweed.

814. **A. viridiflora** (Raf.) Eaton. Common green milkweed.

Occasional in the plains about Boulder, 5100-6000 ft. (Daniels, 405).

Massachusetts to Montana; Florida to New Mexico.

815. **A. angustifolia** (Nutt.) Dec. [*Asclepias stenophylla* Gray]. Narrow-leaved green milkweed.

Common in the plains about Boulder, 5100-6000 ft. (Daniels, 298).

South Dakota to Colorado; Missouri to Texas and New Mexico.

348. ASCLEPIAS L. Milkweed.

816. **A. speciosa** Torr. Showy milkweed.

Frequent in the plains about Boulder, 5100-6000 ft. (Daniels, 262).

Manitoba to British Columbia; New Mexico to California.

817. **A. brachystephana** Engelm. Short-crowned milkweed.

Rare on the plains about Boulder, 5100-6000 ft. (Daniels, 404).

Wyoming to Texas and Arizona.

818. **A. incarnata** L. Swamp milkweed.

In swales and along streams in the plains, 5100-6000 ft. (Daniels, 671).

New Brunswick to Manitoba; Florida to New Mexico.

819. **A. pumila** (Gray) Vail [*A. verticillata pumila* Gray]. Dwarf milkweed.

Local in the plains about Boulder, 5100-6000 ft. (Daniels, 386).

South Dakota to Montana; Arkansas to New Mexico.

Order 38. POLEMONIALES.

Family 91. CUSCUTACEAE Dumont. Dodder family.

349. CUSCUTA L. Dodder.

820. **C. curta** Engelm. [*C. Gronovii curta* Engelm.] Short-styled dodder.

On *Ambrosia psilostachya* DC., along Union Pacific Railroad east of Boulder, 5400 ft. (Daniels, 696).

Colorado to Utah.

821. **C. indecora** Choisy. Pretty dodder.

On *Thermopsis pinetorum* Greene. Rocky ledge at Marshall, 5600 ft. (Daniels, 426).

Illinois to Nebraska and Colorado; Florida to California; Tropical America.

Family 92. CONVOLVULACEAE Vent. Bindweed family.

350. EVOLVULUS L.

822. **E. Nuttallianus** R. & S. [*E. argenteus* Pursh]. Nuttall's evolvulus.

Common on the plains about Boulder, 5100-6000 ft. (Daniels, 474).

South Dakota to Colorado; Texas to Arizona.

351. PHARBITIS Choisy. Morning glory.

823. **P. purpurea** (L.) Voight [*P. hispida* Choisy; *Ipomoea purpurea* (L.) Roth]. Common morning glory.

Escaped along Arapahoe Road, 5300 ft. (Daniels, 792).

Tropical America, thence to North America.

352. CONVOLVULUS L. Bindweed.

824. **C. arvensis** L. Field bindweed.

Along streets of Boulder, 5300-5700 (Chautauqua grounds) ft. (Daniels, 816).

Europe, thence to North America.

825. **C. ambigens** House. HAIRY BINDWEED.

Plains near Boulder (Rydberg). Perhaps only a state of the preceding.

COLORADO to NEW MEXICO and CALIFORNIA.

353. VOLVULUS Medic. BRACTED BINDWEED.

826. **V. interior** (House) Cockerell. Nov. comb. [*Convolvulus interior* House]. INLAND BRACTED BINDWEED.

Low flats near Valmont Dike, 5200-5300 ft. (Daniels, 669).

NEBRASKA to COLORADO; OKLAHOMA to ARIZONA.

Family 93. POLEMONIACEAE. Jacob's ladder family.

354. PHLOX L. PHLOX.

827. **P. multiflora** A. Nelson. MANY-FLOWERED PHLOX.

North Boulder Peak (Rydberg).

MONTANA to COLORADO.

828. **P. depressa** (E. Nelson) Rydberg [*P. multiflora depressa* E. Nelson]. LOW PHLOX.

Dry slopes of the foothills, 6000-8000 ft. (Daniels, 105).

COLORADO.

829. **P. longifolia** Nutt. LONG-LEAVED PHLOX.

Near Long's Peak (Porter & Coulter; also Coulter in Wabash College Herb.).

MONTANA to WASHINGTON; COLORADO to OREGON.

355. MICROSTERIS Greene.

830. **M. micrantha** (Kellogg) Greene [*Collomia micrantha* Kellogg]. SMALL-FLOWERED MICROSTERIS.

At Boulder (Cockerell).

NEBRASKA to WYOMING; COLORADO to CALIFORNIA; SOUTH AMERICA (CHILI and BOLIVIA to MAGELLAN STRAITS).

356. LINANTHUS Benth.

831. **L. Harknessii** (Curran) Greene [*Gilia Harknessii* Curran]. HARKNESS' LINANTHUS.

Flood-sands of streams, north slope of Green Mt., 6000-8000 ft. (Daniels, 467).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

357. **GILIA** R. & P. GILIA.

832. **G. spicata** Nutt. SPIKED GILIA.

Mountains between Sunshine and Ward (Rydberg).

NEBRASKA to WYOMING; COLORADO to UTAH.

833. **G. attenuata** (Gray) A. Nelson [*G. aggregata attenuata* Gray]. ACUTE-LOBED GILIA.

Foothills and mesas about Boulder, 5700-9000 ft. (Daniels). White flowered, but it passes into the following variety through a series of forms of all shades of pink from nearly white to almost scarlet.

IDAHO to COLORADO and UTAH.

833a. **G. attenuata collina** (Greene) Cockerell. Nov. comb. [*Callisteris collina* Greene]. FOOTHILL GILIA.

Alpine forested slopes near Eldora, and also near the summit of Flagstaff Hill, 6000-9000 ft. (Daniels, 343). The pink of the flowers varies from nearly white to scarlet.

Range of the type?

834. **G. candida** Rydb. [*Callisteris leucantha* Greene]. WHITE GILIA.

Common on the mesas, foothills and mountain slopes, 5700-9000 ft. (Daniels, 46). Corollas often pinkish, perhaps hybrids with the above. Also South Boulder Peak, and in the mountains between Sunshine and Ward (Rydberg).

COLORADO.

835. **G. pinnatifida** Nutt. SMALL-FLOWERED GILIA.

Common throughout and very variable, 5100-10000 ft. (Daniels, 45). Also in the mountains between Sunshine and Ward (Rydberg).

NEBRASKA and WYOMING to NEW MEXICO.

836. **G. sinuata** Benth. WAVY-LEAVED GILIA.

Common in the plains, mesas, and lower foothills, 5100-6500 ft. (Daniels, 193).

COLORADO and NEW MEXICO to CALIFORNIA.

837. **G. inconspicua** (Smith) Dougl. INCONSPICUOUS GILIA.

On the foothills, 5900-8000 ft. (Daniels).

COLORADO and UTAH to ARIZONA and MEXICO.

358. COLLOMIA Nutt.

838. **C. linearis** Nutt. [*Gilia linearis* (Nutt.) Gray]. NARROW-LEAVED COLLOMIA.

Very common throughout in shady or half-shady places, especially on creek sands, 5100-9000 ft. (Daniels, 51). Also at Ward (Rydberg).

NORTH DAKOTA and MANITOBA to BRITISH COLUMBIA; ARIZONA to CALIFORNIA; introduced eastward.

838a. **C. linearis Boulderensis** Daniels. Nov. var.

Leaves narrower than in the type, sharply acuminate; flower-clusters densely capitate, the calyx-lobes and the bracts strongly pungent; a dwarfish form, blossoming earlier than the type. Near *Gilia linearis subulata* Gray.

Plains about Boulder, 5400-5700 ft. (Daniels, 60).

359. POLEMONIUM L. JACOB'S LADDER. GREEK VALERIAN.

839. **P. pulcherrimum** Hook. FAIREST JACOB'S LADDER.

Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 1021). Also from Eldora to Baltimore, and in the mountains between Sunshine and Ward, Brand makes this species a synonym of the next.

COLORADO.

840. **P. delicatum** Rydb. DELICATE JACOB'S LADDER.

At timberline (or just below) under shrubs, Arapahoe Peak, 10500-11500 ft. (Daniels, 872).

COLORADO and NEW MEXICO.

841. **P. molle** Greene. SOFT JACOB'S LADDER.

Eldora to Baltimore (Rydberg).

COLORADO.

842. **P. robustum** Rydb. STOUT GREEK VALERIAN.

Boulder creek near Falls, 6500-7500 ft. (Daniels, 296).

COLORADO.

843. **P. mellitum** (Gray) Greene [*P. confertum mellitum* Gray]. YELLOW GREEK VALERIAN.

Eldora to Baltimore (Rydberg).

WYOMING and COLORADO to NEVADA.

843½. **P. confertum** Gray. PURPLE GREEK VALERIAN.
Redrock lake, 10100 ft. (Ramaley & Robbins).
WYOMING to COLORADO.

844. **P. Brandegeei** (Gray) Greene [*Gilia Brandegéei* Gray]. BRANDEGEE'S GREEK VALERIAN.
Mountains between Sunshine and Ward (Rydberg).
COLORADO.

Family 94. HYDROLEACEAE. H. B. K. Hydrolea family.

360. HYDROPHYLLUM L. WATERLEAF.

845. **H. Fendleri** (Gray) Heller [*H. occidentale Fendleri* Gray]. FENDLER'S WATERLEAF.
Common along streams in shade, and in deep mountain cañons, 5100-8600 ft. (Daniels, 129). Also in the mountains between Sunshine and Ward (Rydberg).
WYOMING and IDAHO to NEW MEXICO.

361. MACROCALYX Trew.

846. **M. Nyctelea** (L.) Kuntze [*Ellisia Nyctelea* L.]. NYCTELEA.
Along streams and in gulches in mesas, 5100-6000 ft. (Daniels, 597).
SASKATCHEWAN to MONTANA; VIRGINIA to COLORADO.

362. PHACELIA Juss. PHACELIA.

847. **P. leucophylla** Torr. WHITE-LEAVED PHACELIA.
Mountains between Sunshine and Ward (Rydberg).
SOUTH DAKOTA to WASHINGTON; COLORADO to UTAH.

848. **P. heterophylla** Pursh. VARIOUS-LEAVED PHACELIA.
Common on the mesas and foothills, 5600-8000 ft. (Daniels, 40). Also Eldora to Baltimore (Rydberg).
MONTANA to WASHINGTON; COLORADO to CALIFORNIA.

849. **P. glandulosa** Nutt. GLANDULAR PHACELIA.
Boulder Cañon above Falls, 7000-8000 ft. (Daniels, 548).
MONTANA to TEXAS and ARIZONA.

850. **P. Neo-Mexicana alba** (Rydb.) Daniels. Nov. comb. White New Mexican Phacelia.

Eldora to Baltimore (Rydberg).

Wyoming to New Mexico.

363. EUTOCA R. Br.

851. **E. sericea** Graham in Hook. [*Phacelia sericea* (Grah.) Gray]. Silky Phacelia.

Common about Ward, 9000-9500 ft. (Daniels, 312). Also Eldora to Baltimore (Rydberg).

Montana to British Columbia; Colorado to Nevada.

Family 95. BORAGINACEAE Gray. Borage family.

364. LAPPULA Moench. Stickseed.

852. **L. floribunda** (Lehm.) Greene [*Echinospermum floribundum* Lehm.]. Large-flowered stickseed.

Frequent in Bear and Boulder Cañons, 6000-7500 ft. (Daniels, 448).

Manitoba to Alberta; New Mexico to California.

853. **L. angustata** Rydb. Narrow-leaved stickseed.

Common in cañons in the foothills, 5600-7500 ft. (Daniels, 674).

Colorado to Wyoming.

854. **L. occidentalis** (Wats.) Greene [*Echinospermum Redowskyi occidentale* Wats.] Western stickseed.

Common on the plains about Boulder, 5100-6000 ft. (Daniels, 6).

Saskatchewan to Washington; Missouri to New Mexico.

855. **L. cupulata** (Gray) Rydb. [*Echinospermum Redowskyi cupulatum* Gray]. Cupulate stickseed.

Plains about Boulder, 5100-6000 ft. (Daniels, 9).

South Dakota to Idaho; Texas to Colorado.

364½. ERITRICHIUM Schrader. MOUNTAIN FORGET-ME-NOT.

855½. **E. argenteum** Wight. SILVERY MOUNTAIN FORGET-ME-NOT.

Redrock lake, 10100 ft. (Ramaley & Robbins).

WYOMING and COLORADO to UTAH.

365. OREOCARYA Greene. MOUNTAIN NUT.

856. **O. suffruticosa** (Torr.) Greene [*Krynitzkia Jamesii* Gray]. JAMES'S MOUNTAIN NUT.

Slopes of Green Mountain, 6300 ft. (Daniels, 527). Plains and foothills near Boulder (Rydberg).

SOUTH DAKOTA to WYOMING and COLORADO.

857. **O. virgata** (Porter) Greene [*Krynitzkia virgata* (Porter) Gray]. VIRGATE MOUNTAIN NUT.

Common on the plains, mesas, and foothills, 5100-8000 ft. (Daniels, 19).

WYOMING to COLORADO.

857½. **O. pulvinata** A. Nels. PULVINATE MOUNTAIN NUT.

Redrock lake, 10100 ft. (Ramaley & Robbins).

COLORADO.

366. ALLOCARYA Greene.

858. **A. scopulorum** Greene. MOUNTAIN ALLOCARYA.

Aspen bogs at Glacier lake, 8600-9000 ft. (Daniels, 701). Also at Boulder (Rydberg).

MONTANA to WASHINGTON; COLORADO to NEVADA.

367. CRYPTANTHE Lehm.

859. **C. crassisepala** (T. & G.) Greene [*Krynitzkia crassisepala* (T. & G.) Gray]. THICK-SEPALLED CRYPTANTHE.

Frequent on the plains, 5100-6000 ft. (Daniels, 389).

SASKATCHEWAN to MONTANA; TEXAS to UTAH and MEXICO.

860. **C. Pattersonii** (Gray) Greene [*Krynitzkia Pattersonii* Gray]. PATTERSON'S CRYPTANTHE.
In the spray of Boulder Falls, 7500 ft. (Daniels, 609).
WYOMING and COLORADO.

368. MERTENSIA Roth. LUNGWORT. BLUEBELLS.

861. **M. punctata** Greene. PUNCTATE BLUEBELLS.
Bear Cañon, 7000 ft. (Daniels, 716).
COLORADO.

862. **M. polyphylla** Greene. MANY-LEAVED BLUEBELLS.
Along stream in alpine valley near snow, above Bloomerville, and in Boulder Cañon above the Falls, 8000-10000 ft. (Daniels, 320). Also from Eldora to Baltimore, and at Ward (Rydberg).
WYOMING to COLORADO.

863. **M. lateriflora** Greene. SIDE-FLOWERED LUNGWORT.
Along streams on mountain slope above Bloomerville near snow, 9300 ft. (Daniels. 337). Redrock lake, 10100 ft. (Ramaley & Robbins). Eldora to Baltimore (Rydberg).
COLORADO.

864. **M. viridula** Rydb. GREENISH LUNGWORT.
Cañons in the foothills, 6000-8000 ft. (Daniels, 34).
COLORADO.

865. **M. amoena** A. Nels. PLEASANT LUNGWORT.
At Boulder; and from Eldora to Baltimore (Rydberg).
WYOMING to COLORADO.

866. **M. linearis** Greene. LINEAR-LEAVED LUNGWORT.
Subalpine meadows, Boulder Cañon beyond the Falls, 7000-8000 ft. (Daniels, 226). Also at Boulder; and from Eldora to Baltimore (Rydberg).
ASSINIBOIA to NEBRASKA and COLORADO.

867. **M. lanceolata** (Pursh) DC. LANCE-LEAVED LUNGWORT.
Common throughout except in high alpine places, 5100-9000 ft. (Daniels, 14). Very variable.
MONTANA to COLORADO and NEW MEXICO.

868. **M. Secundorum** Cockerell. HAIRY LUNGWORT.

Near mouth of Boulder Cañon (Cockerell), the type locality, where it was discovered by students of the State Preparatory School, whence the specific name.

COLORADO.

869. **M. micrantha** Aven Nelson. SMALL-FLOWERED LUNGWORT.

Flagstaff Hill, 6000-6500 ft. (Daniels, 636). Also Sugar Loaf Mt., collected by Dr. Ramaley (Nelson), the type locality.

COLORADO.

870. **M. perplexa** Rydb. PERPLEXING LUNGWORT.

Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 645). Also mountains south of Ward the type-locality (Rydberg).

COLORADO.

871. **M. alpina** (Torr.) Don. ALPINE LUNGWORT.

Arapahoe Peak above timberline, 11500-12000 ft. (Daniels, 1022).

COLORADO.

369. LITHOSPERMUM L. GROMWELL. PUCCOON.

872. **L. canescens** (Michx.) Lehm. HOARY PUCCOON.

At Boulder (Rydberg).

ONTARIO to NORTH DAKOTA; ALABAMA to COLORADO and ARIZONA.

873. **L. linearifolium** Goldie [*L. angustifolium* Michx.]. NARROW-LEAVED PUCCOON.

At Boulder (Rydberg).

ILLINOIS and MANITOBA to BRITISH COLUMBIA; TEXAS to ARIZONA.

874. **L. breviflorum** Engelm. & Gray [*L. albescens* Greene]. SHORT-FLOWERED PUCCOON.

Common on the plains, mesas, and meadows on the lower foothills, 5100-6300 ft. (Daniels, 130).

ARKANSAS to COLORADO; TEXAS to NEW MEXICO and MEXICO.

370. **ONOSMODIUM** Michx. FALSE GROMWELL.

875. **O. occidentale** Mackenzie. WESTERN FALSE GROMWELL.

Common on the plains and mesas, 5100-6000 ft. (Daniels, 183). Also at Longmont (Rydberg).

MANITOBA to BRITISH COLUMBIA; MISSOURI to TEXAS and UTAH.

371. **LYCOPSIS** L. BUGLOSS.

876. **L. arvensis** L. SMALL BUGLOSS.

Roadsides near entrance to Boulder Cañon, 5400-5500 ft. (Daniels, 165). Not in Rydberg's Flora.

EUROPE and ASIA, thence to NORTH AMERICA.

Family 96. **VERBENACEAE** St. Hil. **Vervain family.**

372. **VERBENA** L. VERVAIN.

877. **V. hastata** L. BLUE VERVAIN.

Along streams in the plains, but ascending Boulder creek for a considerable distance into the foothills, 5100-6500 ft. (Daniels, 579).

NOVA SCOTIA to BRITISH COLUMBIA; FLORIDA to CALIFORNIA.

878. **V. bracteosa** Michx. [*V. rudis* Greene]. LARGE-BRACTED VERVAIN.

Common in waste places, and on the plains, 5100-6000 ft. (Daniels, 2).

MICHIGAN to ALBERTA and BRITISH COLUMBIA; FLORIDA to CALIFORNIA.

878a. **V. bracteosa albiflora** Cockerell. Nov. var. WHITE-FLOWERED LARGE-BRACTED VERVAIN.

Differs from the type in having white flowers. Campus of the University of Colorado, July 15, 1908 (Cockerell).

879. **V. ambrosifolia** Rydb. RAGWEED-LEAVED VERVAIN.

At Boulder, and in Boulder Co. (Rydberg).

SOUTH DAKOTA to COLORADO; TEXAS to ARIZONA and MEXICO.

879½. **V. Canadensis** (L.) Brit. [*V. Aubletia* Jacq.]. COMMON WILD VERBENA.

St. Vrain river (Porter and Coulter).

INDIANA to COLORADO; FLORIDA to NEW MEXICO and MEXICO.

373. PHYLA Lour. FOG-FRUIT.

880. **P. cuneifolia** (Torr.) Greene [*Lippia cuneifolia* Torr.]. WEDGE-LEAVED FOG-FRUIT.

Along the railroad between Boulder and Marshall, and on the sandy shores of Boulder creek for some distance in the foothills, 5300-6200 ft. (Daniels, 406).

SOUTH DAKOTA to WYOMING; TEXAS to ARIZONA and MEXICO.

Family 97. LAMIACEAE. Dead nettle family.

374. TEUCRIUM L. GERMANDER.

881. **T. occidentale** Gray. WESTERN GERMANDER.

Swales in the plains, 5100-5500 ft. (Daniels, 407).

ONTARIO to BRITISH COLUMBIA; PENNSYLVANIA to COLORADO and CALIFORNIA.

375. SCUTELLARIA L. SKULLCAP.

882. **S. galericulta** L. HOODED SKULLCAP.

At Boulder (Rydberg).

NEWFOUNDLAND to ALASKA; NORTH CAROLINA to ARIZONA: EUROPE: ASIA.

883. **S. Brittonii** Porter. BRITTON'S SKULLCAP.

Common on the foothills and mesas, 5700-8000 ft. (Daniels, 146). Also from Eldora to Baltimore (Rydberg). St. Vrain river, as *S. resinosa* Torr. (Porter and Coulter), unless this plant be indeed the next.

WYOMING to COLORADO.

883½. **S. virgulata** A. Nels. [*S. Brittonii virgulata* (A. Nels.) Rydb.]. WAND-LIKE SKULLCAP.

Along streams in mesas, 5700-6000 ft. (Daniels, 33).

WYOMING to COLORADO.

376. **NEPETA** L. Catnip. Catmint.

884. **N. Cataria** L. Common catnip.

Common in waste places, and following the roads for some distance in the foothills, 5100-8000 ft. (Daniels, 459).

Europe and Asia, thence to North America.

377. **GLECOMA** (*GLECHOMA*) L. Ground ivy.

885. **G. hederacea** L. [*Nepeta Glechoma* Benth.]. Gill-over-the-ground.

At Boulder (Rydberg). Found in Boulder, April, 1905, by Miss Tollie Rudd; a specimen was sent to Dr. Rydberg.

Europe and Asia, thence to North America.

378. **DRACOCEPHALUM** L. Dragon's-head.

886. **D. parviflorum** Nutt. Small-flowered dragon's-head.

Common on the plains and foothills, 5100-8000 ft. (Daniels, 87).

New York to Alaska; New Mexico to Arizona.

379. **PRUNELLA** (*BRUNELLA*) L. Self-heal. Heal-all.

887. **P. (B.) vulgaris** L. Common self-heal.

Common in damp places on the plains, and occasional in remote cañons, 5100-8000 ft. (Daniels, 240).

Europe and Asia, thence to North America, where northward it is possibly native.

380. **LEONURUS** L. Motherwort.

888. **L. Cardiaca** L. Common motherwort.

Common in waste places, and following the roads for some distance in the foothills, 5100-8000 ft. (Daniels, 460).

Europe and Asia, thence to North America.

381. **STACHYS** L. Hedge nettle.

889. **S. scopulorum** Greene. Crag hedge nettle.

In swales in the plains, 5100-5500 ft. (Daniels, 502). Also at Longmont (Rydberg).

Minnesota, Mackenzie and Alberta to New Mexico.

382. **SALVIA** L. SAGE.

890. **S. lanceolata** Willd. LANCE-LEAVED SAGE.
Common on the plains, 5100-6000 ft. (Daniels, 280).
SOUTH DAKOTA to MONTANA; TEXAS to ARIZONA and MEXICO.

383. **MONARDA.** L. HORSEMINT. BERGAMOT.

891. **M. menthaefolia** Grah. MINT-LEAVED BERGAMOT.
Common on the plains and foothills, 5100-8000 ft. (Daniels, 955). Also mountains between Sunshine and Ward (Rydberg).
ILLINOIS to MANITOBA and IDAHO; TEXAS to COLORADO.

892. **M. stricta** Wooton. STRICT BERGAMOT.
At Boulder (Rydberg).
WYOMING to NEW MEXICO and ARIZONA.

893. **M. mollis** L. SOFT BERGAMOT.
Common on the plains and foothills, 5100-8000 ft. (Daniels, 222).
MISSOURI to SOUTH DAKOTA and MONTANA; GEORGIA to TEXAS and COLORADO.

894. **M. pectinata** Nutt. [*M. Nuttallii* A. Nels.]. PECTINATE HORSE-MINT.
Abounding in the plains and mesas, 5100-6000 ft. (Daniels, 13). Boulder is the type-locality of *M. Nuttallii* A. Nels.
COLORADO to UTAH; TEXAS to ARIZONA.

895. **M. Ramaleyi** A. Nels. RAMALEY'S HORSE-MINT.
Boulder creek near Boulder, the type locality (Rydberg).
COLORADO.

384. **HEDEOMA** Pers. PENNYROYAL.

896. **H. hispida** Pursh. HISPID PENNYROYAL.
Common on the plains and mesas, 5100-6000 ft. (Daniels, 195).
COLORADO to UTAH; TEXAS to ARIZONA.

385. **LYCOPUS** L. WATER HOARHOUND.

897. **L. lucidus** Turcz. WESTERN WATER HOARHOUND.

Along ditches and streams, 5100-5400 ft. (Daniels, 783).

MINNESOTA to BRITISH COLUMBIA; MISSOURI to COLORADO and CALIFORNIA.

898. **L. Americanus** Muhl. [*L. sinuatus* Ell.; *L. Europeus sinuatus* (Ell.) Gray]. AMERICAN WATER HOARHOUND.

Along ditches and streams and in swales, 5100-6000 ft. (Daniels, 508).

NEWFOUNDLAND to BRITISH COLUMBIA; FLORIDA to CALIFORNIA.

386. **MENTHA** L. MINT.

899. **M. spicata** L. [*M. viridis* L.]. SPEARMINT.

Along the Arapahoe Road, 5300-5400 ft. (Daniels, 742).

EUROPE and ASIA, thence to NORTH AMERICA.

900. **M. Penardi** (Briq.) Rydb. [*M. arvensis Penardi* Briq.]. PENARD'S MINT.

Along ditches and streams, 5100-8000 ft. (Daniels, 164).

NEBRASKA to MACKENZIE and BRITISH COLUMBIA; COLORADO to UTAH.

Family 98. **SOLANACEAE** Pers. **Nightshade family.**

387. **PHYSALIS** L. GROUND CHERRY.

901. **P. longifolia** Nutt. [*P. lanceolata laevigata* Gray]. LONG-LEAVED GROUND CHERRY.

Boulder Cañon, 5600 ft. (Daniels, 153).

IOWA to MONTANA; ARKANSAS to ARIZONA and MEXICO.

902. **P. lanceolata** Michx. PRAIRIE GROUND CHERRY.

Common on the plains and mesas in loose or sandy soils, 5100-6000 ft. (Daniels, 523).

MICHIGAN to WYOMING; SOUTH CAROLINA to ARIZONA and MEXICO.

903. **P. Virginiana** Mill. VIRGINIA GROUND CHERRY.

Cultivated fields and roadsides on the plains, and foothills, appearing like an introduced weed, 5100-8000 ft. (Daniels, 684). Also between Sunshine and Ward (Rydberg).

New York to Manitoba and Montana; Florida to Texas and Colorado.

904. **P. heterophylla** Nees. Clammy ground cherry.

At Boulder and Longmont (Rydberg).

New Brunswick to Saskatchewan; Florida to Texas and Utah.

905. **P. comata** Rydb. Hairy western ground cherry.

Plains and mesas, 5100-6000 ft. (Daniels, 403).

Nebraska and Colorado to Texas.

906. **P. rotundata** Rydb. Round-leaved ground cherry.

Plains about Boulder, chiefly in loose sands, 5100-5700 ft. (Daniels, 487).

North Dakota to Colorado; Texas to New Mexico.

388. QUINCULA Raf. Purple ground cherry.

907. **Q. lobata** (Torr.) Raf. [*Physalis lobata* Torr.]. Lobed purple ground cherry.

At Boulder and Longmont (Rydberg). A few miles north of Boulder, abundant on the Pierre (Cretaceous) shales, May 1906 (Cockerell).

Kansas to Colorado; Texas to California and Mexico.

389. ANDROCERA Nutt. Bur nightshade.

908. **A. rostrata** (Dunal) Rydb. [*Solanum rostratum* Dunal; *A. lobata* Nutt.]. Common bur nightshade.

Common in waste places, 5100-6000 ft. (Daniels, 384). The original host of the Colorado beetle or potato-bug.

North Dakota to Wyoming; Texas to New Mexico and Mexico; as an introduced weed throughout the eastern United States.

390. SOLANUM L. Nightshade.

909. **S. triflorum** Nutt. Three-flowered nightshade.

Common in yards, waste places, and loose soils on the plains, 5100-6000 ft. (Daniels, 282).

Ontario to Alberta; Kansas to Arizona.

909½. **S. interius** Rydb. Inland nightshade.
Near Boulder (Rydberg).
Nebraska to Colorado; Texas to California.

910. **S. villosum** (Mill.) Lam. [*S. nigrum villosum* Mill.]. Villous nightshade.
At Boulder (Rydberg).
Wyoming to British Columbia; Colorado to Lower California.

391. LYCOPERSICON (*LYCOPERSICUM*) Mill. Tomato.

911. **L. Lycopersicum** (L.) Karst. [*Solanum Lycopersicum* L.]. Common tomato.
Adventitious along the Arapahoe Road, 5300-5400 ft. (Daniels, 791).
South America, thence common in cultivation.

392. LYCIUM L. Matrimony vine.

912. **L. vulgare** L. Common matrimony vine.
South of University Campus, Boulder (W. W. Robbins). Not in Rydberg's Flora.
Europe, Africa, and Asia, thence to North America.

393. DATURA L. Thorn-apple.

913. **D. Stramonium** L. Jimson weed.
Waste places, especially common along railroads, and on creek-sands in Boulder Cañon, 5100-6000 ft. (Daniels, 810).
Asia, thence cosmopolitan.

914. **D. Tatula** L. Purple thorn-apple.
Streets of Boulder, 5300-5600 ft. (Daniels, 566). Also at Salina (Ramaley).
South America, thence cosmopolitan.

394. NICOTIANA L. Tobacco.

915. **N. attenuata** Torr. Night-blooming tobacco.
Mountains between Sunshine and Ward (Rydberg).
Montana to British Columbia; New Mexico to California.

Family 99. RHINANTHACEAE St. Hil. Rattle-box family.

395. VERBASCUM L. Mullen.

916. **V. Thapsus** L. Common mullen.

Waste places and cultivated grounds, 5100-6000 ft. (Daniels, 457).

Europe and Asia, thence to North America.

917. **V. Blattaria** L. Moth mullen.

Along Union Pacific Railroad, near Boulder, 5200-5400 ft. (Daniels, 677).

Europe and Asia, thence to North America.

396. LINARIA Mill. Toad-flax.

918. **L. Canadensis** (L.) Dumont. Canada toad-flax.

Common on the mesas in pine groves south of the Chautauqua grounds, 5700-6000 ft. (Daniels, 179).

Nova Scotia to Washington; Florida to California: Central America: South America.

397. COLLINSIA Nutt. Innocence.

919. **C. tenella** (Pursh) Piper [*C. parviflora* Dougl.] Little blue-eyed Mary.

Shady springs and cañons in the foothills and gulches in the mesas, 5700-9000 ft. (Daniels, 267). Also at Ward (Rydberg). St. Vrain's Cañon (Coulter in Wabash College Herb.).

Ontario to British Columbia; Michigan to Arizona and California.

398. SCROPHULARIA L. Figwort.

920. **S. occidentalis** (Rydb.) Bickn. [*S. nodosa occidentalis* Rydb.]. Western figwort.

Cañons, common, 5700-8600 ft. (Daniels, 127).

North Dakota to Washington; Oklahoma to California.

399. PENTSTEMON Soland. Beard-tongue.

921. **P. oreophilus** Rydb. Mountain beard-tongue.

Common on the foothills and mountains, 6500-10000 ft.

(Daniels, 213). Also from Eldora to Baltimore (Rydberg).
COLORADO.

922. **P. alpinus** Torr. [*P. glaber alpinus* Gray; *P. riparius* A. Nels.]. ALPINE BEARD-TONGUE.
Common on the foothills and mountains, 6000-10000 ft. (Daniels, 214). Also at Ward (Rydberg).
COLORADO to WYOMING.

923. **P. unilateralis** Rydb. ONE-SIDED BEARD-TONGUE.
Common throughout in open places, 5300-8600 ft. (Daniels, 7). Also from Eldora to Baltimore (Rydberg).
WYOMING to NEW MEXICO.

924. **P. secundiflorus** Benth. SHARP-LEAVED BEARD-TONGUE.
Common throughout in open situations, 5100-8600 ft. (Daniels, 8).
WYOMING to NEW MEXICO.

925. **P. glaucus** Graham. GLAUCOUS BEARD-TONGUE.
Mountains south of Ward (Rydberg).
WYOMING to UTAH; COLORADO to ARIZONA.

925a. **P. glaucus stenosepalus** Gray. NARROW-SEPALLED BEARD-TONGUE.
Arapahoe Peak at timberline, 11000 ft. (Daniels, 936). Also Eldora to Baltimore (Rydberg). Redrock lake 10100 ft. (Ramaley and Robbins).
Range of the type, but strictly alpine.

926. **P. gracilis** Nutt. SLENDER BEARD-TONGUE.
Common on the plains, mesas, and lower foothills, 5100-8000 ft. (Daniels, 22).
MANITOBA to SASKATCHEWAN; TEXAS to COLORADO.

927. **P. humilis** Nutt. LOW BEARD-TONGUE.
Common throughout in open places, 5100-9200 (Ward) ft. (Daniels, 177). Also Eldora to Baltimore (Rydberg).
MONTANA and ALBERTA to COLORADO and NEVADA.

928. **P. Rydbergii** A. Nels. [*P. erosus* Rydb.]. RYDBERG'S BEARD-TONGUE.

Eldora to Baltimore (Rydberg).
WYOMING and WASHINGTON to COLORADO.

928½. **P. procerus** Dougl. TALL BEARD-TONGUE.
Redrock lake, 10100 ft. (Ramaley and Robbins).
SASKATCHEWAN to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

400. CHIONOPHILA Benth. SNOW-FLOWER.

929. **C. Jamesii** Benth. JAMES'S SNOW-FLOWER.
Arapahoe Peak above timberline, growing usually near the snow, 11500-13500 ft. (Daniels, 911).
WYOMING to COLORADO.

401. MIMULUS L. MONKEY FLOWER.

930. **M. Langsdorfii** Sims. LANGSDORF'S MONKEY FLOWER.
Between Sunshine and Ward (Rydberg).
ASSINIBOIA to ALASKA; NEW MEXICO to CALIFORNIA and MEXICO.

930a. **M. Langsdorfii minor** (A. Nels.) Cockerell. Nov. comb. [*M. minor* A. Nelson]. SMALL LANGSDORF'S MONKEY FLOWER.
Near Boulder, the type locality (A. Nelson).
COLORADO.

931. **M. puberulus** Greene. PUBERULENT MONKEY FLOWER.
Subalpine bogs along streams, Eldora, 8600 ft. (Daniels, 853).
COLORADO.

932. **M. Hallii** Greene. HALL'S MONKEY FLOWER.
Moist banks of stream at foot of Flagstaff Hill, 5700-6000 ft. (Daniels, 25).
COLORADO.

933. **M. Geyeri** Torr. [*M. Jamesii* T. & G.] GEYER'S MONKEY FLOWER.
Along streams and irrigation ditches, 5100-7000 ft. (Daniels, 904).
MICHIGAN to NORTH DAKOTA; ILLINOIS to COLORADO.

934. **M. floribundus** Dougl. MANY-FLOWERED MONKEY FLOWER.

Common in wet sands along streams and ditches, 5100-8000 ft. (Daniels, 247). Also mountains between Sunshine and Ward (Rydberg).

MONTANA to BRITISH COLUMBIA; ARIZONA to CALIFORNIA.

402. LIMOSELLA L. MUDWORT.

935. **L. aquatica** L. AQUATIC MUDWORT.

In shallow water at the margins of Owen's lake, and also Glacier lake, 5200-9000 ft. (Daniels, 662).

Cosmopolitan in cold and alpine situations.

403. GRATIOLA L. HEDGE HYSSOP.

936. **G. Virginiana** L. CLAMMY HEDGE HYSSOP.

Limose places along streams and irrigation ditches, 5100-5800 ft. (Daniels, 377). Marshall lake (W. W. Robbins).

QUEBEC to BRITISH COLUMBIA; FLORIDA to CALIFORNIA.

404. VERONICA L. SPEEDWELL. BROOKLIME.

937. **V. Americana** Schwein. AMERICAN BROOKLIME.

In springs and shallow streams, 5100-8000 ft. (Daniels, 70).

ANTICOSTI to ALASKA; PENNSYLVANIA to CALIFORNIA.

938. **V. Wormskjoldii** R. & S. WORMSKJOLD'S SPEEDWELL.

Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 927). Redrock lake, 10100 ft. (Ramaley and Robbins).

GREENLAND to ALASKA; NEW HAMPSHIRE to COLORADO and CALIFORNIA.

939. **V. serpyllifolia** L. THYME-LEAVED SPEEDWELL.

Aspen bogs at Eldora, 8600 ft. (Daniels, 869). Also at Caribou (Rydberg).

COSMOPOLITAN, except AFRICA and AUSTRALIA.

940. **V. Xalapensis** H. B. K. XALAPA SPEEDWELL.

Common in limose places, 5100-8000 ft. (Daniels, 577). Young's *V. peregrina* from the forests about Boulder is doubtless this plant.

SASKATCHEWAN to BRITISH COLUMBIA; TEXAS to CALIFORNIA.

941. **V. agrestis** L. FIELD SPEEDWELL.

Boulder, April, 1905 (Chas. Sellers). Not in Rydberg's Flora.

EUROPE and ASIA, thence to NORTH AMERICA.

942. **V. Byzantina** (Sibth. & Smith) B. S. P. [*V. Buxbaumii* Tenore]. BYZANTINE SPEEDWELL.

At Boulder (Rydberg).

EUROPE and ASIA, thence to NORTH AMERICA.

405. BESSEYA Rydb.

943. **B. alpina** (Gray) Rydb. [*Synthyris alpina* Gray]. ALPINE SYNTHYRIS.

Massif de l' Arapahoe (Rydberg).

WYOMING to COLORADO.

406. GERARDIA L. PURPLE FALSE FOXGLOVE.

944. **G. Besseyana** Britton. BESSEY'S PURPLE FALSE FOXGLOVE.

Along irrigation ditches, Arapahoe Road, 5200-5400 ft. (Daniels, 789). Also at Longmont (Rydberg).

IOWA to WYOMING; LOUISIANA to COLORADO.

407. CASTILLEJA Mutis. PAINTED CUP. INDIAN PINK. PAINT BRUSH.

945. **C. linariaefolia** Benth. TOAD-FLAX-LEAVED PAINTED CUP.

Very common on the foothills and mountain slopes, and occasional on the higher mesas, 5800-9000 ft. (Daniels, 538). Also North Boulder Peak (Rydberg).

WYOMING to NEW MEXICO, CALIFORNIA and MEXICO

945a. **C. linariaefolia filiformis** Daniels. Nov. var. FILLFORM TOAD-FLAX-LEAVED PAINTED CUP.

Plant dwarf, 1-2¼ decimetres high, stem purplish, villous at the base, leaves filiform, 1 mm. wide, 3-4¼ cm. long, the lower with an occasional lobe or two; flowers few with cleft bracts, the lower of which are green, the upper crimson, these and the flowers puberulent, rather than villous as in the type.

Barren ridges between Sugarloaf Mountain and Glacier Lake, 8700-9200 ft. (Daniels, 976).

946. **C. Crista-galli** Rydb. Cockscomb painted cup.
Eldora to Baltimore (Rydberg).
Montana to Colorado.

947. **C. cognata** Greene. Yellow painted cup.
North slopes of Green Mountain; rare, 7000 ft. (Daniels, 975). Prof. T. D. A. Cockerell suggests that this plant is probably a hybrid of *C. linariaefolia* Benth. and *C. sulphurea* Rydb.
Colorado.

948. **C. integra** Gray. Entire-leaved painted cup.
Abundant throughout, except on the alpine summits; on the plains occurring principally on banks and ridges, 5600-9000 ft. (Daniels, 169). Also from Eldora to Baltimore (Rydberg).
Colorado to New Mexico, Arizona and Mexico.

948½. **C. rhexifolia** Rydb. Rhexia-leaved painted cup.
Redrock lake, 10100 ft. (Ramaley and Robbins).
Alberta and Alaska to Colorado.

949. **C. confusa** Greene. Confused painted cup.
Subalpine meadows, but a few plants were also found on a high bank in the mesas at base of the Flat-irons, 5800-10000 ft. (Daniels, 959). Also at Silver lake and north of Nederland (Ramaley); and from Eldora to Baltimore (Rydberg).
Wyoming to Colorado.

950. **C. Arapahoensis** Daniels. Nov. spec. Arapahoe painted cup.

Perennial, the tufted stems, 2-2½ dm. high, curved at the base, smooth or slightly pubescent below, sparingly villous with white hairs above; basal leaves short, purplish, obtusely spatulate, 8-10 mm. long, about 3 mm. wide; lower stem-leaves, as well as the leaves of the sterile shoots narrowly linear 2½-3¾ cm. long, 3-5 mm. wide, acuminate, 3-ribbed, puberulent; thence the leaves increase progressively in width to the inflorescence, where they are from ½-1 cm. wide, lanceolate acuminate, slightly-clasping at the base, entire, the uppermost pubescent, or somewhat villous on the midribs and margins, three-ribbed, the leaf-traces visible as prominent ridges on the stem; bracts of the inflorescence relatively broad, the lowermost 1-1¼ cm. broad, about 2 cm. long, subacute; the uppermost shorter and relatively broader, obtuse or rounded at the apex; some of the bracts occasionally notched toward the apices, or slightly lobed on each side; the margins and veins somewhat villous; the bracts, as well as the uppermost leaves rosy-pink; calyx with four nearly equal subacute lobes, the sinus of the lateral lobes shallow; calyx rosy-pink, villous; corolla exserted, 2½ cm. long, glabrous, or slightly puberulent above, the tip of the galea rosy pink, which is thrice the length of the slightly incurved lip; the upper pair of stamens more or less extruded from the galea; capsule black-purple 4-5 mm. long, oblong, abruptly acutish.

Wet tundras, above timberline, Arapahoe Peak, Sept. 1, 1906, 11000-12000 ft. (Daniels, 910).

951. **C. lauta** A. Nels. [*C. oreopola subintegra* Fernald]. SUBENTIRE PAINTED CUP.

Near Fourth of July Mine (Ramaley and Robbins).

MONTANA and OREGON to COLORADO.

952. **C. lancifolia** Rydb. LANCE-LEAVED PAINTED CUP.

Mountains between Sunshine and Ward (Rydberg).

ALASKA to OREGON, MONTANA and COLORADO.

953. **C. occidentalis** Torr. [*C. pallida occidentalis* (Torr.) Gray]. WESTERN PAINTED CUP.

Above timberline, Arapahoe Peak, 11000-13000 ft. (Daniels, 884), where also collected by Ramaley & Robbins. Also at Ward (Rydberg). A dwarf alpine form (about 1 dm. high) occurs on the higher altitudes of Arapahoe Peak.

ALBERTA and BRITISH COLUMBIA to COLORADO.

954. **C. sulphurea** Rydb. SULPHUR PAINTED CUP.

Subalpine mountain-slopes and valleys at Eldora and Glacier Lake, 8500-10000 ft. (Daniels, 623). Also at Ward (Rydberg).

SOUTH DAKOTA to WYOMING; COLORADO to UTAH.

408. ORTHOCARPUS Nutt.

955. **O. luteus** Nutt. YELLOW ORTHOCARPUS.

Abundant on the plains and mesas, 5100-6000 ft. (Daniels, 352). Also between Sunshine and Ward (Rydberg).

SASKATCHEWAN to WASHINGTON; COLORADO to NEVADA.

409. ELEPHANTELLA Rydb. LITTLE RED ELEPHANT.

956. **E. Groenlandica** (Retz.) Rydb. [*Pedicularis Groenlandica* Retz.]. GREENLAND LITTLE RED ELEPHANT.

Subalpine meadows at Eldora, thence to Arapahoe Peak above timberline, 8500-12000 ft. (Daniels, 625). Also from Eldora to Baltimore (Rydberg); Ward (Cockerell).

GREENLAND and HUDSON BAY to BRITISH COLUMBIA; LABRADOR to NEW MEXICO and CALIFORNIA.

410. PEDICULARIS L. LOUSEWORT.

957. **P. racemosa** Dougl. RACEMOSE LOUSEWORT.

Eldora to Baltimore (Rydberg). Redrock lake, 10100 ft. (Ramaley and Robbins).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

958. **P. Parryi** Gray. PARRY'S LOUSEWORT.

Above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels). 1023). Redrock lake, 10100 ft. (Ramaley & Robbins).

WYOMING to COLORADO and UTAH.

959. **P. Grayi** A. Nels. [*P. procera* Gray]. GRAY'S LOUSEWORT.

Subalpine slopes at Eldora, 8500-10000 ft. (Daniels, 644). Also at Ward (Cockerell).

WYOMING to COLORADO.

960. **P. scopulorum** Gray. CRAG LOUSEWORT.

Above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels, 882). Redrock lake, 10100 ft (Ramaley and Robbins).

COLORADO.

Family 100. PINGUICULACEAE. Dumort. **Butterwort family.**

411. UTRICULARIA L. BLADDERWORT.

961. **U. vulgaris** L. COMMON BLADDERWORT.
Cold marsh near Long's Peak (Porter & Coulter).
NORTH AMERICA: EUROPE: ASIA.

Eamily 101. OROBANCHACEAE. Lindl. **Broom-rape family.**

412. THALESIA Raf. CANCER-ROOT.

962. **T. fasciculata** (Nutt.) Britton [*Aphyllon fasciculatum* (Nutt.) Gray]. CLUSTERED CANCER-ROOT.
Plains, mesas and foothills, 5100-8000 ft. (Daniels, 18). All the plants collected were parasitic on the roots of *Psoralea tenuiflora* Pursh. My plants, as also some collected by Prof. Cockerell north of Boulder, have larger calyx lobes (5-6 mm.) than is usual in eastern plants.
INDIANA to YUKON; COLORADO to CALIFORNIA and MEXICO.

962a. **T. fasciculata lutea** (Parry) Britton. YELLOW CLUSTERED CANCER-ROOT.
Boulder (W. P. Cockerell).
Range of the type?

Order 39. PLANTAGINALES.

Family 102. PLANTAGINACEAE. Lindl. **Plantain family.**

413. PLANTAGO L. PLANTAIN.

963. **P. major** L. COMMON PLANTAIN.
Waste places and along ditches, 5100-6000 ft. (Daniels, 675).
Cosmopolitan.

964. **P. lanceolata** L. ENGLISH PLANTAIN. RIBGRASS.
Waste places and roadsides, 5100-6000 ft. (Daniels, 793).
EUROPE and ASIA, now cosmopolitan.

965. **P. Purshii** R. & S. [*P. Patagonica gnaphalioides* (Nutt.) Gray]. PURSH'S PLANTAIN.

Common on the plains, 5100-6000 ft. (Daniels, 494).

ONTARIO to BRITISH COLUMBIA; MISSOURI and TEXAS to ARIZONA and MEXICO.

Order 40. RUBIALES.

Family 103. RUBIACEAE. Juss. Madder family.

414. GALIUM L. BEDSTRAW.

966. **G. Vaillantii** DC. [*G. Aparine Vaillantii* Koch]. VAILLANT'S BEDSTRAW.

In gulches and cañons, mainly in the shade, 5100-8000 ft. (Daniels, 120).

MONTANA and BRITISH COLUMBIA to MEXICO.

967. **G. boreale** L. NORTHERN BEDSTRAW.

Common on the mesas, foothills and mountainsides, 5600-8600 ft. (Daniels, 89). Also between Sunshine and Ward (Rydberg).

QUEBEC to ALASKA; NEW JERSEY to CALIFORNIA: EUROPE: ASIA.

968. **G. flaviflorum** Heller. YELLOW-FLOWERED BEDSTRAW.

In gulches at base of the Flat-irons, 5700-6000 ft. (Daniels, 499).

COLORADO to NEW MEXICO.

969. **G. triflorum** Michx. FRAGRANT BEDSTRAW.

Cañons of the foothills, 6000-8000 ft. (Daniels, 466).

NEWFOUNDLAND to ALASKA; ALABAMA to CALIFORNIA.

Family 104. CAPRIFOLIACEAE. Vent. Honeysuckle family.

415. SAMBUCUS L. ELDER.

970. **S. microbotrys** Rydb. SMALL-BERRIED ELDER.

Slopes at Ward, 9200 ft. (Daniels, 306). Also between Sunshine and Ward (Rydberg); Spencer Mountain at Eldora; Silver lake; foot of Long's Peak; Redrock lake, west of Ward (Ramaley).

SOUTH DAKOTA to WYOMING; COLORADO to ARIZONA.

971. **S. melanocarpa** Gray. BLACK-BERRIED ELDER.
Sugarloaf Mountain and North Boulder creek (Ramaley).
ALBERTA to IDAHO, COLORADO and OREGON.

416. VIBURNUM L. ARROWWOOD.

972. **V. pauciflorum** Pylaie. HIGH-BUSH CRANBERRY.
Sugarloaf Mountain (Ramaley).
LABRADOR to ALASKA; PENNSYLVANIA to COLORADO and ALASKA.

973. **V. Lentago** L. SHEEPBERRY. NANNYBERRY.
Gulch south of Boulder (Rydberg). Also Bluebell Cañon, if indeed the locality is not the same (Ramaley).
MAINE to MANITOBA; GEORGIA to COLORADO.

417. LINNAEA Gron. TWIN-FLOWER.

974. **L. Americana** Forbes. AMERICAN TWIN-FLOWER.
South Boulder Peak (Rydberg). Also Magnolia; Eldora; Spencer Mountain at Eldora; foot of Arapahoe Peak; hill south of Ward (Ramaley).
GREENLAND to ALASKA; NEW JERSEY and MICHIGAN to COLORADO and UTAH.

418. SYMPHORICARPOS Juss. SNOW-BERRY.

975. **S. occidentalis** Hook. WESTERN SNOW-BERRY.
Abundant on the higher mesas and foothills, 5700-8000 ft. (Daniels, 94). Also between Sunshine and Ward (Rydberg). South Boulder creek (Ramaley).
MACKENZIE to BRITISH COLUMBIA; MICHIGAN and MISSOURI to COLORADO.

976. **S. vaccinioides** Rydb. HUCKLEBERRY INDIAN CURRANT.
Sugarloaf; foot of Long's Peak (Ramaley).
MONTANA to WASHINGTON; COLORADO to NEVADA.

977. **S. oreophilus** Gray. MOUNTAIN INDIAN CURRANT.
Eldora to Baltimore (Rydberg).
COLORADO to UTAH; NEW MEXICO to ARIZONA.

419. DISTEGIA Raf. FLY-HONEYSUCKLE.

978. **D. involucrata** (Richards.) Cockerell [*Lonicera involucrata* (Richards.) Banks]. INVOLUCRED FLY-HONEYSUCKLE.

Common in cool, deep cañons, 6500-9000 ft. (Daniels, 340). Also from Eldora to Baltimore and in the mountains between Sunshine and Ward (Rydberg): Allen's Park; Eldora; Spencer Mountain; Redrock lake; Ward (Ramaley).

QUEBEC to ALASKA; MICHIGAN to CALIFORNIA and MEXICO.

Family 105. ADOXACEAE. Fritch. Moschatel family.

420. ADOXA L. MOSCHATEL.

979. **A. Moschatellina** L. MUSK-ROOT.

Boulder Cañon (Rydberg).

ARCTIC AMERICA to WISCONSIN and COLORADO: EUROPE: ASIA.

Order 41. CAMPANULALES.

Family 106. CUCURBITACEAE. Juss. Gourd family.

421. MICRAMPELIS Raf. BALSAM APPLE.

980. **M. lobata** (Michx.) Greene [*Echinocystis lobata* (Michx.) T. & G.]. WILD BALSAM APPLE.

Fence-rows and waste places, 5100-6000 ft. (Daniels, 743).

MAINE to MONTANA; VIRGINIA to COLORADO.

Family 107. CAMPANULACEAE. Juss. Bellflower family.

422. CAMPANULA L. BELLFLOWER. HAREBELL. BLUEBELL.

981. **C. uniflora** L. ARCTIC HAREBELL.

Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 938).

Arctic-alpine in the NORTHERN HEMISPHERE.

982. **C. Parryi** Gray. PARRY'S HAREBELL.

Foothills and mountain slopes, 6500-9000 ft. (Daniels, 101).

Also from Eldora to Baltimore (Rydberg).

WYOMING to UTAH; NEW MEXICO to ARIZONA.

983. **C. petiolata** DC. WESTERN BLUEBELL.

Abundant throughout, 5100-9000 ft. (Daniels, 27). Red-rock lake, 10100 ft. (Ramaley & Robbins).

MACKENZIE to WASHINGTON; NEW MEXICO to UTAH.

423. SPECULARIA Heist. VENUS'S LOOKING-GLASS.

984. **S. perfoliata** (L.) A. D C. [*Legouzia perfoliata* (L.) Britton]. COMMON VENUS'S LOOKING-GLASS.

Common on the plains, mesas and foothills, 5100-8000 ft. (Daniels, 56).

MAINE and ONTARIO to BRITISH COLUMBIA; FLORIDA to ARIZONA and OREGON; MEXICO.

985. **S. leptocarpa** (Nutt.) Gray [*Legouzia leptocarpa* (Nutt.) Britton]. WESTERN VENUS'S LOOKING-GLASS.

Mesas at foot of the Flat-irons, 5600-6000 ft. (Daniels, 192).

MISSOURI to MONTANA; TEXAS to COLORADO.

Family 108. LOBELIACEAE. Dumort. Lobelia family.

424. LOBELIA L. LOBELIA.

986. **L. syphilitica Ludoviciana** A. D C. LOUISIANA GREAT BLUE LOBELIA.

Along ditches and streams in the plains, 5100-5600 ft. (Daniels, 784).

LOUISIANA and SOUTH DAKOTA to COLORADO.

Order 42. VALERIANALES.

Family 109. VALERIANACEAE. Batsch. Valerian family.

425. VALERIANA L. VALERIAN.

987. **V. ceratophylla** (Hook.) Piper [*V. edulis* Nutt.]. EDIBLE VALERIAN.

Subalpine meadows at Eldora, 8500-9000 ft. (Daniels, 626).

IDAHO to MONTANA; COLORADO to UTAH.

Order 43. CARDUALES.

Family 110. AMBROSIACEAE. Reich. Ragweed family.

426. IVA L. Marsh-elder.

988. **I. xanthiifolia** (Fresen.) Nutt. Burweed marsh-elder.
Common on the plains along streams, and in waste places, and following the larger streams several miles into the foothills and mountains, 5100-7000 ft. (Daniels, 821). Also in Sunset Cañon (Rydberg).
Michigan and Saskatchewan to Washington; Nebraska to New Mexico.

989. **I. axillaris** Pursh. Small-flowered marsh-elder.
Railroads and waste places, 5100-6000 ft. (Daniels, 832).
Saskatchewan to British Columbia; Oklahoma to California.

427. AMBROSIA L. Ragweed.

990. **A. trifida** L. Great ragweed. Horse-cane.
Common along streams and in low waste places, 5100-6000 ft. (Daniels, 378).
Quebec to Assiniboia; Florida to Colorado.

990a. **A. trifida integrifola** (Muhl.) T. & G. Entire-leaved ragweed.
With the preceding (Daniels, 596).
Range of the type?

991. **A. artemisiaefolia** L. Common ragweed.
Waste places and fields, 5100-6000 ft. (Daniels, 520).
Nova Scotia to British Columbia; Florida to Colorado.

992. **A. psilostachya** DC. Western ragweed.
On the plains, especially along railroads, 5100-6000 ft. (Daniels, 516). Also at Lyons (Rydberg).
Michigan to Saskatchewan and Idaho; Louisiana to California and Mexico.

428. GAERTNERIA Med.

993. **G. tomentosa** (Nutt.) Heller [*Franseria discolor* Nutt.].

WOOLLY GAERTNERIA.

Along railroads in the plains, 5100-5400 ft. (Daniels, 510).

SOUTH DAKOTA to WYOMING; KANSAS to NEW MEXICO.

429. XANTHIUM L. COCKLEBUR.

994. **X. commune** Britton. COMMON COCKLEBUR.

Along streams and in waste places, 5100-6000 ft. (Daniels, 695).

QUEBEC and NEW YORK to UTAH and ARIZONA.

Family 111. CARDUACEAE. Necker. **Thistle family.**

430. EUPATORIUM L. THOROUGHWORT.

995. **E. maculatum** L. SPOTTED JOE-PYE WEED.

Springy gulch at foot of Flagstaff Hill, 5800-6000 ft. (Daniels, 801).

NEW YORK to BRITISH COLUMBIA; KENTUCKY to NEW MEXICO.

431. KUHNIA L.

995½. **K. Hitchcockii** A. Nels. HITCHCOCK'S KUHNIA.

Marshall, collected by E. Bethel, (J. C. Arthur, in Mycologia, Nov., 1909, p. 233). Host of a fungus, *Puccinia Kuhniae* Schw.

KANSAS to COLORADO.

996. **K. glutinosa** Ell. [*K. eupatorioides corymbulosa* T. & G.]. STICKY KUHNIA.

Frequent on the plains, mesas, and lower foothills, 5100-6500 ft. (Daniels, 686).

ILLINOIS to MONTANA; KENTUCKY to COLORADO.

997. **K. Gooddingii** A. Nels. GOODDING'S KUHNIA.

Plains and mesas, 5100-6000 ft. (Daniels, 727). The type is from West Dry Creek, Larimer County, Colorado.

COLORADO to TEXAS and ARIZONA.

432. COLEOSANTHUS Cass. BRICKELLIA.

998. **C. minor** (Gray) Daniels. Nov. comb. [*Brickellia grandiflora minor* Gray; *C. umbellatus* Greene; *C. congestus* A. Nels.]. UMBELLATE BRICKELLIA.

Common on the foothills and mountains, 5800-10000 ft.

(Daniels, 551). Also mountains between Sunshine and Ward (Rydberg).

WYOMING to NEW MEXICO and ARIZONA.

999. **C. albicaulis** Rydb. WHITE-STEMMED BRICKELLIA.

Among rocks and in rocky cañons in the foothills, 6000-8500 ft. (Daniels, 822).

COLORADO to NEW MEXICO and UTAH.

433. LACINIARIA Hill. BLAZING-STAR. BUTTON-SNAKEROOT.

1000. **L. punctata** (Hook.) Kuntze [*Liatris punctata* Hook.]. DOTTED BLAZING-STAR.

Abundant on the plains, mesas, and meadows on the foothills and mountains, 5100-9000 ft. (Daniels, 615). Also in the mountains between Sunshine and Ward (Rydb.). Very variable; an extreme form, gathered in alkali flats near Boulder lake, (Daniels, 768) simulates *L. acidota* (Engelm. & Gray) Kuntze.

IOWA to SASKATCHEWAN and MONTANA; TEXAS to ARIZONA.

1001. **L. ligulistylis** A. Nels. PURPLE-BRACTED BLAZING-STAR.

Bear Cañon, 7000 ft. (Daniels, 758).

SASKATCHEWAN to COLORADO.

434. GUTIERREZIA Lag.

1002. **G. longifolia** Greene. LONG-LEAVED GUTIERREZIA.

Common on the plains and mesas, 5100-6000 ft. (Daniels, 595).

COLORADO to NEW MEXICO and UTAH.

1003. **G. scoparia** Rydb. BROOM GUTIERREZIA.

Plains and mesas, 5100-6000 ft. (Daniels, 984).

WYOMING to COLORADO.

435. GRINDELIA Willd. GUM PLANT.

1004. **G. Texana** Scheele. TEXAN GUM PLANT.

Lower Boulder Cañon (Rydberg).

TEXAS to NEW MEXICO and COLORADO.

1005. **G. serrulata** Rydb. SERRULATE GUM PLANT.

Very abundant on the plains, mesas, and foothills, 5100-7000 ft. (Daniels, 385).

WYOMING to COLORADO.

1005a. **G. serrulata** Rydb. × **G. perennis** A. Nels.

Plants apparently intermediate between this species and the next were found on the plains in Boulder (Daniels, 837).

1006. **G. perennis** A. Nels. PERENNIAL GUM PLANT.

Plains, mesas, and foothills, 5100-7000 ft. (Daniels, 836).

SASKATCHEWAN to IDAHO and COLORADO.

1007. **G. erecta** A. Nels. ERECT GUM PLANT.

Mountains between Sunshine and Ward (Rydberg).

WYOMING to COLORADO.

1008. **G. subalpina** Greene. SUBALPINE GUM PLANT.

Common at Eldora, 8500-10000 ft. (Daniels, 845). Also at Boulder (Rydberg).

WYOMING to COLORADO.

1009. **G. Eldorae** Daniels, Nov. sp. ELDORA GUM PLANT.

Plant glabrous, apparently biennial, 3 dm. tall, branched from, or near the base, the secondary branches 1-2 headed; radical and lower cauline leaves oblanceolate, 3-6 cm. long, slender-petioled, remotely toothed or incised; upper cauline leaves, linear or narrowly oblanceolate, small and bract-like, slightly toothed, subentire, or entire, 1-3 cm. long, 5-8 mm. wide; heads copiously glutinous, 1-1½ cm. broad; bracts numerous, narrow, the tips squarrose-spreading; rays numerous, 1-3 mm. wide, barbules of the pappus plainly obvious.

Eldora, 8500-8700 ft. (Daniels, 859).

Plant near *G. subalpina* Greene, but differing in its smaller, narrower and less prominently toothed or entire leaves, and especially in its smaller heads, which are only about one-half as broad.

436. CHRYSOPSIS Nutt. GOLDEN ASTER.

1010. **C. hirsutissima** Greene. HAIRIEST GOLDEN ASTER.

Plains between Boulder and Marshall along railroad, 5400 ft. (Daniels, 1024).

NORTH DAKOTA to SASKATCHEWAN; COLORADO to ARIZONA.

1010½. **C. foliosa** Nutt. LEAFY GOLDEN ASTER.

Redrock lake, 10100 ft. (Ramaley and Robbins).

MINNESOTA to WASHINGTON; KANSAS to COLORADO.

1011. **C. caudata** Rydb. CAUDATE GOLDEN ASTER.

Mesas, foothills, and mountain slopes, common, 5700-9000 ft. (Daniels, 356).

COLORADO.

1012. **C. villosa** (Pursh) Nutt. VILLOUS GOLDEN ASTER.

Abundant on the plains and foothills, 5100-8000 ft. (Daniels, 1).

MINNESOTA to IDAHO; TEXAS to NEW MEXICO.

1013. **C. amplifolia** Rydb. AMPLE-LEAVED GOLDEN ASTER.

Foothills and mountain slopes, 6000-8000 ft. (Daniels, 687). Also at Ward, and Longmont (Rydb.).

COLORADO.

1014. **C. Bakeri** Greene [*C. incana* Greene; *C. compacta* Greene]. BAKER'S GOLDEN ASTER.

Mountainsides at Eldora, 8500-9000 ft. (Daniels, 862). A plant was gathered in Gregory Cañon, which appears intermediate between this and the preceding.

MONTANA and IDAHO to NEW MEXICO.

1015. **C. arida** A. Nels. ARID GOLDEN ASTER.

Boulder (Rydb.).

KANSAS to MONTANA; NEW MEXICO to ARIZONA.

1016. **C. resinolens** A. Nels. RESINOUS GOLDEN ASTER.

Plains and foothills, 5100-7000 ft. (Daniels, 293).

WYOMING to COLORADO.

1016a. **C. resinolens obtusata** A. Nels. OBTUSE-LEAVED RESINOUS GOLDEN ASTER.

Foot of the Flat-irons, and mountainsides at Eldora, 6000-9000 ft. (Daniels, 809). Also mountains between Sunshine and Ward (Rydberg).

Range of the type, but usually at higher altitudes.

1017. **C. hispida** (Hook.) Nutt. [*C. villosa hispida* Gray]. HISPID GOLDEN ASTER.

Plains about Boulder, 5100-6000 ft. (Daniels, 831).
SASKATCHEWAN to ALBERTA; NEW MEXICO to ARIZONA.

1018. **C. Cooperi** A. Nels. COOPER'S GOLDEN ASTER.
Long's Peak near timberline, the type locality, (A. Nels).
COLORADO.

437. CHRYSOTHAMNUS Nutt. RABBIT-BRUSH.

1019. **C. Parryi** (Gray) Greene [*Bigelovia Parryi* Gray]. PARRY'S RABBIT-BRUSH.
Subalpine valley at Eldora, 8700 ft. (Daniels, 866).
WYOMING to COLORADO.

1020. **C. graveolens** (Nutt.) Greene [*C. nauseosus graveolens* (Nutt.) Piper]. HEAVY-SCENTED RABBIT-BRUSH.
Mesa south of the Chautauqua grounds, Boulder, (Ramaley).
NEBRASKA to MONTANA; NEW MEXICO to UTAH.

1021. **C. pulcherrimus** A. Nels. FAIREST RABBIT-BRUSH.
Alkali flat east of Boulder near Owen's lake, 5200-5300 ft. (Daniels, 663).
MONTANA to COLORADO.

1021a. **C. pulcherrimus fasciculatus** A. Nels. FASCICULATE RABBIT-BRUSH.
Boulder creek, the type locality (A. Nels.).

1022. **C. elegans** Greene. HANDSOME RABBIT-BRUSH.
Subalpine valley at Eldora, 8700 ft. (Daniels, 867).
COLORADO.

438. SIDERANTHUS Nutt. STAR-FLOWER.

1023. **S. annuus** Rydb. ANNUAL STAR-FLOWER.
Arapahoe Road east of Boulder, 5300 ft. (Daniels, 726).
NEBRASKA and COLORADO to TEXAS.

1024. **S. spinulosus** (Pursh) Sweet [*Aplopappus spinulosus* (Pursh) DC.]. SPINULOSE STAR-FLOWER.
Frequent on the plains, 5100-5700 ft. (Daniels, 473).
MINNESOTA to SASKATCHEWAN and MONTANA; TEXAS to ARIZONA.

439. PYRROCOMA Nutt.

1025. **P. crocea** (Gray) Greene [*A. croceus* Gray]. YELLOW

PYRROCOMA.

Boulder (Rydb.).

WYOMING to NEW MEXICO and ARIZONA.

440. OREOCHRYSUM Rydb. MOUNTAIN GOLD.

1026. **O. Parryi** (Gray) Rydb. [*Aplopappus Parryi* Gray]. PARRY'S MOUNTAIN GOLD.

Slopes of Green Mt.; common in the mountains at Eldora, ascending on Arapahoe Peak to the timberline, 7000-11000 ft. (Daniels, 752). Also mountains between Sunshine and Ward (Rydb.).

WYOMING to NEW MEXICO and ARIZONA.

441. TONESTUS A. Nels.

1027. **T. pygmaeus** (T. & G.) A. Nels. [*Aplopappus pygmaeus* (T. & G.) Gray; *Macronema pygmaeum* (T. & G.) Greene]. PYGMY TONESTUS.

Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 917).

WYOMING to COLORADO.

442. SOLIDAGO L. GOLDEN ROD.

1028. **S. decumbens** Greene [*S. humilis nana* Gray]. DECUMBENT GOLDEN ROD.

Barren ridges at Glacier lake, and above timberline on Arapahoe Peak, 9000-12000 ft. (Daniels, 641).

WYOMING to COLORADO.

1028a. **S. decumbens minuescens** A. Nels. DWARF DECUMBENT GOLDEN ROD.

Redrock lake, 10100 ft. (Ramaley and Robbins).

Range of the type.

1029. **S. oreophila** Rydb. [*S. humilis Pattersonii* Gandoger]. MOUNTAIN-LOVING GOLDEN ROD.

Abundant on the foothills and mountains, 6000-11000 ft. (Daniels, 529). Also between Sunshine and Ward (Rydberg).

MACKENZIE to COLORADO.

1030. **S. dilatata** A. Nels. OPEN-TOPPED GOLDEN ROD.

Mountains between Sunshine and Ward (Rydberg). According to A. Nelson authentic specimens have been found from the type locality only, Yellowstone Park.

WYOMING to COLORADO.

1031. **S. pallida** (Porter) Rydb. [*S. speciosa pallida* Porter]. PALE GOLDEN ROD.

Mesa at foot of Flagstaff Hill, 5700-6000 ft. (Daniels, 802). Also Lower Boulder Cañon (Rydberg).

NORTH DAKOTA and NEBRASKA to COLORADO.

1032. **S. viscidula** Rydb. VISCID GOLDEN ROD.

High mesas, foothills, and mountains, 5900-8600 ft. (Daniels, 375).

COLORADO.

1033. **S. glaberrima** Martens. SMOOTHEST GOLDEN ROD.

Common on the plains and foothills, 5100-8000 ft. (Daniels, 616).

MICHIGAN to ALBERTA and IDAHO; MISSOURI to TEXAS and ARIZONA.

1034. **S. concinna** A. Nels. [*S. Missouriensis extraria* Gray]. STOUT MISSOURI GOLDEN ROD.

Plains and foothills, 5100-8000 ft. (Daniels, 977).

ALBERTA to BRITISH COLUMBIA and COLORADO.

1035. **S. Pitcheri** Nutt. PITCHER'S GOLDEN ROD.

Along ditches and streams in the plains, 5100-6000 ft. (Daniels, 505).

MINNESOTA to WASHINGTON; ARKANSAS to COLORADO.

1036. **S. polyphylla** Rydb. MANY-LEAVED GOLDEN ROD.

Along streams in the foothills, especially frequent in Gregory Cañon, 6000-8000 ft. (Daniels, 823).

BRITISH COLUMBIA and WASHINGTON to NEW MEXICO.

1037. **S. Canadensis** L. COMMON GOLDEN ROD.

Boulder Cañon near Falls, 7000 ft. (Daniels, 557).

LABRADOR to MACKENZIE; FLORIDA to COLORADO.

1038. **S. gilvocanescens** Rydb. [*S. Canadensis gilvocanescens* Rydb.]. YELLOWISH-GRAY GOLDEN ROD.

Alkali flats and dry plains about Boulder lake and Owen's lake, 5100-5300 ft. (Daniels, 782).

MINNESOTA to NORTH DAKOTA; NEBRASKA to COLORADO.

1039. **S. nana** Nutt. DWARF GOLDEN ROD.

Dry slopes of Green Mountain, 6000-8100 ft. (Daniels, 825). An allied form occurs on the plains.

MONTANA to COLORADO and ARIZONA.

1040. **S. pulcherrima** A. Nels. PRETTIEST GOLDEN ROD.

Common on the plains about Boulder, 5100-6000 ft. (Daniels, 983). Also mountains between Sunshine and Ward (Rydberg).

MINNESOTA to NORTH DAKOTA; COLORADO to ARIZONA.

1041. **S. radulina** Rydb. HARSH-LEAVED GOLDEN ROD.

Plains, mesas, foothills and mountains, frequent, 5600-8000 ft. (Daniels, 753). Also at Meadow Park (Rydberg).

COLORADO to UTAH.

1042. **S. trinervata** Greene. THREE-NERVED GOLDEN ROD.

Boulder Cañon, ascending at least as far as the Falls, 5500-7000 ft. (Daniels, 553).

SOUTH DAKOTA to WYOMING; COLORADO to ARIZONA.

1043. **S. mollis** Bartl. [*S. nemoralis incana* Gray]. HOARY GOLDEN ROD.

Mesas at foot of the Flat-irons, and foothills along Boulder Cañon, 5500-8000 ft. (Daniels, 574).

NORTH DAKOTA to MONTANA; TEXAS to COLORADO.

443. OLIGONEURON Small.

1044. **O. canescens** Rydb. [*Solidago rigida humilis* Porter]. HOARY STIFF GOLDEN ROD.

Common on the plains, 5100-6000 ft. (Daniels, 781).

SASKATCHEWAN to MONTANA; NEBRASKA to COLORADO.

444. TOWNSENDIA Hook.

1045. **T. grandiflora** Nutt. LARGE-FLOWERED TOWNSENDIA.

Common in rough hilly places throughout, 5100-8600 ft. (Daniels, 41).

SOUTH DAKOTA to WYOMING; OKLAHOMA to COLORADO.

1046. **T. exscapa** (Richardson) Porter [*T. sericea* Hook.]. SILKY TOWNSENDIA.

Common at Boulder (Cockerell).

SASKATCHEWAN to MONTANA; TEXAS to NEW MEXICO.

445. EUCEPHALUS Nutt.

1047. **E. Engelmannii** (Gray) Greene [*Aster Engelmannii* Gray]. ENGELMANN'S ASTER.

In cañons about Eldora, 8500-10000 ft. (Daniels, 841).

MONTANA to BRITISH COLUMBIA; COLORADO to WASHINGTON.

1048. **E. glaucus** Nutt. [*Aster glaucus* (Nutt.) T. & G.]. GLAUCOUS ASTER.

Hills adjoining Boulder Cañon, and on the slopes of Green Mountain, local, 6000-8000 ft. (Daniels, 569). Also mountains between Sunshine and Ward (Rydberg).

WYOMING to COLORADO and UTAH.

446. ASTER L. STARWORT.

1049. **A. Underwoodii** Rydb. UNDERWOOD'S ASTER.

Cañons and mountain sides at Eldora, 8500-10000 ft. (Daniels, 1025). Also Eldora to Baltimore (Rydberg).

WYOMING to COLORADO.

1050. **A. Nelsonii** Greene. NELSON'S ASTER.

Subalpine valley at Eldora, 8600-8700 ft. (Daniels, 861).

WYOMING to COLORADO.

1051. **A. violaceus** Greene. VIOLET ASTER.

Cañons at Eldora, 8600-8700 ft. (Daniels, 554).

COLORADO.

1052. **A. exiguus** (Fern.) Rydb. [*A. ciliatus* Muhl.] CILIATE ASTER.

Common on the plains and foothills, 5100-7000 ft. (Daniels, 999). Also in Sunset Cañon (Rydb.).

VERMONT to WASHINGTON; PENNSYLVANIA to ARIZONA and MEXICO.

1053. **A. crassulus** Rydb. THICKISH ASTER.

Sunset Cañon; common on the plains, 5100-8000 ft. (Daniels, 720).

NORTH DAKOTA to IDAHO; COLORADO to CALIFORNIA. (?)

1054. **A. polycephalus** Rydb. MANY-HEADED ASTER.

Common on the plains and foothills, 5100-7000 ft. (Daniels, 1000).

ALBERTA to NEBRASKA; TEXAS to ARIZONA.

1055. **A. commutatus** Gray [*A. incanopilosus* (Lindl.) Sheldon]. WHITE PRAIRIE ASTER.

Common on the plains and foothills, 5100-7000 ft. (Daniels, 717).

MINNESOTA to WYOMING; KANSAS to NEVADA.

1056. **A. laevis** L. SMOOTH ASTER.

Cañons and wooded slopes on the foothills, 5800-8000 ft. (Daniels, 685).

ONTARIO to SASKATCHEWAN; LOUISIANA to NEW MEXICO.

1057. **A. Porteri** Gray. PORTER'S ASTER.

Abundant throughout, 5100-10000 ft. (Daniels, 697). Also mountains between Sunshine and Ward (Rydberg). Very variable; an extreme form, only 1-1½dm., high, was collected on bare ridges at Glacier lake.

COLORADO.

1058. **A laetevirens** Greene. LIGHT-GREEN-LEAVED ASTER.

Cañons at Eldora, 8600-8700 ft. (Daniels, 858).

COLORADO and WYOMING.

1059. **A. coerulescens** DC. [*A. salicifolius coerulescens* (DC.) Gray]. CAERULEAN ASTER.

Swales in the plains, 5100-6000 ft. (Daniels, 995).

WYOMING to TEXAS.

1060. **A. Osterhoutii** Rydb. OSTERHOUT'S ASTER.

About lakes and swales and along ditches in the plains, 5100-6000 ft. (Daniels, 779).

COLORADO.

1061. **A. adscendens** Lindl. ASCENDING ASTER.
Mountains between Sunshine and Ward (Rydberg).
ASSINIBOIA to COLORADO and NEVADA.

1062. **A. Andrewsii** A. Nels. ANDREWS'S ASTER.
Near Eldora, 9500 ft., the type locality (Nelson).
COLORADO.

1063. **A. Eatonii** (Gray) Howell [*A. foliaceus Eatonii* Gray; *Brachyactis hybrida* Greene]. EATON'S ASTER.
Banks of Boulder creek, 5400 ft. (Daniels, 592).
MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

447. MACHAERANTHERA Nees.

1064. **M. Bigelovii** (Gray) Greene [*Aster Bigelovii* Gray]. BIGELOW'S ASTER.
Common on the plains and foothills, 5100-7000 ft. (Daniels, 724).
COLORADO to NEW MEXICO.

1064½. **M. varians** Greene. VARYING ASTER.
Redrock lake, 10100 ft. (Ramaley and Robbins).
COLORADO to NEW MEXICO.

1065. **M. coronopifolia** (Nutt.) A. Nels. WART-CRESS-LEAVED ASTER.
Eldora, 8600 ft. (Daniels, 1026).
SOUTH DAKOTA to MONTANA; TEXAS to ARIZONA.

1066. **M. aspera** Greene. HARSH ASTER.
High slopes of Green Mountain, 7500-8100 ft. (Daniels, 209). Also mountains between Sunshine and Ward (Rydberg).
COLORADO.

1067. **M. Pattersonii** (Gray) Greene [*Aster Pattersonii* Gray]. PATTERSON'S ASTER.
Caribou (Rydberg).
COLORADO.

448. ERIGERON L. FLEABANE.

1068. **E. lonchophyllus** Hook. LANCE-LEAVED FLEABANE.

Subalpine bogs at Eldora, 8500-9000 ft. (Daniels, 856).
SASKATCHEWAN to MONTANA; COLORADO to NEVADA.

1069. **E. minor** (Hook.) Rydb. SMALLER FLEABANE.
Aspen bogs at Eldora, 8500-9000 ft. (Daniels, 1027).
SASKATCHEWAN to BRITISH COLUMBIA; COLORADO to UTAH.

1070. **E. jucundus** Greene [*E. acris debilis* Gray; *E. debilis* Rydb.]. PLEASANT FLEABANE.
Massif de l' Arapahoe, and Eldora to Baltimore (Rydberg).
HUDSON BAY to BRITISH COLUMBIA; COLORADO to UTAH.

1071. **E. pinnatisectus** (Gray) A. Nels. [*E. compositus pinnatisectus* Gray]. PINNATE FLEABANE.
South of Ward (Rydberg).
WYOMING to COLORADO.

1072. **E. compositus** Pursh. COMPOSITE FLEABANE.
Mountains between Sunshine and Ward (Rydberg). Long's Peak (Porter & Coulter; Coulter in Wabash College Herb.).
MONTANA to YUKON; COLORADO to WASHINGTON.

1073. **E. multifidus** Rydb. MULTIFID FLEABANE.
Ridges at Glacier lake, 8600-9000 ft. (Daniels, 307). Also from Eldora to Baltimore (Rydberg). Sugarloaf Mountain (Cockerell).
ASSINIBOIA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

1074. **E. trifidus** Hook. [*E. compositus trifidus* (Hook.) Gray]. THREE-PARTED FLEABANE.
Mountains about Ward, 9000-9500 ft. (Daniels, 757).
ALBERTA and BRITISH COLUMBIA to COLORADO.

1075. **E. melanocephalus** A. Nels. [*E. oreocharis* Greene]. BLACK-HEADED FLEABANE.
Wet tundras, Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 898). Also at Caribou (Rydberg).
WYOMING to COLORADO.

1076. **E. simplex** Greene [*E. uniflorus* Auct.]. SIMPLE FLEABANE.
Wet tundras, Arapahoe Peak above timberline, 11000-12000

ft. (Daniels, 1008).

LABRADOR and ARCTIC AMERICA to ALASKA; COLORADO to CALIFORNIA: EUROPE.

1077. **E. leucotrichus** Rydb. WHITE-HAIRED FLEABANE.

Above timberline, Arapahoe Peak, 11000-12000 ft. (Daniels, 875). Also at Caribou (Rydberg). Probably to be united with the preceding, of which it seems but a larger form.

WYOMING to COLORADO.

1078. **E. glandulosus** Porter. GLANDULAR FLEABANE.

High and bare ridges above Sunset between Sugarloaf Mountain and Glacier lake, 8500-9000 ft. (Daniels, 642). Also Boulder Cañon (Porter and Coulter).

WYOMING to COLORADO.

1078½. **E. pumilus** Nutt. SMALL FLEABANE.

St. Vrain creek (Coulter in Wabash College Herb.).

NORTH DAKOTA to WASHINGTON; KANSAS to UTAH.

1079. **E. salsuginosus** (Richardson) Gray. BROAD-RAYED FLEABANE.

Along Arapahoe Trail to Arapahoe Peak above timberline, 9000-1200 ft. (Daniels, 873). Redrock lake, 10100 ft. Ramaley & Robbins).

ALBERTA to ALASKA; COLORADO to CALIFORNIA.

1079a. **E. salsuginosus glacialis** (Nutt.) Gray. ICE FLEABANE.

At Caribou (Rydberg). Redrock lake, 10100 ft. (Ramaley and Robbins).

WYOMING to NEW MEXICO and UTAH.

1080. **E. superbus** Greene. SUPERB FLEABANE.

Rich slopes of Green Mountain, 7000-8100 ft. (Daniels, 973). Also mountains between Sunshine and Ward (Rydberg).

COLORADO.

1081. **E. salicinus** Rydb. WILLOW FLEABANE.

Boulder Cañon on the hill slopes, 5700 ft. (Daniels, 288).

COLORADO.

1082. **E. macranthus** Nutt. LARGE-FLOWERED FLEABANE.

Common in the foothills and mountains, 6500-10000 ft. (Daniels, 472). Also at Sunset, and from Eldora to Baltimore (Rydberg).

MONTANA to BRITISH COLUMBIA; COLORADO and UTAH to OREGON.

1082a. **E. macranthus mirus** A. Nelson. WONDERFUL FLEABANE.

Boulder County, the type locality (Nelson).

1083. **E. speciosus** D C. SHOWY FLEABANE.

Mountains between Sunshine and Ward (Rydberg).

MONTANA to WASHINGTON; COLORADO and UTAH to OREGON.

1084. **E. subtrinervis** Rydb. THREE-NERVED FLEABANE.

Mountainsides at Eldora, 8500-9000 ft. (Daniels, 646).

SOUTH DAKOTA and WYOMING to NEW MEXICO.

1085. **E. eximius** Greene. CHOICE FLEABANE.

Boulder Cañon above the Falls and on mountainsides at Eldora, 7000-9000 ft. (Daniels, 860). Also from Eldora to Baltimore (Rydberg).

COLORADO.

1086. **E. Smithii** Rydb. SMITH'S FLEABANE.

Subalpine meadows at Eldora, 8500-9000 ft. (Daniels, 865).

COLORADO.

1087. **E. ramosus** (Walt.) B. S. P. [*E. strigosus* Muhl.]. COMMON FLEABANE.

Fields and waste places on the plains, 5100-6000 ft. (Daniels, 570).

NOVA SCOTIA to BRITISH COLUMBIA; FLORIDA to CALIFORNIA.

1088. **E. Bellidastrum** Nutt. DAISY FLEABANE.

Mesas at foot of Flat-irons, 5700-6000 ft. (Daniels, 691).

SOUTH DAKOTA to WYOMING; KANSAS to ARIZONA.

1089. **E. divergens** T. & G. DIVERGENT FLEABANE.

Plains and mesas about Boulder and Marshall, 5100-6000 ft. (Daniels, 435).

NEBRASKA to WASHINGTON; TEXAS to CALIFORNIA.

1090. **E. flagellaris** Gray [*E. stolonifer* Greene]. STOLONIFEROUS FLEABANE.

Abundant on the plains, 5100-6000 ft. (Daniels, 3).

SOUTH DAKOTA to WYOMING; NEW MEXICO to UTAH.

448½. WYOMINGIA A. Nels. MOUNTAIN DAISY.

1091. **W. cana** (Gray). A. Nels. [*Erigeron canus* Gray]. HOARY MOUNTAIN DAISY.

Sunset Cañon (Rydberg).

SOUTH DAKOTA to WYOMING; NEBRASKA to NEW MEXICO.

449. LEPTILON Raf. HORSEWEED.

1092. **L. Canadense** (L.) Britton [*Erigeron Canadensis* L.]. COMMON HORSEWEED.

Fields and waste places, common, 5100-8000 ft. (Daniels, 585).

NORTH AMERICA, thence spreading throughout the world.

1092a. **L. Canadense pusillum** (Nutt.) Daniels. Nov. comb. [*Erigeron pusillus* Nutt.]. DWARF HORSEWEED.

The common form of the foothills, ½-1 dm. high, and but few-flowered, 6000-8000 ft. (Daniels, 694).

450. ANTENNARIA Gaertn. EVERLASTING. CAT'S-FOOT.

1093. **A. media** Greene. MEDIUM CAT'S-FOOT.

Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 1005).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

1094. **A. umbrinella** Rydb. UMBER CAT'S-FOOT.

Arapahoe Peak above timberline, 11000-12000 ft. (Daniels, 932).

MONTANA and IDAHO to COLORADO.

1095. **A. concinna** E. Nels.

Alpine forest at Ward, 9000-9300 ft. (Daniels, 304).
COLORADO to UTAH.

1096. **A. rosea** (D. C. Eaton) Greene. ROSY CAT'S-FOOT.
Common throughout the foothills and mountains, and descending to the mesas and plains along gulches, 5700-9000 ft. (Daniels, 775). Also North Boulder Peak and from Eldora to Baltimore (Rydberg).
ALBERTA to YUKON; COLORADO to CALIFORNIA.

1097. **A. imbricata** E. Nels. IMBRICATE CAT'S-FOOT.
At timberline, Arapahoe Peak, 10500-11000 ft. (Daniels, 934).
MONTANA to COLORADO and UTAH.

1098. **A. corymbosa** A. Nels. [*A. nardina* Greene]. CORYMBED CAT'S-FOOT.
Alpine forest at Ward, 9000-9300 ft. (Daniels, 305).
MONTANA and OREGON to COLORADO.

1099. **A. parvifolia** Nutt. [*A. formosa* Greene; *A. microphylla* Rydb.]. SMALL-LEAVED CAT'S-FOOT.
Common on barren knolls throughout, 5100-10000 ft. (Daniels, 702).
SASKATCHEWAN to BRITISH COLUMBIA; NEBRASKA to NEW MEXICO.

1100. **A. oxyphylla** Greene. SHARP-LEAVED CAT'S-FOOT.
Common on the mesas, foothills, and mountains, 5700-10000 ft. (Daniels, 115).
SOUTH DAKOTA to MONTANA; NEBRASKA to COLORADO.

1101. **A. aprica** Greene. SUNNY CAT'S-FOOT.
Mountains at Ward, a dwarf form, 4 cm. high, 9000-9300 ft. (Daniels, 1028). Also Eldora to Baltimore (Rydberg). Piper, however, Cont. U. S. Nat. Herb. **11**, 605, makes this species identical with *A. parvifolia* Nutt.
SOUTH DAKOTA to ALBERTA; NEW MEXICO to UTAH.

1102. **A. marginata** Greene. MARGINATE CAT'S-FOOT.
Foothills along Boulder Cañon, 6500-8000 ft. (Daniels, 1029). The plants have leaves glabrous and bright green

above.

COLORADO to NEW MEXICO and ARIZONA.

1103. **A. pulcherrima** (Hook.) Greene [*A. Carpathica pulcherrima* Hook.]. FAIREST CAT'S-FOOT.

Long's Peak (Porter & Coulter).

SASKATCHEWAN and YUKON to WASHINGTON and COLORADO.

1104. **A. anaphaloides** Rydb. FALSE PEARLY EVERLASTING.

Massif de l' Arapahoe (Rydberg).

MONTANA and OREGON to CALIFORNIA.

451. ANAPHALIS D C. PEARLY EVERLASTING.

1105. **A. subalpina** (Gray) Rydb. [*A. margaritacea subalpina* Gray]. SUBALPINE PEARLY EVERLASTING.

Common throughout the foothills and mountains, 6000-10000 ft. (Daniels, 552). Also between Sunshine and Ward (Rydberg).

SOUTH DAKOTA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

452. GNAPHALIUM L. CUDWEED.

1106. **G. Wrightii** Gray. WRIGHT'S CUDWEED.

Boulder Cañon near Falls, 7400 ft. (Daniels, 1030). Also Meadow Park and at Lyons (Rydberg).

COLORADO and NEW MEXICO to CALIFORNIA and MEXICO.

1107. **G. sulphurescens** Rydb. SULPHURESCENT CUDWEED.

Boulder (Rydberg).

WYOMING to WASHINGTON; TEXAS to NEW MEXICO.

1108. **G. palustre** Nutt. MARSH CUDWEED.

Aspen bogs at Glacier lake, 9000 ft. (Daniels, 711).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

453. GYMNOLOMIA H. B. K.

1109. **G. multiflora** (Nutt.) B. & H. MANY-FLOWERED GYMNOLOMIA.

Boulder Cañon near the Falls, at Eldora, and in Sunset Cañon, 6000-10000 ft. (Daniels, 565). Also between Sunshine and Ward (Rydberg).

MONTANA to NEVADA; NEW MEXICO to ARIZONA.

454. **RUDBECKIA** L. CONE-FLOWER.

1110. **R. flava** Moore. YELLOW CONE-FLOWER.

On the plains and foothills, 5100-8000 ft. (Daniels, 428).

NORTH DAKOTA and WYOMING to COLORADO.

1111. **R. laciniata** L. GRAY-HEADED CONE-FLOWER. GOLDEN GLOW.

Common along streams, 5100-9500 ft. (Daniels, 561).

QUEBEC to IDAHO; FLORIDA to ARIZONA.

455. **RATIBIDA** Raf.

1112. **R. columnaris** (Sims) D. Don [*Lepachys columnaris* (Sims) T. & G.]. LONG-HEADED CONE-FLOWER.

Abundant on the plains and mesas, 5100-6000 ft. (Daniels, 21).

SASKATCHEWAN to BRITISH COLUMBIA; TENNESSEE to TEXAS, ARIZONA and MEXICO.

1112a. **R. columnaris pulcherrima** (D C.) D. Don. BROWN LONG-HEADED CONE-FLOWER.

With the type but much less frequent, 5100-6000 ft. (Daniels, 201).

Range of the type.

456. **WYETHIA** Nutt.

1113. **W. amplexicaulis** Nutt. CLASPING-LEAVED WYETHIA.

Arapahoe Pass (Rydberg).

MONTANA to BRITISH COLUMBIA; COLORADO to NEVADA.

457. **HELIANTHUS** L. SUNFLOWER.

1114. **H. lenticularis** Dougl. COMMON SUNFLOWER.

Plains, mesas and lower foothills, especially in denuded soils, 5100-7000 ft. (Daniels, 400).

NORTH DAKOTA to IDAHO; TEXAS to ARIZONA.

1114a. **H. lenticularis coronatus** Cockerell. RED-STREAKED SUNFLOWER.

Found by Mrs. T. D. A. Cockerell near her home in Boulder.

1115. **H. petiolaris** Nutt. PETIOLED SUNFLOWER.

Common in waste places and denuded soils throughout except in the alpine region, 5100-9500 ft. (Daniels, 67). Also from Eldora to Baltimore (Rydberg).

MINNESOTA and SASKATCHEWAN to OREGON; TEXAS to CALIFORNIA.

1115a. **H. petiolaris phenax** Cockerell.

Boulder, the type locality (Cockerell).

1116. **H. subrhomboideus** Rydb. SUBRHOMBOID SUNFLOWER.

Locally frequent on the mesas fronting the Flat-irons, 5700-6000 ft. (Daniels, 656).

MANITOBA to MONTANA; NEBRASKA to COLORADO.

1117. **H. pumilus** Nutt. DWARF SUNFLOWER.

Abundant on the plains, mesas, and foothills, 5100-7500 ft. (Daniels, 59).

WYOMING and COLORADO.

1118. **H. grosse-serratus** Martens. COARSELY TOOTHED SUNFLOWER.

Lowlands and stream-flats in the plains, 5100-5400 ft. (Daniels, 670).

NEW YORK to WYOMING; PENNSYLVANIA to TEXAS and COLORADO.

1119. **H. fascicularia** Greene [*H. giganteus Utahensis* D. C. Eaton; *H. Utahensis* A. Nelson]. UTAH SUNFLOWER.

Boulder (Rydberg).

ASSINIBOIA to ALBERTA; COLORADO to ARIZONA.

458. HELIANTHELLA T. & G.

1120. **H. quinquenervis** Gray. FIVE-RIBBED FALSE SUNFLOWER.

In cañons and on rich mountain slopes at Eldora and along the Arapahoe Trail, 8600-10000 ft. (Daniels, 843). Also Eldora to Baltimore (Rydberg).

SOUTH DAKOTA to IDAHO and COLORADO.

459. VERBESINA L. CROWNBEARD.

1121. **V. exauriculata** (Rob. & Greenm.) Cockerell [*Verbesina* *encelioides exauriculata* Rob. & Greenm.; *Ximenesia exauriculata* (Rob. & Greenm.) Rydb.]. WESTERN CROWNBEARD.

Boulder (Rydberg). In great abundance near Lafayette (Cockerell).

MONTANA to TEXAS and ARIZONA.

460. BIDENS L. BUR-MARIGOLD.

1122. **B. vulgata** Greene. COMMON STICKTIGHTS.

Along ditches and in low grounds, 5100-5500 ft. (Daniels, 788).

ONTARIO to BRITISH COLUMBIA; NORTH CAROLINA to CALIFORNIA.

1123. **B .glaucesens** Greene. GLAUCESCENT BUR-MARIGOLD.

Along ditches and streams and in swales, 5100-5500 ft. (Daniels, 667). Hardly glaucescent as it occurs about Boulder.

SASKATCHEWAN to MONTANA; KANSAS to COLORADO.

1123½. **B. tenuisecta** Gray. WESTERN SPANISH NEEDLES.

Marshall lake (W. W. Robbins).

COLORADO to IDAHO; TEXAS to ARIZONA and MEXICO.

461. THELESPERMA Less.

1124. **T. gracile** Gray. SLENDER THELESPERMA.

Common on the plains and mesas, and occurring also on the open mountain slopes, 5100-9000 ft. (Daniels, 233). Also between Sunshine and Ward (Rydberg).

NEBRASKA to COLORADO; MISSOURI and TEXAS to ARIZONA.

462. PICRADENIOPSIS Rydb.

1125. **P. oppositifolia** (Nutt.) Rydb. [*Bahia oppositifolia* Nutt.]. OPPOSITE-LEAVED BAHIA.

Boulder (Rydberg).

SOUTH DAKOTA to MONTANA; TEXAS to ARIZONA.

463. BAHIA Lag.

1126. **B. dissecta** (Gray) Britton [*B. chrysanthemoides* Gray]. FINE-LEAVED BAHIA.

Infrequent along cañons, 6000-9000 ft. (Daniels, 719). Also mountains between Sunshine and Ward (Rydberg).

WYOMING to NEW MEXICO and ARIZONA.

464. TETRANEURIS Greene.

1127. **T. lanigera** Daniels, Nov. nom. [*Actinella lanata* Nutt., 1841; not Pursh, 1814; *Tetraneuris lanata* (Nutt.) Greene]. WOOLLY ACTINELLA.

Barren ridges between Sunset and Glacier lake, 7000-9000 ft. (Daniels, 643), Redrock lake, 10100 ft. (Ramaley and Robbins). Pursh's *A. lanata* equals *Eriophyllum lanatum* (Pursh) Forbes, a plant of the Pacific coast, hence a new name is necessary for Nuttall's plant. If *Actinea* Juss. should replace *Tetraneuris* Greene (as the new Gray's Manual maintains), our plant becomes *Actinea lanigera* Daniels.

WYOMING and COLORADO.

465. RYDBERGIA Greene.

1128. **R. grandiflora** (T. & G.) Greene [*Actinella grandiflora* T. & G.]. LARGE-FLOWERED RYDBERGIA.

Arapahoe Peak above timberline, 10500-13500 ft. (Daniels, 878). Also mountains south of Ward (Rydberg).

MONTANA to NEW MEXICO and CALIFORNIA.

466. HELENIUM L. SNEEZEWEED.

1129. **H. montanum** Nutt. MOUNTAIN SNEEZEWEED.

Along ditches and streams in the plains east of Boulder, 5100-5400 ft. (Daniels, 780).

MINNESOTA and SASKATCHEWAN to WASHINGTON; MISSISSIPPI to COLORADO.

467. GAILLARDIA Foug.

1130. **G. aristata** Pursh. AWNED GAILLARDIA.

Common on the plains, mesas and foothills, 5100-8000 ft. (Daniels, 37).

SASKATCHEWAN to BRITISH COLUMBIA; COLORADO to OREGON.

468. BOEBERA Willd.

1131. **B. papposa** (Vent.) Rydb. [*Dysodia chrysanthemoides* Lag.]. FETID MARIGOLD.

Roadsides, waste places and sandy stream flats, 5100-7000 ft. (Daniels, 594). Also at Lyons (Rydberg).

OHIO to MONTANA; ARKANSAS to ARIZONA and MEXICO.

469. ANTHEMIS L. MAYWEED.

1132. **A. Cotula** L. COMMON MAYWEED.

Yards and waste places, 5100-6000 ft. (Daniels, 593).

EUROPE, thence to NORTH AMERICA.

470. ACHILLEA L. YARROW.

1133. **A. lanulosa** Nutt. [*A. Millefolium lanulosa* (Nutt.) Piper]. WOOLLY YARROW.

Open grounds throughout, 5100-9000 ft. (Daniels, 360). Also mountains between Sunshine and Ward (Rydberg).

ONTARIO to YUKON; OKLAHOMA to CALIFORNIA and MEXICO.

470½. CHRYSANTHEMUM L. OXEYE DAISY.

1133½. **C. Leucanthemum** L. COMMON OXEYE DAISY.

Bluebird Mine, in quantity, 1910 (Miss Pearl Turner).

EUROPE, thence to NORTH AMERICA.

471. ARTEMISIA L. WORMWOOD. SAGE-BRUSH. MUGWORT.

1134. **A. dracunculoides** Pursh. PRAIRIE MUGWORT.

Abundant on the plains, mesas and foothills, 5100-8000 ft. (Daniels, 833).

MONTANA to IDAHO; TEXAS to CALIFORNIA.

1135. **A. Scouleriana** (Besser) Rydb. [*A. desertorum Scouleriana* Besser]. SCOULER'S SAGE.

Gregory Cañon and adjacent mesas and foothills, 5600-8000 ft. (Daniels, 612).

BRITISH COLUMBIA to COLORADO.

1136. **A. Forwoodii** S. Wats. FORWOOD'S SAGE.

Abundant on the plains, mesas, and foothills, 5100-7500 ft. (Daniels, 992).

ASSINIBOIA to MONTANA and NEW MEXICO.

1137. **A. spithamaea** Pursh. ALPINE MUGWORT.

Arapahoe Peak above timberline, 11000-12500 ft. (Daniels, 920).

LABRADOR to ALASKA and COLORADO.

1138. **A. frigida** Willd. BARRENS SAGE.

Common in dry open places throughout, 5100-10000 ft. (Daniels, 451).

HUDSON BAY to ALASKA; TEXAS to UTAH.

1139. **A. scopulorum** Gray. ROCKY MOUNTAIN SAGE.

Mountains south of Ward (Rydberg).

WYOMING to COLORADO and UTAH.

1140. **A. biennis** Willd. BIENNIAL WORMWOOD.

Boulder Cañon at Eldora, 8600 ft. (Daniels, 846).

NOVA SCOTIA to MACKENZIE; PENNSYLVANIA to CALIFORNIA.

1141. **A. saxicola** Rydb. [*A. Chamissoniana saxatilis* Besser]. ROCK SAGE.

Long's Peak (Rydberg).

WYOMING to COLORADO.

1142. **A. silvicola** Osterh. SYLVAN SAGE.

Subalpine slopes and valleys at Eldora, 8600 ft. (Daniels, 996).

COLORADO to NEW MEXICO.

1143. **A. gnaphalodes** Nutt. CUDWEED SAGE.

Common on the plains, mesas, foothills, and lower mountain slopes, 5100-9000 ft. (Daniels, 755). The original spelling of the specific name is as above, though the word should have been *gnaphalioides*.

NORTH DAKOTA to WYOMING; ARKANSAS to COLORADO; naturalized eastward to NEW YORK and ONTARIO.

1144. **A. Brittonii** Rydb. BRITTON'S SAGE.

Plains, mesas, and foothills, 5100-8000 ft. (Daniels, 967).

COLORADO to UTAH.

1145. **A. diversifolia** Rydb. DIVERSE-LEAVED SAGE.

Valleys in the foothills, 6000-8000 ft. (Daniels, 966).

IDAHO to BRITISH COLUMBIA; COLORADO to WASHINGTON.

1146. **A. tridentata** Nutt. COMMON SAGE-BRUSH.

Barren mountain slopes near Bluebird Mine, between Glacier lake and Eldora, 8500-9500 ft. (Daniels).

NEBRASKA and MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

472. PETASITES Tourn. SWEET COLTSFOOT.

1147. **P. sagittata** (Pursh) Gray. ARROW-LEAVED SWEET COLTSFOOT.

Eldora to Baltimore (Rydberg). Eldora lake, May, 1910 (W. W. Robbins).

LABRADOR to ALASKA; MINNESOTA to COLORADO.

473. ARNICA L. ARNICA.

1148. **A. platyphylla** A. Nels. BROAD-LEAVED ARNICA.

Arapahoe Trail just below timberline on Arapahoe Peak, 9000-10500 ft. (Daniels, 948).

MONTANA and IDAHO to COLORADO.

1149. **A. pumila** Rydb. [*A. parvifolia* Greene]. DWARF ARNICA.

Gregory Cañon, 6600 ft. (Daniels, 903).

WYOMING to COLORADO and UTAH.

1150. **A. cordifolia** Hook. HEART-LEAVED ARNICA.

In the wooded region throughout, 6000-11000 ft. (Daniels, 270). Also Eldora to Baltimore; between Sunshine and Ward; and Massif de l' Arapahoe (Rydberg).

MONTANA to BRITISH COLUMBIA; COLORADO to CALIFORNIA.

1151. **A. Rydbergii** Greene. RYDBERG'S ARNICA.

Eldora to Baltimore (Rydberg).

MONTANA to COLORADO.

1152. **A. subplumosa** Greene [*A. Chamissonis longinodosa* A. Nels.]. SUBPLUMOSE ARNICA.

Boulder Cañon above the Falls, 7000-8000 ft. (Daniels, 537).

MONTANA to COLORADO.

1153. **A. pedunculata** Rydb. PEDUNCLED ARNICA.

Under pines in the mesas south of the Chautauqua grounds, 5800-6000 ft. (Daniels, 176). Gulch south of Boulder (Rydberg).

NORTH DAKOTA to WASHINGTON; COLORADO to CALIFORNIA.

1153½. **A. monocephala.** Rydb. SINGLE-HEADED ARNICA.

Long's Peak (Porter & Coulter).

MONTANA and IDAHO to COLORADO.

1154. **A. Parryi** Gray [*A. eradiata* (Gray) Heller]. PARRY'S ARNICA.

Arapahoe Trail just below timberline, Arapahoe Peak, thence well toward Eldora, 9000-10500 ft. (Daniels, 946). Also at Caribou (Rydberg).

MONTANA to BRITISH COLUMBIA; COLORADO to WASHINGTON.

474. SENECIO L. GROUNDSEL.

1155. **S. scopulinus** Greene [*S. Bigelovii Hallii* Gray]. HALL'S GROUNDSEL.

Subalpine meadows at Eldora, 8600 ft. (Daniels, 624).

WYOMING to COLORADO.

1156. **S. chloranthus** Greene. GREEN-FLOWERED GROUNDSEL.

Subalpine bogs at Eldora, 8600 ft. (Daniels, 990).

COLORADO.

1157. **S. pudicus** Greene. BASHFUL GROUNDSEL.

Along Boulder Cañon, and at Eldora, 7000-10000 ft. (Daniels, 547). Also between Sunshine and Ward (Rydberg).

COLORADO.

1158. **S. carthamoides** Greene. ALPINE GROUNDSEL.

Arapahoe Peak above timberline, 10500-11000 ft. (Daniels, 943).

WYOMING to COLORADO.

1159. **S. blitoides** Greene. BLITE GROUNDSEL.

Arapahoe Peak above timberline, 10500-12000 ft. (Daniels, 1006).

COLORADO.

1160. **S. triangularis** Hook. TRIANGULAR-LEAVED GROUNDSEL.

Common in subalpine bogs and along stream banks at Eldora, and ascending to timberline, Arapahoe Peak, 8600-11000 ft. (Daniels, 635). Also between Sunshine and Ward (Rydberg).

ALBERTA to ALASKA; COLORADO to CALIFORNIA.

1161. **S. admirabilis** Greene. ADMIRABLE GROUNDSEL.

Subalpine bogs at Eldora, 8600 ft. (Daniels, 650).

WYOMING to COLORADO.

1162. **S. lapathifolium** Greene. LAPATHUS-LEAVED GROUNDSEL.

High slope near snow above Bloomerville, 9000-10000 ft. (Daniels, 315).

COLORADO.

1163. **S. crassulus** Gray. THICKISH GROUNDSEL.

Above timberline, Arapahoe Peak, 10500-11000 ft. (Daniels, 945). Also at Ward; and Eldora to Baltimore (Rydberg).

MONTANA to IDAHO; COLORADO to UTAH.

1164. **S. rapifolius** Nutt. TURNIP-LEAVED GROUNDSEL.

Boulder Cañon near Falls, 7000-8000 ft. (Daniels, 543).

SOUTH DAKOTA to IDAHO and COLORADO.

1165. **S. hydrophilus** Nutt. WATER-LOVING GROUNDSEL.

Alpine valley near snow above Bloomerville, 9000-10000 ft. (Daniels, 319).

MONTANA to COLORADO and NEVADA.

1166. **S. Hookeri** Gray. HOOKER'S GROUNDSEL.

Eldora to Baltimore (Rydberg).

ALBERTA and BRITISH COLUMBIA to COLORADO.

1166½. **S. Columbianus** Greene. COLUMBIAN GROUNDSEL.

Middle Boulder Cañon 9000 ft. (Coulter in Wabash College Herb.).

This is, in part at least, the *S. lugens Parryi* Eaton of Porter & Coulter.

SASKATCHEWAN to ALASKA; MINNESOTA to COLORADO.

1167. **S. perplexus** A. Nels. PERPLEXING GROUNDSEL.

North slope of Flagstaff Hill, 6000 ft. (Daniels, 148). Plant too old, the basal leaves gone, perhaps *S. dispar* A. Nels.

Redrock lake, 10100 ft. (Ramaley & Robbins). Middle Boulder Cañon (Porter & Coulter in Wabash College Herb.). Also from Eldora to Baltimore, and at Boulder (Rydberg).

WYOMING and IDAHO to COLORADO.

1168. **S. atratus** Greene [*S. lugens foliosus* Gray]. LEAFY GROUNDSEL.

Arapahoe Trail just below timberline, Arapahoe Peak, thence to Eldora, 8600-10500 ft. (Daniels, 947). Also at Ward; between Sunshine and Ward; and Eldora to Baltimore (Rydberg).

COLORADO.

1169. **S. Purshianus** Nutt. PURSH'S GROUNDSEL.

Redrock lake 10100 ft. (Ramaley & Robbins).

SASKATCHEWAN to BRITISH COLUMBIA; TEXAS to UTAH.

1170. **S. Harbourii** Rydb. HARBOUR'S GROUNDSEL.

Mountains south of Ward, the type locality, and between Sunshine and Ward (Rydberg).

COLORADO.

1171. **S. Plattensis** Nutt. PLATTE RAGWORT.

Common on the plains and mesas, 5100-6000 ft. (Daniels, 36).

ONTARIO to SOUTH DAKOTA; MISSOURI and TEXAS to COLORADO.

1172. **S. salicinus** Rydb. WILLOW RAGWORT.

Foothills about Boulder, 6000-7000 ft. (Daniels, 1031).

COLORADO.

1173. **S. Nelsonii** Rydb. [*S. rosulatus* Rydb.]. NELSON'S RAGWORT.

Exceedingly abundant throughout, and occurring in a maze of forms so confluent that any segregation seems impossible, 5100-11000 ft. (Daniels, 210). Also at Caribou; and between Sunshine and Ward (Rydberg).

COLORADO.

1174. **S. Fendleri** Gray. FENDLER'S RAGWORT.

Plains and foothills about Boulder, 5600-8000 ft. (Daniels, 10).

COLORADO to UTAH and NEW MEXICO.

1175. **S. lanatifolius** Osterh. [*S. Fendleri lanatus* Osterh.]. WOOLLY-LEAVED RAGWORT.

Barren ridges, Glacier lake to Eldora, 8500-9000 ft. (Daniels, 218). Basal leaves very crisp.

COLORADO.

1176. **S. Balsamitae** Muhl. [*S. aureus Balsamitae* (Muhl.) T. & G.; *S. flavulus* Greene; *S. flavovirens* Rydb. in part]. NARROW-LEAVED GOLDEN SQUAW-WEED.

Long's Peak (Porter & Coulter).

QUEBEC to MARYLAND northwestward across the continent.

1177. **S. longipetiolatus** Rydb. LONG-PETIOLED RAGWORT.

Plains at Boulder, uncommon, 5600 ft. (Daniels, 61).

WYOMING to COLORADO.

1178. **S. crocatus** Rydb. [*S. aureus croceus* Gray; *S. dimorphophyllus* Greene; *S. heterodoxus* Greene]. SAFFRON RAGWORT.

Arapahoe Peak above timberline, and at Eldora, 8600-12000 ft. (Daniels, 870). Also on Long's Peak (Rydberg).

WYOMING to COLORADO.

1179. **S. cymbalariodes** Nutt. [*S. aureus borealis* T. & G. NORTHERN GOLDEN RAGWORT.

Subalpine meadows at Glacier lake, 9000 ft. (Daniels, 705).

MACKENZIE to COLORADO and UTAH.

1180. **S. pseudaureus** Rydb. FALSE GOLDEN RAGWORT.

Long's Peak (Rydberg).

MACKENZIE to BRITISH COLUMBIA; NEW MEXICO to NEVADA.

1180½. **S. mutabilis** Greene [*S. aurellus* Rydb.]. MUTABLE RAGWORT.

Redrock lake, 10100 ft. (Ramaley & Robbins).

COLORADO.

1181. **S. ambrosioides** Rydb. RAGWEEDLIKE GROUNDSEL.

Common in the mountainous region, 7000-10000 ft. (Daniels, 629). Also at Ward (Rydberg).

NORTH DAKOTA to MONTANA; NEW MEXICO to ARIZONA.

1182. **S. Riddellii** T. & G. [*S. filifolius Fremontii* T. & G.]. RIDDELL'S GROUNDSEL.

Frequent on the plains about Boulder, 5100-6000 ft. (Daniels, 481).

NEBRASKA to COLORADO; TEXAS to NEW MEXICO.

1183. **S. multicapitatus** Rydb. MANY-HEADED GROUNDSEL.

Plains about Boulder, 5600 ft. (Daniels, 401).

COLORADO to NEW MEXICO and ARIZONA.

1184. **S. spartioides** T. & G. BROOM-LIKE GROUNDSEL.

Along Boulder Cañon road, 5500 ft. (Daniels, 804). Also mountains between Sunshine and Ward (Rydberg).

NEBRASKA to WYOMING; TEXAS to ARIZONA.

475. CIRSIUM Hill. THISTLE.

1185. **C. Parryi** (Gray), Cockerell. Nov. comb. [*Cnicus Parryi* Gray; *Carduus Parryi* (Gray) Greene]. PARRY'S THISTLE.

Boulder (Rydberg).

COLORADO to NEW MEXICO and UTAH.

1186. **C. scopulorum** (Greene) Cockerell. Nov. comb. [*Cnicus eriocephalus* Gray; *Carduus scopulorum* Greene]. CRAG THISTLE.

Arapahoe Peak above timberline, 10500-12000 ft. (Daniels, 887). Also at Ward (Rydberg).

COLORADO.

1187. **C. griseum** (Rydb.) Cockerell. Nov. comb. [*Carduus griseus* Rydb.]. GRAY THISTLE.

Ward (Rydberg).

COLORADO.

1188. **C. Americanum** (Gray), Daniels. Nov. comb. [*Cnicus Americanus* Gray; *Carduus Centaureae* Rydb.; *Cirsium*

Centaureae (Rydb.) Cockerell. Nov. comb.]. KNAPWEED THISTLE.

Common in the foothills and mountains, 6000-10000 ft. (Daniels, 442). Also mountains between Sunshine and Ward (Rydberg).

WYOMING to COLORADO.

1188a. **C. Americanum** (Gray), Daniels. **C. griseum** (Rydb.) Cockerell.

Ward (Rydberg).

1188½. **C. acaulescens** (Gray) Daniels; Nov. comb. **C. Americanum** (Gray) Daniels.

Plains and foothills near Boulder (Rydberg).

1189. **C. erosum** (Rydb.) Cockerell. Nov. comb. [*Carduus erosus* Rydb.]. EROSE-BRACTED THISTLE.

Boulder Cañon, 7000-7500 ft. (Daniels, 1032). Bracts merely erose, otherwise like the preceding.

COLORADO.

1190. **C. Coloradense** (Rydb.) Cockerell. Nov. comb. [*Carduus Coloradensis* Rydb.]. COLORADO THISTLE.

Subalpine valley at Eldora, and frequent along the Arapahoe Trail, 8600-10000 ft. (Daniels, 855).

COLORADO.

1191. **C. Plattense** (Rydb.) Cockerell. Nov. comb. [*Carduus Plattensis* Rydb.]. PLATTE THISTLE.

Plains about Boulder, 5100-6000 ft. (Daniels, 63).

NEBRASKA to COLORADO.

1192. **C. undulatum** (Nutt.) Spreng. [*Cnicus undulatus* (Nutt.) Gray; *Carduus undulatus* Nutt.].

Common on the plains, 5100-6000 ft. (Daniels, 673).

MICHIGAN to ASSINIBOIA and MONTANA; TEXAS to UTAH.

1193. **C. megacephalum** (Nutt.) Cockerell. Nov. comb. [*Cnicus undulatus megacephalus* (Nutt.) Gray; *Carduus megacephalus* Nutt.]. LARGE-HEADED THISTLE.

Plains about Boulder, 5100-6000 ft. (Daniels, 986).

SOUTH DAKOTA to IDAHO; MISSOURI to TEXAS and COLORADO.

1194. **C. ochrocentrum** Gray [*Cnicus ochrocentrus* Gray; *Carduus ochrocentrus* (Gray) Greene]. YELLOW-SPINED THISTLE.

Plains, 5100-6000 ft. (Daniels, 1033).

NEBRASKA to COLORADO; TEXAS to ARIZONA.

476. CENTAUREA L. STAR THISTLE.

1195. **C. Cyanus** L. BLUEBOTTLE. CORNFLOWER. BACHELOR'S BUTTON.

Escaped into roadsides and streets about Boulder, 5300-5600 ft. (Daniels, 140).

EUROPE, thence to NORTH AMERICA.

Family 112. CICHORIACEAE. Reich. Chicory family.

477. PTILORIA Raf.

1196. **P. ramosa** Rydb. BRANCHING PTILORIA.

Boulder (Rydberg).

NEBRASKA and MONTANA to COLORADO.

1197. **P. pauciflora** (Torr.) Raf. [*Stephanomeria runcinata* Nutt.]. FEW-FLOWERED PTILORIA.

Plains about Boulder, 5100-6000 ft. (Daniels, 475). Also between Sunshine and Ward (Rydberg).

COLORADO to NEVADA; TEXAS to ARIZONA.

478. TRAGOPOGON L. SALSIFY.

1198. **T. pratensis** L. YELLOW GOAT'S-BEARD.

Boulder Cañon road and about Boulder, 5100-7000 ft. (Daniels, 559).

EUROPE, thence to NORTH AMERICA.

1199. **T. porrifolius** L. SALSIFY. OYSTER PLANT.

Common about Boulder, 5100-6000 ft. (Daniels, 17).

EUROPE, thence to NORTH AMERICA.

1199a. **T. porrifolius** L. × **T. pratensis** L.

Aurora St., Boulder (Cockerell).

479. CICHORIUM L. Chicory.

1200. **C. Intybus** L. Common chicory.

Along roadsides and in waste places, 5100-5600 ft. (Daniels, 1034).

Europe, thence to North America.

480. LYGODESMIA D. Don.

1201. **L. grandiflora** T. & G. Large-flowered Lygodesmia.

Roadside at entrance to Boulder Cañon and along the streets in Boulder, 5300-5600 ft. (Daniels, 166).

Wyoming to Idaho; Colorado to Arizona.

1201½. **L. juncea** (Pursh) D. Don. Rush-like Lygodesmia.

Common about Boulder (Ramaley).

Minnesota to Saskatchewan and Alberta; Missouri to New Mexico.

481. CREPIS L. Hawk's-beard.

1202. **C. petiolata** Rydb. Petioled hawk's-beard.

Gregory Cañon, and aspen bogs at Glacier lake, 6800-9000 ft. (Daniels, 351). Redrock lake, 10100 ft. (Ramaley & Robbins).

Wyoming and Colorado.

1202½. **C. glaucella** Rydb. Glaucescent hawk's-beard.

Redrock lake, 10100 ft. (Ramaley & Robbins).

Montana to Colorado.

1202¾. **S. perplexa** Rydb. Perplexing hawk's-beard.

Redrock lake, 10100 ft. (Ramaley & Robbins).

North Dakota and Alberta to Nebraska and Colorado.

1203. **C. runcinata** (James) T. & G. Runcinate hawk's-beard.

Ward, 9200 ft. (Cockerell).

North Dakota and Alberta to Colorado.

1204. **C. denticulata** Rydb. Toothed hawk's-beard.

Aspen bog at Glacier lake, 3500-9000 ft. (Daniels, 706).

Wyoming to Colorado and Utah.

1205. **C. angustata** Rydb. NARROW-LEAVED HAWK'S-BEARD.
North slope of Flagstaff Hill along Boulder Cañon, 6000 ft. (Daniels, 147).
MONTANA to WASHINGTON; COLORADO to OREGON.

1206. **C. occidentalis** Nutt. WESTERN HAWK'S-BEARD.
Boulder (Rydberg).
MONTANA to WASHINGTON; COLORADO to CALIFORNIA.

1207. **C. alpicola** (Rydb.) A. Nels. ALPINE HAWK'S-BEARD
Long's Peak, 11000 ft., the type locality (Nelson).
ROCKY MOUNTAINS.

482. HIERACIUM L. HAWKWEED.

1208. **H. gracile** Hook. SLENDER HAWKWEED.
At and above timberline under dwarfed spruce, Arapahoe Peak, Colo., 10000-12000 ft. (Daniels, 871). Also at Caribou (Rydberg).
MONTANA and ALASKA to COLORADO and CALIFORNIA.

1209. **H. albiflorum** Hook. WHITE-FLOWERED HAWKWEED.
Wooded banks, Bear Cañon, and other deep cañons in the foothills, 6000-8000 ft. (Daniels, 750). Also mountains between Sunshine and Ward (Rydberg).
YUKON to COLORADO and CALIFORNIA.

1210. **H. Fendleri** Schultz Bip. FENDLER'S HAWKWEED.
Under pines, east slope of Flagstaff Hill, 6000-7000 ft. (Daniels, 215).
SOUTH DAKOTA to NEW MEXICO and ARIZONA.

482½. NOTHOCALAIS Greene.

1210½. **N. cuspidata** (Pursh) Greene [*Troximon cuspidatum* Pursh]. CUSPIDATE TROXIMON.
St. Vrain Cañon (Coulter in Wabash College Herb.).
ILLINOIS to SOUTH DAKOTA; MISSOURI to COLORADO.

483. AGOSERIS Raf.

1211. **A. agrestis** Osterh. FIELD AGOSERIS.
Common on the foothills and mountains, 6000-9000 ft. (Daniels, 1035).
COLORADO

1212. **A. Leontodon** Rydb. DANDELION AGOSERIS.

Mountainsides at Eldora, 8600-10000 ft. (Daniels, 991).

SOUTH DAKOTA to MONTANA, COLORADO to ARIZONA.

1213. **A. glauca** (Nutt.) Greene [*Troximon glaucum* Nutt.]. GLAUCOUS AGOSERIS.

Abundant on the plains, 5100-6000 ft. (Daniels, 20).

SASKATCHEWAN to WASHINGTON; COLORADO to UTAH.

1214. **A. parviflora** (Nutt.) Dietr. [*Troximon glaucum parviflorum* (Nutt.) Gray]. SMALL-FLOWERED AGOSERIS.

Frequent about Boulder, and in meadows and grassy bogs at Eldora, 5100-8600 ft. (Daniels, 622).

NORTH DAKOTA to ALBERTA and COLORADO.

1215. **A. laciniata** (Nutt.) Greene [*Stylosanthus laciniatus* Nutt.]. CUT-LEAVED AGOSERIS.

Boulder (Rydberg).

WYOMING to IDAHO; COLORADO to CALIFORNIA.

1216. **A. humilis** Rydb. LOW AGOSERIS.

Bogs at Eldora, 8600-9000 ft. (Daniels, 633).

WYOMING to COLORADO.

1217. **A. rostrata** Rydb. BEAKED AGOSERIS.

Abundant on the mesas and foothills, 5700-9000 ft. (Daniels, 232). Also mountains between Sunshine and Ward (Rydberg). A plant was gathered in Gregory Cañon, which bore two heads of flowers.

COLORADO.

484. TARAXACUM Hall. DANDELION.

1218. **T. Taraxacum** (L.) Karst. [*T. officinale* Weber]. COMMON DANDELION.

Common in fields and along roadsides, 5100-7000 ft. (Daniels, 261). Ward, 9200 ft. (Cockerell).

EUROPE, thence to NORTH AMERICA.

1218½. **T. montanum** Nutt. MOUNTAIN DANDELION.

Redrock lake, 10100 ft. (Ramaley & Robbins).

MONTANA to COLORADO.

485. LACTUCA L. LETTUCE.

1219. **L. integrata** (Gren. & Godr.). A. Nels. [*L. virosa* Auct., not L.] PRICKLY LETTUCE.
Common in waste places, 5100-6000 ft. (Daniels, 653).
EUROPE, thence to NORTH AMERICA.

1220. **L. Canadensis** L. COMMON WILD LETTUCE.
Boulder Cañon, and along other streams in the foothills, 6000-7000 ft. (Daniels, 564).
NOVA SCOTIA to SASKATCHEWAN; FLORIDA to COLORADO.

1221. **L. Ludoviciana** (Nutt.) DC. LOUISIANA LETTUCE.
Between Sunshine and Ward (Rydberg).
NORTH CAROLINA to MISSOURI and COLORADO and TEXAS.

1222. **L. pulchella** (Pursh) DC. SHOWY LETTUCE.
Plains about Boulder, 5100-6000 ft. (Daniels, 399).
SASKATCHEWAN to WASHINGTON; MISSOURI to CALIFORNIA.

1223. **L. spicata** (Lam.) Hitchc. [*L. leucophaea* Gray]. COMMON BLUE LETTUCE.
Sunset Cañon, 6300 ft. (Daniels, 982). Also Boulder (Rydberg).
NEWFOUNDLAND to MANITOBA; NORTH CAROLINA to COLORADO.

486. SONCHUS L. SOW-THISTLE.

1224. **S. arvensis** L. FIELD SOW-THISTLE.
Waste places in Boulder, 5300-5600 ft. (Daniels, 1036).
EUROPE, thence to NORTH AMERICA.

1225. **S. asper** (L.) Hill. HARSH SOW-THISTLE.
Boulder Cañon road, and Gregory Cañon road, 5600-6000 ft. (Daniels, 458).
EUROPE, thence to NORTH AMERICA.

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APPENDIX A.

Tidestrom in the Am. Midl. Nat. 2, 35, has described as a new species this aspen under the name of *P. aurea* Tidestrom, with the remark that it forms forests throughout Colorado, Utah, and adjoining territory. But the differences relied upon to separate it from Michaux's species seem to me to be at most varietal, and hence I prefer to call the Colorado tree *P. tremuloides aurea* (Tidestrom) Daniels. See page 98.

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