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FRANCIS RAMALEY
EDITOR

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CONTENTS

SOME RECENT POETRY AND THE EMOTIONALIZING OF EVOLUTION[1]

By Fred B. R. Hellems

As my eyes turn backward through the arches of science and poetry spanning a quarter of a century, they are led to a detaining vision of reconstruction. The doctrine of evolution had seriously shaken the foundations whereon so many of our contemporaries fondly believed the superstructure of life and hope must rest; and not a few gloomily asserted that if once this sweeping hypothesis became a familiar law, the fairy castles of poetry must fall as low as the stately temples of religion. I particularly remember the fears of one noble man, eminent in religion rather than theology, in general literature rather than technical scholarship. He was one of the rare living spirits that called compellingly to youth and bade us ever turn our visions toward the signals on the heights. At the close of a plea, remarkable, if not finally convincing, for the old religion, he turned to poetry, voicing most eloquently the dread I have suggested above. Never shall I forget the profound impression produced upon us by his sympathetic quoting of Matthew Arnold's plangent lines:[2]

> The sea of faith
> Was once, too, at the full, and round earth's shore
> Lay like the folds of a bright girdle furled.
> But now I only hear
> Its melancholy, long, withdrawing roar,
> Retreating to the breath
> Of the night-wind, down the vast edges drear
> And naked shingles of the world.

In my heart was that gloomy sinking such as only youth in its hour of perturbed emotions can know. I felt as though I had followed the night-wind "down the vast edges drear and naked shingles" until I

[1] Reprinted from *Poet Lore*, Vol. XX, No. 11, pp. 113–21, by permission of the publisher.

[2] "Dover Beach," vss. 21–28.

stood in a lonely world by a sea of doubt and pain with no shore of hope beyond.

And yet I felt that these comparatively new doctrines were even then adequately established, and knew that some of our poets were already embodying them as beautiful members in their fabric of verse. Furthermore, I felt that poetry must either be capable of emotionalizing, spiritualizing if you will, the facts that seemed grimmest, the scientifically approved doctrines that seemed most forbidding, or must die a death not altogether undeserved. Then by sheer good luck, shortly after hearing that poignantly voiced foreboding, I was brought into renewed and more intimate contact with the pre-Socratic philosophers and the metrical dissertation of that glowing disciple of Epicurus, who "died chief poet by the Tiber-side."[1] From this contact was begotten the belief, soon strengthened by association with Goethe, that evolution offered, not merely poetical material, but the possibility of a poetry more beautiful, more glorious, more nearly final than the world had ever seen. And my belief has grown steadily to this hour. Naturally, that supreme development can be achieved only when the doctrines have become a part of man's heart and imagination, as well as of his reason. That the hour has not yet struck is obvious, a fact that has been emphasized by our honored Nestor, Professor Charles Eliot Norton, in the semi-centennial number of *The Atlantic*. But the history of mankind has shown that one of the great functions of the Muse is to serve truth or doctrine by an emotionalizing process. From the most primitive chants of undeveloped tribes to the latest and highest hymn of aspiration, this educatively appealing power of poetry is most unmistakably manifest. Furthermore, the breadth of theme already compassed should lead us to expect that it may readily sweep on to universality. In the mean time, poetry will both familiarize itself with the new subject-matter and make it more familiar to mankind, thus laying the foundations for the world-awaited masterpieces of the future. And it seems to me that in some of our recent poetry this is being done, and even at times finely done.

[1] LUCRETIUS, *De Rerum Natura*.

How most of the Victorian poets—Swinburne is hardly a Victorian—treated the hypothesis of evolution, we all remember. In the writings of Tennyson, for instance, which offer the most familiar example, there is abundant recognition of the doctrine. Frequently the Laureate shows his formal acceptance of the new order of things, albeit he will always reconcile the new and the old; occasionally he really grasps some phase of the theory and gives it back to us in melodious lines of graceful truth. On the whole, however, I have never been able to escape the conviction that as a poet he admitted the scientifically inevitable with more than half reluctance. "Science grows and Beauty dwindles" probably had a wider meaning for him than it carries in its place in the later "Locksley Hall." But in the younger generation of English poets I seem to find that the doctrine and its corollaries have become a part of the heart and imagination, and occupy a perfectly natural place in their metrical outpourings.

Nor is it strange that the new material was slowly assimilated. At first blush there could be nothing more unpromising for the votaries of the Muse than the theory that has revolutionized our conception of man and his place in the universe. My patient reader will produce in himself the psychological attitude I am groping after, if he will accompany me through the following clear and striking tabulation from that fiercest of militant evolutionists, Professor Ernst Haeckel.[1]

1. This perishable body, our earth, had gone through a long process of cooling before water in liquid form (the first condition of organic life) could settle thereon.

2. The ensuing biogenetic process, the slow development and transformation of countless organic forms, must have taken many millions of years—considerably over a hundred.

3. Among the different kinds of animals which arose in the later stages of the biogenetic process on earth the vertebrates have far outstripped all others in the competition in the evolutionary race.

4. Of the invertebrates the most important branch was formed by the mammalia.

5. Of the mammalia the most highly developed are the primates.

[1] *The Riddle of the Universe*, English ed., pp. 13–14, 1905.

6. The youngest and most perfectly developed twig of the primates is man, who sprang from a series of manlike apes toward the end of the Tertiary period.

Verily, the picture is not alluring, but we have been forced to accept it as truth of life. And from truth of life even Apollo himself must never flee. Nay, it is here or nowhere that his kingship must be finally established.

Inevitably the attitude of our poets toward the doctrine will show something of the divisions cleaving the rest of mankind. In the upward march from the primal slime through countless forms of pithecoid and still lowlier ancestors, one band of thinkers will see either a "splendid accident," or at most the operation of an utterly incomprehensible power to which we are of absolutely no concern. In this same ascent another band of thinkers will trace a "beneficent Omnipotence" operating through all nature, from the tiniest ion, or electron, or nucleus of energy, or whatever may have been the first particle of matter, to the final crown of the universe, which is man.

Of the newer poets who accept the former solution, with all its connotations, we may find an unflinching example in Mr. William Watson. This hardy singer, in a prose argument to "The Hope of the World," accepts freely, but not gladly, the "splendid accident" theory. And he goes on to assert that in view of our present knowledge "the heroic course is rather to reject than to welcome the solace of an optimism, which apparently rests upon no securer foundation than that of instinctive hope alone."

But in view of the ease with which an extremist of Mr. Watson's type may be arraigned for "flippancy, youthful certainty, slap-dash pseudo-science" and other terrible things, let us try to appreciate his real attitude toward the great question of religious faith by glancing at one of his sonnets, which well deserves quotation for its intrinsic worth:[1]

> Dismiss not so, with light hard phrase and cold,
> Ev'n if it be but fond imagining,
> The hope whereto so passionately cling

[1] *Poems*, Vol. II, p. 20, 1905.

The dreaming generations from of old!
Not thus, to luckless men, are tidings told
Of mistress lost, or riches taken wing;
And is eternity a slighter thing,
To have or lose, than kisses or than gold?

Nay, tenderly, if needs thou must, disprove
My loftiest fancy, dash my grand desire
To see this curtain lift, these clouds retire,
And Truth, a boundless dayspring, blaze above
And round me; and to ask of my dead sire
His pardon for a word that wronged his love.

It was in this mood, then, this mingling of prayer and pain, that our author accepted the conclusion he has uttered for us in honest verse.

In "The Hope of the World"[1] he voices finally and unhesitatingly the view that Life and her consort Law are unaccompanied in their lofty realm by unconquerable Love. Heaven vouchsafes no sign that through all the frame of Nature her aim is a boundless ascent benign, that she led man in kindliness up the steeps.

In cave and bosky dene
  Of old there crept and ran
The gibbering form obscene
  That was and was not man.
The desert beasts went by
  In fairer covering clad;
More speculative eye
  The couchant lion had,
And goodlier speech the birds, than we when we began.

Then this incipient self of ours climbed at last in a mere fortuitous hour, the child of a thousand chances. That in our hearts Hope still lingers unsubdued, he will admit:

She tells me, whispering low:
  "Wherefore and whence thou wast,
Thou shalt behold and know
  When the great bridge is crossed.
For not in mockery He
  Thy gift of wondering gave,

[1] *Poems*, Vol. I, pp. 122–30, 1905.

Nor bade thine answer be
The blank stare of the grave.
Thou shalt behold and know; and find again thy lost."

But he feels constrained to withstand the voice so passing sweet, the hand so profuse, and concludes with this stirring address:

Carry thy largesse hence,
Light Giver! Let me learn
To abjure the opulence
I have done nought to earn;
And on this world no more
To cast ignoble slight,
Counting it but the door
Of other worlds more bright.
Here, where I fail or conquer, here is my concern:

Here, where perhaps alone
I conquer or I fail,
Here, o'er the dark Deep blown,
I ask no perfumed gale;
I ask the unpampering breath
That fits me to endure
Chance, and victorious Death,
Life, and my doom obscure,
Who know not whence I am sped, nor to what port I sail.

We may glance also at "The Dream of Man,"[1] described as a fantasy. The Spirit of Man, the unwearied climber up the slopes of the ages, has conquered all powers soever, has transformed even the Lord of Death until he enters as a guest, serenely featured and waking no dread; has conquered the virgin planets and peopled the desert stars. To Man in this overweening pride God appears, and to humble his vaunting spirit, conducts him to a mighty peak of vision, saying:

"Look eastward toward time's sunrise." And, age upon age untold,
The Spirit of Man saw clearly the Past as a chart out-rolled,—
Beheld his base beginnings in the depths of time, his strife
With beasts and crawling horrors for leave to live, when life
Meant only to slay and to procreate, to feed and to sleep among

[1] *Poems*, Vol. I, pp. 201–11, 1905.

Mere mouths, voracities boundless, blind lusts, desires without tongue,
And ferocities vast, fulfilling their being's malignant law,
While nature was but one hunger, and one hate, all fangs and maw.
With that, for a single moment, abashed at his own descent,
In humbleness Man's Spirit at the feet of the Maker bent;
But, swifter than light, he recovered the stature and pose of his pride,
And, "Think not thus to shame me with my mean birth," he cried,
"For this is my loftiest greatness, that I was born so low;
Greater than Thou the ungrowing am I that for ever grow."

Eventually Man overthrew Death; but "his Soul rejoiced not, for the breath of his being was strife." So he prayed for succor until God from his lonelier height restored Death and Hope; and with them renewed the delight of seeking and the rapture of striving, the only transcendent joy.

This time, then, we find not only the acceptance of the upward struggle, but the recognition that it has been our highest pride for the past and must be our deepest joy in the future. Many may still feel that Love and unsubdued Hope are the final truth of the universe as well as the final cry of the human heart; but even the most conservative will scarcely deny that Mr. Watson has garnered sheaves of real poetry from this field that once appeared so unpromising. Surely the field must be naturally fertile or the sheaves could not be so rich and fair. Moreover, as the result of Mr. Watson's garnering, not a few of his fellow-men will be helped to realize emotionally the field they have already entered upon with the footsteps of reason.

Leaving the trend represented by Mr. Watson, we may find in such a singer as Mr. Stephen Phillips the voice of those who prefer to see an "omnipotent Benevolence" behind the veil. He accepts just as freely and fully the general course of evolution; but he finds therein the planning mind of the demiurge, the guiding hand of the father, who is kindly, even if far removed and dimly discerned. "Midnight—the 31st of December, 1900,"[1] is the title of a Janus-faced poem. The writer is primarily thinking forward; but his eye can descry no vision of the future dissevered from the history of the past; his vaticinations

[1] *New Poems*, pp. 28–40, 1907.

of what the Lord will do are based upon his conception of what the Lord has already done.

In the years that have been, in the rocks I have shown ye a record
And a ledger in layers of chalk;
I have shown ye a book and a diary faithful in caverns,
An account in the depths of the earth.
When ye swayed to and fro as a jelly in ooze of the ocean,
I foresaw, I determined, I planned.
And I brooded on primal ooze as a mother broodeth,
And slime as a cradle I watched.
When ye hung on the branches of trees, when ye swung and ye chattered,
I made ready, prepared and decreed
That in years that should be I would bring ye with patience through aeons,
From slime through the forest to bliss;
I would wean ye from climbings and fury to wings and to wisdom,
From dark sea-stupor to life.

So the poet looks forward to man's higher triumphs under the guiding of the all-seeing and all-doing, who is likewise the all-kind. The waves of the ether shall be man's wheels; the tempest shall be sent on his errands. Matter and distance shall be no more. The illusion of death shall pass.

In that day shall a man out of uttermost India whisper
And in England his friend shall hear;
And a maid in an English meadow have sight of her lover
Who wanders in far Cathay.
. . . .
And the dead whom ye loved, ye shall walk with, and
speak with the lost.

But even in this death-conquering glory the spirit of mortals, now become immortal, is forbidden to be proud, in memory of their lowly origin and fearsome development.

Yet remember the ancient things, the things that have been,
And meekly inherit the earth!

For the moment we are not concerned with the unpleasant realization that parts of the poem, with its great potentialities, are dangerously, almost desperately, prosaic. Mr. Phillips is still a true poet, from whom we have a right to expect much, unless his strength fails. We are not even concerned with the fact that his optimistic deism may be more comfortable than the unfainting scepticism of Mr. Watson. For us the significant feature is that Mr. Phillips has taken evolution to his heart, and unshrinkingly withal. He finds therein not merely a reasonable working hypothesis but an accepted manifestation of the ways of God toward man, which he will sing in gladness and hope.

Thus far I have kept before my eyes the general upward march of evolution; but there are many parts almost as attractive as the whole. One of these, for instance, would be the evolution of religion, a subject that immediately sets some of Swinburne's lines ringing in our ears. Others have formed felicitous themes for Mr. Kipling's pen, which is thoroughly up to date, whatever else it may or may not be.

But having deliberately fenced myself off from these, I may turn to such a topic as the outworking of ancestral influences in our personalities. The recapitulation of the race's experience in the individual—a theory now rejoicing in the inspiriting description of "onto-phylogenetic parallelism"—is the larger view, of which heredity from less remote ancestors is a more familiar phase. Through your eyes and mine are looking, not merely you and I, but our thousands of ancestors. From our earliest years we are ourselves by virtue of being our forefathers as well; in later life it is even possible to confuse the results of our individual experiences with the transmitted heritage. Not a few poets have seen the possibilities of the theme; but I am inclined to believe that among recent writers Mr. Phillips has given it the finest expression. "Thoughts in a Meadow,"[1] in my respectful judgment, is one of the best things the author of "Marpessa" has yet written; and he has already given us not a few poems for which our literature is really richer.

The thread runs like this: The never-absent sadness of mortals, felt even in the Maytime meadow, might have been avoided if the soul had wakened on a world just newly created, if it were the first that had breathed.

[1] *Ibid.*, pp. 91–93, 1907.

But ah, through thine eyes unnumbered dead ones are peering

. . . .

And by ghosts is the blowing meadow-land unforgotten;
Memories deepen the blue.

The sunset is pathetic through tears not our own. From far-off hills we feel a divine beckoning. We tremble at the lightning from unknown eyes in a throng.

And a child will sorrow at evening bells over meadows,
And grieve by the breaking sea.
O never alone can we gaze on the blue and the greenness;
Others are gazing and sigh;
And never alone can we listen to twilight music;
Others listen and weep,
And the woman that sings in the dimness to millions is singing;
Not to thee, O my soul, alone.

But if we are the products of all that has gone before, so in equal truth is the "flower in the crannied wall." It is obviously true of the flower as seen by us; for we see it with the eyes of the world's history. We are the primal slime; we are the arboreal creatures with dimly glowing eyes; we are the club-wielding dwellers in the cave. But we are also the mind that told the stars in their arising; the mighty thinker who died of hemlock; yea, the Nazarene who died on the cross. The next step is to realize that this is equally true of the daisy or the columbine. The Temple of the Smallest Flower contains the secret of God just as truly as the Temple of Reason, or the Church of Christ, or the whole course of man's development. The most spiritualistic interpreter of the universe must accept the facts of the world-process, even if he sublimate them into a transcendental religion.

This lesson we may read most agreeably in the second part of "The Flower of Old Japan,"[1] a volume wherein Mr. Alfred Noyes has tried to lead us to the Kingdom by piping us back to youth. The God who guided mankind to his present heights is the God who made the rose; and our guiding and the rose's making belong to the same cosmic order.

[1] *The Flower of Old Japan and Other Poems*, 1907. For the quotation see p. 165.

What does it take to make a rose,
Mother mine?
The God that died to make it knows
It takes the world's eternal wars,
It takes the moon and all the stars,
It takes the might of heaven and hell
And the everlasting love as well,
Little child.

Many other phases of evolution are calling to my pen; and even on the topics already introduced I should like to summon the evidence of other writers. However, this meager treatment of three rather representative men may suffice to emphasize the feeling that evolution will present an ever more fertile field for poetry, and that poetry is bringing about the emotionalizing of the doctrine. Each day this scientific truth will become a more integral part of our emotional natures, and so will inevitably be transmuted into verse. I have never been troubled by any serious doubts about the persistence and power of poetry; nor have I today any patience with such a pessimistic query about the Muse as is voiced by Mr. Phillips.[1]

How should she face the ghastly, jarring Truth
That questions all, and tramples without Ruth?

She will face it as she has ever faced it. The many mournful elegies on the great god Pan and the Muses nine are piped but for the passing hour. That rapturous Grecian world could have seen little hope for poetry in the material grandeur that was Rome. The dwellers in the imperial city on the Tiber must have been even more hopeless about the new religion founded by one Christus, whose followers were so obstinate and so inhuman. The cultured leaders of the splendid, triumphant Roman Catholic church must have believed that from the somber, creeping Protestant religion there could never spring an epic at all comparable to Dante's. And so the tale is never told. The honored speaker with whom my paper began was simply repeating the old foreboding in its new environment. But Pan and the Muses abide; and who shall doubt that under the spreading branches of the tree of knowledge they will be more winsome than ever before, the pipe and the song be sweeter on their lips?

[1] "The Dreaming Muse," in *New Poems*, pp. 94–96, 1907.

SOME PHASES OF MUSICAL AESTHETICS

By George M. Chadwick

In an age when scientific methods are so universally employed in searching the records of the past that supposed truths may be verified as such or exposed as errors, it is unreasonable to expect that the arts can escape this critical examination; nor is this to be regretted, even though it destroy many a beautiful theory extending even to the myths of the ancients. "'What is truth?' said jesting Pilate, and would not stay for an answer." May it not be asked, Who by staying has received an answer? The greatest historians have but outlined their subjects, and no philosopher has yet found the center or measured the extent of the human universe. Of modern science it may be said that one of its most impressive lessons to the world is its rebuke to past ignorance and its reminder of present limitations. What is, and what ought to be, are possibly two questions of paramount importance to a certain class, involving as they do the questions, what was, and what ought to have been. To this class of moralizing theorists it is well to give a timely warning.

Through the centuries runs a thread which we call *Art*—or shall we say there blooms a lovely flower from the hopes, the dreams and the sufferings of humanity which *is* Art? The definition is immaterial, for, after all, its meaning is beyond our comprehension. The passing years bring to the artist at least a partial transference of interest in the question of "What is art?" to that of What is the attitude of the world toward art, and what is the relation of art to the life of the world? If art be the flower, how shall one define the flower, not being able to explain the nature of the plant from which it blossomed? It is art in some form, define it as you will, that for ages has been inseparable from individual and national life; and after all the attempts to explain this or that art of any given period or nation, the vital question remains, What was the attitude of that period or that nation toward art? Was it a phenomenon which appeared from time to time in the creations of a few exceptional geniuses, to be in turn imitated by lesser genius or mere talent, until at last there was accumulated a vast amount of material to which one may refer as constituting the art of that particular period or nation?

Such questions, which may seem to be mere platitudes, are, I am convinced, only such to the few, for even among the better educated class there is often to be found not only an absence of a knowledge of music (that phase of art which we are at present considering), but, to put it rather humorously, there exists an undefined feeling that music contains no "department of learning"—which possibly explains why those who regret their ignorance of other subjects do not hesitate to confess to, and seem almost proud of, their ignorance of music.

The volumes of history are too full of "wars and rumors of wars" to allow much space for the dreams of the world's dreamers to be recorded, and hence it is along the byways rather than on the well-traveled broad road of recorded history that we catch glimpses, not so much of art, but of what men and women have thought of art, and of what was its message to them. Each human heart goes at last to its grave, and with it is buried the key which alone can unlock its real history—a history which contains art's message to that heart; for that message could not be retranslated into words, being an indefinable something which for the time being freed from its narrow prison house "the spirit, which may be so 'cabined, cribbed, confined' as not to come to any consciousness of itself."[1]

In comparing the different periods of the history of music, whether measured by decades, generations or centuries, after all that can be said on the subject of the reaction on the composer of the social and political influences of his time, a final consideration must be that of the *musical personality* of the composer himself, which is revealed at least in part by his attitude toward music, and which is measured not by the rank of his genius but rather by his sincerity. This sincere earnestness as contrasted with a selfish mercenary attitude is a very vital question. The following passage, also from Professor Corson's *Introduction to Browning*, can be applied to music:

[1] PROFESSOR HIRAM CORSON, *Introduction to Browning*.

It follows that the relative merit and importance of different periods of a literature should be determined by the relative degrees of spirituality which these different periods exhibit. The intellectual power of two or more periods, as exhibited in their literatures, may show no marked difference, while the spiritual vitality of these same periods may very distinctly differ.

Julian Schmidt in his *Geschichte der deutschen Kunstliteratur* also refers to this phase of music in the following:

With Beethoven's symphonies we feel that there is in question something quite different from the alternation of pleasure and pain, in which speechless music otherwise lives. We forbode the abyss of a spiritual world, and torture ourselves in trying to understand it. The attempt has often been made to make these feelings clear to one's self, to translate for one's self the tones into words. By strict musicians this has been censured, and rightly, for it is a fruitless attempt; the attempt is, however, too natural. We wish to know what so impelled the tone-poet to boundless desperation, to extravagant jubilation; we seek an explanation from the mysteriously beautiful features of this sphinx. The necessity obtrudes itself the more when the music becomes more and more finely subtilized, as in Beethoven's last period.

It is not the purpose of this paper to discuss systematically the philosophy and aesthetics of music, but rather merely to call the attention of the reader to certain phases of these subjects, for it is the general confusion of ideas pertaining to music that is to be regretted. The clear vision of modern investigation has eliminated much that was often mere nonsense but, veiled in mysterious language, passed for wisdom. It has emphasized the necessity of considering every art as inseparable from its own peculiar medium of expression, instead of attempting to explain all the arts from the same standpoint, or at least of applying certain principles to each and all. To classify the principles of any art, especially music, is as difficult a task as that of classifying the religious emotions of humanity. If a religion, as expounded by its founder, be the expression of the so-called belief of a certain class, shall we say that an art is likewise the expression of the belief of a class in the views of its founder or founders—if it were possible actually to discover such a parallel relation? Or shall we accept the view of Buckle?[1] that—

[1] *History of Civilization in England*, Vol. I, p. 8.

what is called a new philosophy or a new religion is generally not so much a creation of fresh ideas, but rather a new direction given to ideas already current among contemporary thinkers.

It is unnecessary to say that these words are as true when applied to the history of an art as to that of a philosophy or a religion. Indeed Buckle's emphasis of the importance of statistics in establishing historical principles applies with equal force to the history of music, the only question being, What are those statistics, and where are they to be found? In music as in the other arts the most vital truths are contained within the art itself, but who shall define the relation of those facts to the individual, to the nation and to those centuries which have measured the vast extent of some of the great epochs of art?

When Hegel defined music as "the most subjective of all arts," he recognized its true nature, at least so far as it may be subject to philosophical or scientific investigation. If sound does not exist until it is, as it were, translated to our consciousness through the medium of the physical ear, may we not likewise assert that music by the same process is music only after being thus translated it becomes in turn retranslated into intellectual or emotional concepts? But, as we shall see later, this conclusion leads to mere speculation, which has often in the past wandered far from the truth by this frequent confusion of cause and effect.

If we begin with the definition by Helmholtz, that "the construction of scales and of harmonic tissue is a product of artistic invention, and by no means furnished by the formation or natural function of the ear, as it has hitherto been most generally asserted," we can develop a series of scientific statements which will lead to a better understanding of the material basis of the art of music. First, however, let us briefly examine some of the phases of the history of music. The composer is a child of his own generation—perhaps even more so than the poet. The music of each epoch bears the stamp, musically speaking, of that epoch, even in the matter of national characteristics, and in this sense like architecture it records in its own peculiar manner much of the inner life of men and nations, though with this difference, that is has oftener been perverted as a medium of mere personal gratification.

But after all, this very phase of it is important to consider, for it reveals something of the world's attitude toward it, and also something of its influence on social life. Thus, paint never so perfectly in language a picture of society dominated by the splendors of the court, say of Louis XIV, that picture will remain incomplete without its music; or, to state it otherwise, the music of that period is one of the means by which the imagination can be stimulated and thereby a closer relation be established between the past and present. Modern instrumental music was then in its infancy, and hence the quaint, graceful and even beautiful music of that time we are inclined to consider as a mere embellishment of social, and especially of court, life, rather than as an art to be seriously reckoned with. But we cannot tell what was its influence on those who heard it and to whom no dreams of a future Beethoven were granted. Perchance for them this music, which seems too shallow to float our modern ideals, flowed a mighty river toward the ocean of Infinity.

The rise of the court style of music, especially in Germany, and in its near related country, Austria, dates from the time of Bach's son, Karl Philipp Emanuel, who was connected as a musician with the court of Frederick the Great. While in one sense it culminated in Beethoven, in another and deeper sense Beethoven soon burst its fetters and asserted the brotherhood of mankind in defiance to royalty and institutions. But if music is not a language, how is this possible? One explanation is this: If we note the contrast between Beethoven's attitude and that of Haydn and Mozart, not only toward music but toward the social and political conditions of Europe, we can realize how surely in the music of Beethoven we find less and less a mere source of pleasant entertainment, and more and more a great inspiration not to be influenced or dictated to by those conditions which for centuries had ruled.

Only the few greatest composers have had that strength of genius which is able to defy the demands of their time and to live far in advance of that time. And yet, if music is a universal art, why must the composer be controlled by the influence and dictates of his own generation? There are explanations to be found in the works of the composers, but these sources of information are not in their collective sense available to the general public, and are known, even by the musician, only as a result of years of study. The debt which each generation or epoch of creative musical energy owes the past, especially, as in some instances, its immediate past, is as great as that of the poets, to say nothing of that of the other arts. That the genius of Shakespeare, Bach or Beethoven stands a high mountain peak among the foothills of lesser genius ought not to cause one to ignore the foothills. A study of the composers of the sixteenth and seventeenth centuries reveals an almost unbroken line of development to at least the lesser compositions of Bach, and this process of development extends to the present time—development only in the case of rare genius, otherwise only change or even retrogression.

From the ancients to the present there seems always to have been a desire to explain music as a language. Hardly in a single instance have these explanations possessed any real value except as examples of beautifully written passages of prose or poetry. In 1854 Dr. Eduard Hanslick, afterward professor of musical history and aesthetics in the University of Vienna, published his *Vom musikalisch-Schönen*, an epoch-making work which has been translated into French, Italian and English. In it he exposed the errors and absurdities which so prevailed in the literature of universal aesthetics. His writings were more bitterly attacked on account of his own attacks not only on Wagner's music, but likewise on some of Wagner's essays on music. Hanslick was a conservative and as such his attitude toward Wagner is not altogether incomprehensible. But so valuable is this work that it is almost a necessity to quote it more than once in the following pages. Kant's statement that "the Germans are the only people who at present use the aesthetic for what others call the criticism of taste," and his disbelief in attempts to systematize aesthetics was not contradicted by the attitude of Hanslick, for he did not seek to construct a system of musical aesthetics, but rather to destroy the errors of so-called existing systems, though it is better to omit the word system when referring to this department of musical literature. Hanslick explains that—

the tendency in science to study, as far as possible, the objective aspect of things could not but affect researches into the nature of *beauty*. A satisfactory result, however, is only to be attained by relinquishing a method which starts from subjective sensation, only to bring us face to face with it once more, after taking us for a poetic ramble over the surface of the subject. Any such investigation will prove utterly futile, unless the method obtaining in natural science be followed at least in the sense of dealing with the things themselves, in order to determine what is permanent and objective in them, when dissociated from the ever-varying impressions which they produce.

And again:

Beauty in music is still as much as ever viewed only in connection with its subjective impressions, and books, critiques and conversations continually remind us that the *emotions* are the only aesthetic foundation of music, and that they alone are warranted in defining its scope.

More than thirty years after the publication of Hanslick's book, Dr. Hugo Riemann (afterward professor in the University of Leipzig) published a *Catechism of Musical Aesthetics* in which he attempted to reconcile the views of Hanslick and those of his opponents. It is needless to say that this book from the pen of so profound a musical scholar was a valuable addition to the literature of musical aesthetics. As to the matter of the reconciliation the results may well be questioned. The scientific mind recognizes that when science leaves off art begins—a truth well expressed by Helmholtz in the following:

A work known and acknowledged as the product of mere intellect, will never be accepted as a work of art, however perfect be its adaptation to its end.

The psychology of music is a subject which has thus far been but glanced at, and will remain so until there is a unified effort on the part of psychologists and musicians to investigate it. Whatever has been accomplished by the physicists and the psychologists leaves almost untouched the subject of music as an art, the recorded experiments being as a rule limited to the mere sensation of tone or a few tones, and hence the results are as far removed from an understanding of music as the knowledge of the anatomist is from explaining the soul of man. Nevertheless these experiments have had their influence in correcting false ideas. The following illustrations will possibly explain some of the conditions which govern scientific observations of music.

The mind cannot comprehend a present, *a now*, that is so infinitesimal a period of time that, like the imaginary line of the mathematician, it has neither breadth not thickness, or in other words that is so instantaneous that it has neither beginning nor end; therefore it cannot contemplate in a sustained chord a point of absolute repose, but rather a continuation of motion, or at least a progress or transition from a past to a future. This element of motion or progression from a past to a future is the common ground upon which psychology and music must meet, for it involves mere sensation on the one hand and rhythm and mere sensation on the other. Nearly all writers on this subject have made the mistake of referring to the vibrations of sound as an expression of motion, a mistake which is at once apparent when we consider that these vibrations are incomprehensible to the ear, and are only understood as translated by scientific apparatus to the mind through the medium of mathematical demonstration. In this sense Dr. Riemann is wrong when he asserts that "it is only the change of pitch or strength that produces the impression of movement—wrong scientifically though not wrong musically speaking, as for all practical purposes he is right in the same sense that one is right in using the terms past, present and future as applied to life. Relative to the relation of musical sounds to the emotions through the medium of the nerves, I quote the following important passage from Hanslick:

> It is true, of course, that the cause of every emotion which music arouses is chiefly to be found in some specific mode of nerve activity induced by an auditory impression. But how the excitation of the auditory nerve (which we cannot trace even to its source) is transformed into a definite sentiment; how a physical impression can pass into a state of mind; how, in fine, a sensation can become an emotion—all this lies beyond the mysterious bridge which no philosopher has ever crossed.

In the year 585 B.C., Sakadas, the flute-player, was awarded a prize at the Pythian games for a *nomos* that represented in tones the combat of Apollo with the dragon Python. The idea of representing a combat by the tones of a flute appears amusing if not absurd to us, for we are acquainted with so many deep-toned and powerful instruments that seem better capable of conveying musically the spirit of this combat, which is one proof that such matters are conclusions of a merely relative nature, rather than scientific facts. There is probably but one limit which can be placed for all time on the human ear, viz., its inability to hear as sounds of definite pitch those exceeding the extreme low or high notes of a compass of about eight octaves; and doubtless equally certain is it that the most beautiful and the noblest themes, especially of a lyric nature, will be heard within a compass represented by the middle two or three octaves of the piano keyboard, the higher and lower octaves beyond this compass being used by the composer to reinforce, echo or possibly to serve as a contrast to these middle ones. Passages such as that in the *Lohengrin* prelude, where high sustained chords are played by four solo violins, are no contradiction to this, for not as a melody but "as a something floating in the loftiest sunlit heights, gradually sinking down to earth," is this passage heard. As an opposite illustration note the entrance of the 'cellos and basses in Beethoven's Ninth Symphony or in Schubert's B minor Symphony. Transfer these latter passages to the register of the violins and instantly their sense of mysterious solemnity would be lost. Such matters are decided intuitively by the composer rather than by a process of reasoning.

As a very simple test in connection with the subject of melody take a slow theme from, say, a Mozart or Beethoven composition, and have it played in the same *tempo* in each instance on the piano, then the violin, French horn, oboe, clarinet, etc., and note the different effect on the emotions. To refer to the "longing quality of the horn," the "plaintive quality of the oboe," the "exquisitely sensitive quality of the violin," etc., would afford no scientific solution of the problem, for science demands absolute proof and not a subjective impression which might be as far from the truth as were the flute notes of Sakadas. Equally impossible is it to explain why the melody chosen was beautiful and inspired and not commonplace and stupid. And yet again, why the difference between the performance, even of a simple theme, by an artist and by a mere tyro? I have asked these questions, not in order to answer them, but as a means of calling attention to a few of the many problems which are generally dismissed in an offhand manner as being neither difficult of solution nor of importance.

As one proof that music is not a *language* capable of "describing an emotion," note the following test which the writer has frequently performed in the classroom. A composition, for example Schumann's "Warum?" is played and then each student, not already acquainted with the composition, is asked to explain its meaning. Scarcely in a single instance has the right answer been given; but when it is then played a second time, after having the title announced, all the members of the class at once recognize the relation between the music and its title. If music be a *language* it must convey in such a test at least the same *impression*, no matter how defined by the student, but it does not. The concord element of repose and the discord element of unrest are factors to be considered, but they do not explain the difference between a beautiful composition and a mere succession of chords. Scientific methods of investigation lead at last to a contemplation of music from the idea of the *beautiful*. But what is the beautiful? In the words of Voltaire, "Ask the philosophers—and they will answer you in jargon." And now do all these arguments lead to but this? Scientifically, "yes!" but musically, "no!" for after wandering still farther along the well-paved but treeless highroad of science, we shall at last reach the groves wherein the gods and nymphs danced and dreamed unconcerned with questions of the "why and the wherefore" of life's problems.

That the scientists themselves are not altogether at home when speaking of music, is illustrated by the following quotation from Herbert Spencer,[1] which reveals not only a misunderstanding of the fundamental principles of the aesthetics of music, but of the actual process of musical composition. He refers to music as "a language of feelings which may ultimately enable men vividly and completely to impress on each other the emotions they experience from moment to moment." The fatal error here is that a composition does not

[1] *Origin and Function of Music.*

express the experience of a moment—a recorded mood so to speak—but is the artistically finished results of months or years of technical work in perfecting a composition which to the public seems an "inspiration." This is cited as an argument against Hanslick by an eminent English theorist, Sir John Stainer, who during the last two years of his life was professor of music at Oxford University. It is almost incomprehensible how so "learned a musician" as Stainer could have overlooked so fatal a blunder as Spencer's, however good the intention of the latter as explained in Stainer's succeeding quotation from the same source: "In its bearings upon human happiness, this emotional language which musical culture develops and refines, is only second in importance to the language of the intellect, perhaps not even second to it." The musician can at least be thankful that Spencer's intentions were good, and that he was at least a friend and not an enemy. If the scientists have so misunderstood music, may not the musicians be forgiven if, at times, they exhibit an ignorance of science?

Before leaving this part of the subject let us note that if these problems of mere tone or of a simple melody are so difficult to explain in the language of science, how shall we hope to explain the gorgeous tone colors of the orchestra, the vast proportions of the symphony and above all the musical personality of the composer, which asserts itself through this unexplainable medium of musical sounds? All men and women can, in at least a limited sense, understand what may be called the *technique* of the poet, the painter or the sculptor. I am not speaking of his inspirations or of the higher flights of his genius, but of the process of his actual work, i.e., in the case of the painter, his reproduction on canvas of that which already exists to the physical eye. But for the composer there is no guide in this sense. At his command, from out the realm of silence Sound steps forth. But he cannot will it thus or thus by the magic of his creative power. Wagner[1] well defines this distinction when he writes:

> If a plastic artist be compared with a musician [composer], the diversity referred to is obvious; a poet stands between the two in such wise that as far as he is consciously constructing he leans toward the plastic artist, whilst he comes in contact with the musician in the obscure region of his unconsciousness.

[1] *Essay on Beethoven.*

So important is Wagner's *Essay on Beethoven* that it is hoped the irresistible temptation to quote from it will be pardoned:

> Assuredly the inner impulses of that man's will could never, or but indistinctly, modify the manner in which he apprehended the outer world; they were too violent, and also too gentle, to cling to the phenomena upon which his glance fell in timorous haste, and finally with the mistrust felt by one constantly dissatisfied. Nothing involved him in that transient delusion which could entice Mozart forth from his inner world to search after external enjoyment. A childish delight in the amusements of a great and gay town could hardly touch Beethoven; the impulses of his will were too strong to find the slightest satisfaction in such motley pursuits. If his inclination to solitude was nourished hereby, that inclination, again, coincided with the independence he was destined for. A wonderfully sure instinct guided him in this particular respect and became the mainspring of the manifestations of his character. No cognition of reason could have directed him better than the irresistible bent of his instinct.

The attitude of Wagner toward Schopenhauer is well explained in the following from the translator's preface:

> It may perhaps not be superfluous to state here that Schopenhauer confesses his view of music to be essentially incapable of proof; that his theories of dreams and visions is in the main hypothetical; and that Wagner makes use of the latter by way of analogy and elucidation only.

Not by a process of reasoning, not by willing it, but rather owing to the receptive attitude of his genius does the composer create. He becomes as it were a medium through which music flows; but the intensity of his longing to draw from out the invisible realm of sound the melodies and harmonies which haunt him, at times like some mad desire, causes him to appear as though actuated by the most powerful promptings of his will. But if we follow the work of the composer through the weeks, months or even years of his struggle with these inspirations which succeed each other, shaped in turn by the subtle influence of preceding ones, we shall find that, especially in the case of a great orchestral composition, he is involved in tasks requiring a mental concentration equal to that demanded by the most difficult mathematical problems of astronomy. How he alters the original sketches of his inspiration, unites all the material and perfects the form until at last he gives to the world the completed work, so perfect in every detail, so consistent in its development that it seems to be the inspiration of a single mood—such a problem can but reveal to us that to neither philosophy nor science can we look for a final explanation of the strange phenomena of musical composition. To further emphasize its difficulty I quote the following from Wagner's writing:

He [Schopenhauer] starts from the surprise we all feel that music speaks a language immediately intelligible to each of us without the mediation of intellectual conceptions, in which respect it differs entirely from poetry, the sole materials of which are concepts serving to transmit the *idea*. According to the philosopher's lucid and convincing definition, the ideas of the world and its essential phenomena are in a Platonic sense the *object* of the fine arts in general; whilst the poet brings these ideas home to our consciousness by the use of rational concepts in a manner peculiar to his art, Schopenhauer believes it imperative to recognize *in music itself an idea of the world*, since whosoever could completely elucidate music, or rather translate it into rational concepts, would at the same time have produced a philosophy explaining the world.

Schopenhauer puts forth this hypothetical elucidation as a paradox, seeing that music cannot, properly speaking, be explained by concepts at all. Yet, on the other hand, he furnishes the sole sufficient material for a more extended illustration of the correctness of his profound view; to which, probably, he did not apply himself more closely, as he, a layman, was not sufficiently master of and familiar with the art; and, moreover, as he could not refer his knowledge of it definitely enough to an understanding of the works of that musician who first revealed to the world the deepest mysteries of music; for it is impossible to estimate Beethoven exhaustively as long as Schopenhauer's profound paradox is not correctly explained and solved.

If now we turn from the phenomena of musical composition to that of the effect on the hearer, we may well ask, Can philosophy or science explain any direct relation between the process of a musical creation and the emotions of the hearer as awakened by music? The importance of Hanslick's views as contrasted with the superficiality of much that was previously, and is still, written about music, is at once apparent. It is as impossible to perceive the boundary line which separates the hearing of music from the effect of that hearing on the imagination as it is to perceive the separation of that which we discussed as the inspiration of the composer from the objective element included in the process of composition.

If music is not a language, why have some of even the greatest composers occasionally given descriptive titles to their instrumental compositions? An answer to this question would be influenced by a consideration of the period in which a composer lived. The dominating influences (in the classical period) of musical forms—especially those of the sonata and symphony—did not encourage the use of titles. In the succeeding romantic period the tendency to depart somewhat from these strict forms accounts, at least partially, for the desire to explain by a title the nature of a composition. Thus Liszt, instead of symphonies, composed the symphonic-poems "Tasso," "Mazeppa," etc. This tendency has been emphasized, especially by the ultra-modern composers, to such an extent that we now witness attempts to reproduce in the orchestra such subjects as "Don Quixote," Böcklin's painting "The Isle of Death," and so on through a long list. This has encouraged among a certain class of musical enthusiasts the idea that somehow by a process of mysterious meditations one can attain to an "understanding" of these compositions. It is well to note in connection with the above reference to modern tendencies the following from an article on Beethoven by Otto Jahn:

> Beethoven usually refrained from uttering words calculated to beguile people into the belief that he who understands the title, understands also the composition. His music *says all he wished to say.*

Dannreuther, in *Macmillan's Magazine*, July, 1876, writes of the last and greatest period of Beethoven's life as follows:

> He passes beyond the horizon of a mere singer and poet, and touches upon the domain of the seer and prophet where, in unison with all genuine mystics and ethical teachers, he delivers a message of love and resignation, identification with the sufferings of all living creatures, deprecation of self, negation of personality, release from the world.

If this seems to lead us away from a reconciliation of those opposing ideas which we have been considering, let us remember that it can only be understood *musically* and hence illustrates the difficulty of translating subjective musical phenomena into concepts of written language. The music of Beethoven's last period *in the language of music itself*, "touches upon the domain of the seer and prophet" in comparison with all other music.

We must recognize that though music is a universal art it is constantly changing. The music which, so far as we can now know, was a part of the luxury of the brilliant life of seventeenth-century European monarchs, is forgotten to all but the few who from time to time open these dusty volumes of the past. One by one all but a few of the symphonies of Haydn and Mozart have been crowded to one side by later compositions, which in turn may pass into oblivion. No hand can stop this onward march of humanity, be it progress or retrogression. Whether like the noblest writings and poetry of the ancients the greatest music will survive, or whether, as fade the pigments of the painter's canvas, not the music of the past but the response to that music shall become dimmed and another music of which we cannot prophecy shall alone awaken that response—who shall say? So awful is this problem that the musician instinctively turns from it in his love for his art as it now is, and asks again the question, What is this strange, incomprehensible art which in an unknown language has voiced the joys and sorrows of the world, and yet lends itself to the mere idle entertainment of that world? To the few and to the many must come at times the thought so beautifully expressed by Jean Paul Richter when he exclaimed:

> O Music! Thou who bringest the receding waves of eternity nearer to the weary heart of man as he stands upon the shore and longs to cross over! Art thou the evening breeze of this life or the morning air of the other one?

This is an age when the virtuoso type of musician, whether composer or performer, possesses a dominating influence. The thoughtful musician can but hesitate, for this very reason, to look upon it as a golden age. In the history of every art the period of extreme virtuosity, of excessive refinement, has prophesied if not actually marked the approach of its decline—and sincerity is no longer its "informing spirit." Wilhelm Ambros, over fifty years ago, wrote in his *Die Grenzen der Poesie und der Musik:*

Thus art-philosophy, art criticism, lives on in a turbid environment, and no one knows whether this is a fermentative process preceding a new development, or a process of decomposition.

One of the greatest musical personalities of the past century, Anton Rubinstein, as he contemplated the past and the possible future of his beloved art, wrote:[1]

I feel that I shall not live long enough now to enjoy the coming Bach or Beethoven—and that is sorrowful to me. My only solace is that I may still have the same enthusiasm for an organ Prelude or Fugue of a Bach that *was;* for a Sonata, a String Quartet, or a Symphony of a Beethoven that *was;* for a Song or Impromptu or Moment Musicale of a Schubert that *was;* for a Prelude or Nocturne or Polonaise or Mazurka of a Chopin that *was;* for a national Opera of the Glinka that *was*—today as ever.

[1] *A Conversation on Music*

EXTINCT AND EXISTING GLACIERS OF COLORADO

By Junius Henderson

CONTENTS

Definition and Characteristics

Exact definition of the term "glacier" seems virtually impossible. From the nature of the case, there must be many ice-masses which are clearly glaciers, others certainly not glaciers, and others so near the border-land between glaciers and non-glacial ice-bodies that it is purely a matter of individual opinion as to whether the term is applicable. Such cases are common. Thus, no hard and fast line divides "long" and "short," "big" and "little," "mountain" and "hill," "river" and "rivulet." We may easily see why exact definition is impossible in a region in which the accumulation of snow and the melting are exactly balanced so that just before the fresh snow begins to fall in autumn the last drift disappears. If in such a case the relation of dissipation to the accumulation of snow should be slightly changed, as by a decrease in the mean summer temperature, or an increase in the annual snowfall, or a change in the direction or velocity of the prevailing winds, then we should have a small portion of the largest drift left over each autumn and added to the following winter's drift. Thus by repeated accretions, the drift would in time become a large and deep snow-field which would soon become ice, and when it reached a depth so great that the pressure of the column would overcome the molecular resistance of the ice, it would begin to "flow" or spread outward. In case of the accumulation on the side of a mountain or in a gulch, manifestly the movement would be mostly or entirely down the slope from the place of accumulation, and, in case of its occurrence in a gulch, would follow the meandering of the gulch and thus form a "stream" of ice. Such is the typical glacier of a high mountain system. Clearly the original snow-drift was not a glacier. It did not become one when a little was left over and added to by the following year's drift, nor even by a number of such accretions. The beginning of a downward or outward movement of itself would not necessarily transform it into a glacier. A body of well-consolidated snow, not fully changed into ice, may slowly creep downward or extend a tongue downward upon a steep slope,[1] or, if the center of the accumulation be deep enough, it may creep without any slope of the underlying ground. Finally our drift, by small annual accretions, may extend down a gulch for many miles, the great body of it composed of true glacial ice, separated from the upper part of the snow of the accumulating area by a well-defined *bergschrund*. It would be crevassed by slow movement over the variable grade of the bed of the gulch, grinding the rocks beneath it as it moves forward with almost resistless power, sending on down the valley beyond its greatest extension a stream of milky water, laden with the fine sediments scoured from the rocks. No one could then doubt that it is a glacier, yet who can tell at what precise moment in its development it became a glacier? A similar question arises in its retreat when climatic conditions become unfavorable for its continued existence. Just when does it cease to be a glacier and become merely *névé?* In some cases a well-defined *bergschrund* (the great crevasse or system of crevasses extending across a glacier at the point where the ice by accelerated motion breaks away from the partly consolidated snow and ice of the upper *névé*) may, according to Chamberlin and Salisbury,[2] be taken as the dividing line, and when in its retreat it reaches that line, the term should probably no longer be applied. The difficulty of applying this test is great because the transition from snow to ice is gradual and the *bergschrund* may be not a simple line, but rather a

[1] KING, CLARENCE, *Report of the Geological Exploration of the Fortieth Parallel*, Vol. I, pp. 477–78, 1878.

[2] CHAMBERLIN, THOMAS C., and SALISBURY, ROLLIN D., *Geology*, Vol. I, p. 258, 1905.

broad zone of crevassed ice, the crevasses differing little in appearance, though quite distinct in origin, from the crevasses in the lower portion of the glacial stream. It is not strange, then, that difference of opinion may arise even among experts, concerning the propriety of applying the name glacier to many of the smaller ice-bodies of the Rocky Mountains and other western mountains. Not only newspaper and popular magazine writers, but also quasi-scientific writers, such as Muir, and geologists, such as Russell, have applied the name to many bodies of ice which most glacialists would refuse to recognize as glaciers.

Notwithstanding the difficulties, some sort of a definition seems necessary. In the Alps, conditions were such that the need of a refined definition was not pressing. In the Sierras and Southern Rockies, where glaciers of large size are rare or altogether wanting, and where there are thousands of *névé* remnants and glaciers bordering upon extinction, the need of exact definition seems urgent, but the search has been vain. Russell's discussion[1] admits the unsatisfactory results of an attempt to define accurately the term.

Emmons,[2] in criticizing Muir's and Russell's work and objecting to Stone's designation of the Hallett ice-mass as a glacier, says (pp. 215–16) that a symposium of the members of the Washington Philosophical Society was called to consider the matter of a definition prior to the publication of Russell's report, but that "no definition was offered which met with universal approbation." Emmons' own definition in the same paper (pp. 217–18), to enable one "to decide in a given case whether to call it a *névé*-field or a glacier," seems as deficient as any in this respect. His suggestion that it must be a stream of ice "contracted into a relatively narrow channel between two more or less parallel walls" certainly did not help matters. The phrase "relatively narrow channel" is as indefinite as any other definition, and when he requires confinement between two more or less parallel walls he emphasizes a character which seems wholly unimportant. Why should a stream of ice ten miles long which

[1] RUSSELL, ISRAEL C., "Existing Glaciers of the United States," *Fifth Ann. Report of U.S. Geol. Surv.*, pp. 309–13, 1885; *Glaciers of North America*, Ginn & Co., pp. 1–17, 1901.

[2] EMMONS, S. F., "On Glaciers in the Rocky Mountains," *Proc. Colo. Sci. Soc.*, Vol. II, pp. 211–27, 1888.

touches the canyon walls or valley walls at all points be considered a glacier, and a similar body of ice having all the same characters except that it has been melted along the sides so that a space of one, ten or a thousand feet intervenes between the ice and the wall be deemed *névé?* Who is to decide whether the slope of the valley sides must be ten degrees, one degree or a fraction of a degree to constitute a wall?

Other writers have set forth the general characters of a glacier, rather than attempting brief definition, but even that does not enable one to determine with certainty in every case whether a given ice-field should be called a glacier.

Unfortunately the word glacier is, in some portions of the Southern Rockies and Sierras, coming to mean nothing more than a perennial bank of ice or snow, and the writer has heard it applied to very small snow-banks, indeed. This is due partly to local pride—the determination of every community that it shall not be outdone by rival communities—and partly to a desire on the part of tourists and explorers who get into out-of-the-way places to believe that they are making discoveries of value. But neither local zeal nor explorer's enthusiasm should lead to designating natural objects by names which are inapplicable. It is scientifically just as important to discover that things do not exist as to discover that they do. The traveler who, by thorough exploration of a region hitherto unknown, ascertains definitely that it contains no glaciers, has rendered just as much service to geographical and geological science and contributed as definitely to the sum of human knowledge, as if he should discover a thousand glaciers.

A glacier is a body of ice originating in an area where the annual accumulation of snow exceeds the dissipation, and moving outward or downward to an area where dissipation exceeds accumulation. Snow which has stood for some time becomes granular and changes to ice which is granular, though that condition is difficult to recognize except when the ice is considerably "weathered." The granular snow is called *névé* or *firn*. Its transition into glacier-ice is gradual, so that there is no sharp line of demarkation.

Phenomena of Existing Glaciers

Certain characters are possessed by all glaciers and others by most glaciers, but all of these characters may under certain circumstances be exhibited by ice-bodies which are not fairly entitled to the name. Among them may be mentioned the following:

Movement.—Although brittle, the ice of a glacier moves outward or downward from the area of accumulation, not by the sliding of the mass as a whole, but in a manner not yet thoroughly understood, though somewhat analogous to the very slow flow of a viscous mass, conforming to the shape of the bed over which, or the channel within which, it moves. Both the observation of glaciers and laboratory experiments show that ice may be "moulded into almost any desired shape if carefully subjected to sufficient pressure, steadily applied through long intervals of time."[1]

The rate of movement varies from a few feet to hundreds of yards per annum, and is greatest in summer. It is also usually greatest near the center, bending the lines of stratification into segments of circles. Similar movement is frequently found in steep snow- and ice-banks which are not glaciers, and quite certainly the movement of a glacier is initiated in the *névé* itself, or the *névé* would not continue to renew the glacier by passing down into it. Therefore, the fact of movement simulating that of a glacier does not prove that a given ice-body is a glacier. The movement of the glacier gives rise to "rock-flour" sediments, crevasses, moraines, etc.

Moraines.—Earth, rocks and other débris are picked up by freezing to the edges and bottom of the ice, by falling from adjacent cliffs, and by being blown or washed upon the surface from near-by exposed land areas. This débris is carried forward and deposited where the ice reaches an altitude (in case of mountain glaciers) at which it melts. Thus terminal moraines are formed at the extremity, lateral moraines along the sides and ground moraines along the bed of the ice-stream. In case of mountain glaciers which are furnished with abundant rock débris from the crumbling of adjacent canyon walls, terminal moraines are often built very rapidly, so that if the end of the ice-tongue remains

[1] Chamberlin, Thomas C., and Salisbury, Rollin D., *Geology*, Vol. I, pp. 248–49, 1905.

stationary for a few years a high ridge is formed. Such ridges abound in the glaciated valleys of the Rocky Mountains and Sierras, and in many places where the fluctuations of the ice-tongue have been numerous the ancient moraines are complicated, intersecting each other at various angles. An excellent and easily accessible example of this may be seen on North Boulder Creek, Boulder County, Colorado, below Silver Lake, and others are equally good. The morainal material varies much in fineness, boulders weighing tons being included in the finest of glacial mud, without assortment. Rock ridges resembling terminal moraines in form, but of different origin, will be discussed further on.

"Rock-flour."—The moving ice, dragging boulders frozen in the bottom and sides, scours off the rocks upon which it rests, polishing and striating them and producing a fine sediment which has been called "rock-flour." This sediment gives to the water which pours from beneath the glacier a greenish-white or milky appearance, also furnishing the fine mud which is found mingled in large proportion with the rocks of the moraine, often giving it a fresh appearance as if it had just been dumped out in a wet condition by a gigantic steam shovel. This is one of the best indications of present activity of a glacier, as the mud would be washed off by a very few seasons' storms, leaving only the larger rock fragments exposed. Such sediments may not always be produced continually even by true glaciers, for they do not always move with the same velocity and may indulge sometimes in periods of comparative rest. Similar mud may be produced on a much smaller scale by the *névé*, and hence would not of itself be determinative.

A very different kind of mud, composed of wind-blown dust, fragments of vegetation, insects, etc., and possibly somewhat coarser rock fragments washed on to the ice from surrounding cliffs, must be distinguished from glacial mud. It mingles with the winter's snows and is left as a residue when the snow melts. Consequently it is found in many situations where even perpetual snow does not exist.

Size and Depth.—Manifestly the difficulty of determining just when a glacier ceases to exist, leaving only its *névé* as a reminder, prevents the fixing of a minimum limit. An ice-body a quarter of a mile long may have all the characters of the finest and largest Alpine glaciers, while much larger ice-bodies may exist under peculiar circumstances with no glacial characters. As to the maximum limit, the antarctic and arctic glaciers cover several hundred thousand square miles, and the continental glacier in Pleistocene time covered the greater part of the north half of North America. The width of a glacier may be greater than its length, but that is unusual.

Exaggerated ideas are common concerning the depth of glaciers. Glaciation in Colorado districts usually extended only from 300 to 600 feet up the canyon walls, though in some places there were depths of 1,500 feet, or more. None of the glaciers or *névé*-fields yet reported in Colorado has a probable depth of more than 100 feet, measured at right angles with the plane of the surface. The minimum would be a depth barely sufficient to cause motion, which depends upon slope, temperature and other factors. The great Greenland and antarctic ice-caps are believed to have a thickness of several thousand feet.

Crevasses.—The moving ice, although brittle, will conform to its bed without fracture, if conditions are just right as before explained, but usually great cracks in the ice, called crevasses, open wherever there is much tension, as where the center moves much more rapidly than the edge, or where the glacier moves over an inequality in the bed, when the top is stretched and gives way. Crevasses generally occur in glaciers, though it is theoretically possible for one to move without forming them, under favorable conditions. Still they are not confined to glaciers, but occur in banks of ice and well-consolidated snow on steep mountain slopes, and are not conclusive evidence of the glacial character of ice, as is commonly supposed. Exaggerated ideas are abroad concerning the depth of crevasses. In small glaciers they are limited by the depth of ice, and in very deep glaciers the depth of crevasses is limited by the pressure of the ice. Crevasses are often covered with snow, making travel over a glacier dangerous, and care should always be taken when clear ice is not exposed.

Bergschrund.—This is the great crevasse which usually stretches across the ice near the walls of the cirque. It "marks the line where the more rapidly moving ice below pulls away from the more slowly moving ice above."[1] "It is formed near where the upward-sloping *névé* meets the rock walls enclosing it."[2] "It extends along the cirque wall and opens every spring by the motion of the *névé* on its downstream side. . . . . In the most nearly perfect cirques the *bergschrund* is one single rent . . . . constitutes the dividing line between the moving *névé* and the quiescent *névé;* it is the upper limit of glacial motion. The only factor which determines the location of the *bergschrund* in any valley is the depth of the *névé*."[3] "The *bergschrund* is formed by the moving of the lower part of the snowfield away from the portion above."[4] If any sharp line is to be taken to divide a glacier from *névé*, this seems to be the only one at all satisfactory. A beautiful example is found on Arapahoe Glacier.

Stratification.—All glaciers exhibit stratification. Usually clear blue ice alternates with more spongy strata. The strata, as they near the end of the glacier in their downward movement, bend upward toward the surface, thus, as observed at their surface outcrop, dipping toward the head of the glacier.[5] On Arapahoe Glacier "dips of thirty or more degrees are common a hundred yards from the edge and the steepness increases as the margin is approached."[6] The nature of the stratification has been much discussed. It has long been contended that the "blue bands" were quite different in their origin from the strata of deposition, the usual view being that they were due to pressure. Recent investigations do not seem wholly to support that idea. Reid in 1898[7] noted the "persistence of the original stratification occasioned by the snowfall of successive years on the *névé*," but this structure was distinguished from "the transverse blue band-

[1] Reid, Harry Fielding, "The Mechanics of Glaciers," *Journ. Geol.*, Vol. IV, pp. 920, 1896.

[2] Russell, Israel C., "Glaciers of Mount Ranier," *Eighteenth Ann. Rept. U.S. Geol. Surv.*, for 1896–97, Part II, p. 382, 1898.

[3] Matthes, François E., "Glacial Sculpture of the Big Horn Mountains, Wyoming," *Twenty-first Ann. Rept. U.S. Geol. Surv.*, for 1899–1900, Part II, pp. 185, 190, 1900.

[4] Chamberlin, Thomas C., and Salisbury, Rollin D., *Geology*, Vol. I, p. 258, 1905.

[5] Reid, Harry Fielding, "The Mechanics of Glaciers," *Journ. Geol.*, Vol IV, pp. 917–23, 1896; "The Flow of Glaciers and Their Stratification," *Appalachia*, Vol. XI, pp. 1–6, 1905.

[6] Fenneman, N. M., "The Arapahoe Glacier in 1902," *Journ. Geol.*, Vol. X, pp. 847–48, 1902.

[7] Reid, Harry Fielding, "The Stratification of Glaciers" (abstract), *Science*, N.S., Vol. VIII, p. 463, 1898.

ing analogous to cleavage, which is occasioned by pressure of the moving ice, being especially developed in constricted or very steep parts of the glacier." Two years later he announced[1] that he had followed the outcrops of strata from the *névé* practically to the end of the glacier and convinced himself that "banded structure is the modified appearance of the outcrops of original stratification." He, however, distinguishes the stratification and blue bands from the banded structure due to pinched crevasses (i.e., crevasses which have closed, but still show on the surface).

The strongest argument which can be used to show that the blue veins are merely the transformed strata is that in some glaciers the stratification can be followed step by step from the reservoir to the lower part of the glacier, where it is seen to correspond to the blue veins. The Unteraar and the Forno glaciers are the only two large glaciers where this has actually been done, but on these glaciers the observation is decisive. On many small glaciers the strata can be followed to the end, but in these cases it rarely happens that they have been completely transformed into blue bands.[2]

Sherzer[3] concluded that "in the case of the Canadian glaciers studied it seems probable that the strata are depositional, in very large part, at least. The stratification of the Victoria continues throughout the glacier's extent." He leaves the matter of the blue bands in doubt, but inclines to Tyndall's pressure theory (pp. 77, 87, 122). In any event, if the blue bands represent original stratification, much modification has occurred.

Dirt-Bands, Zones and Stripes.—Dirt-bands and stratification are intimately associated. Different kinds of bands from different causes have been confused under one term. They have recently been ably discussed by Sherzer.[4] The lines of demarkation between strata are usually soiled streaks. Any rest from deposition sufficient to allow the fresh surface to solidify somewhat from the action of the

[1] Reid, Harry Fielding, "Stratification and Banded Structure of Glaciers" (abstract), *Science*, N.S., Vol. XI, pp. 103–4, 1900.

[2] Reid, Harry Fielding, "The Flow of Glaciers and Their Stratification," *Appalachia*, Vol. XI, p. 6, 1905.

[3] Sherzer, William Hittell, "Glaciers of the Canadian Rockies and Selkirks," *Smithsonian Contrib. to Knowl.*, Pub. No. 1692, Vol. XXXIV, pp. 22, 38, 42–45, 122, 1907.

[4] Sherzer, William Hittell, "Glacial studies in the Canadian Rockies and Selkirks," *Smithsonian Miscell. Coll.*, Pub. No. 1567, Vol. XLVII, pp. 465–69, 1905; "Glaciers of the Canadian Rockies and Selkirks," *Smithsonian Contrib. to Knowl.*, Pub. No. 1692, Vol. XXXIV, pp. 39, 50–54, 118, 119.

wind and from slight thawing and freezing at the surface, and to become covered with wind-blown or other débris, is probably sufficient to mark off the old deposit from the fresh deposit above. Thus, under some circumstances, a few days of warm winds may serve to produce hardened dust-covered layers, and thus separate the snowfalls of successive storms, dividing the aggregate snowfall of the year into thin laminae. Then the more prolonged rest from deposition in the summer, with its active melting and continued dusting, may separate the groups of laminae representing annual snowfalls from each other by a more pronounced line of demarkation. Then cycles of years of excessive dust-storms and reduced precipitation, alternating with cycles of reverse conditions, may give to the broad zones containing the snows of the one class of cycles a much larger proportion of débris, which at a distance would give it a decidedly different color. In Arapahoe Glacier, and probably in most mountain glaciers, another well-known type of dirt-band exists, formed by the accumulation of dust in the melted-back lips of "pinched crevasses"—that is, crevasses that have closed as the ice moved forward beyond the change of slope which produced them. Such pinched-crevasse dirt-bands are sometimes parallel with the stratification and sometimes cut the latter at considerable angle, as would be expected. Sherzer also illustrates a type of fine dust laminae quite superficial and only showing at close view.

Icebergs.—Icebergs in the small lakelets which occur at the foot of the ice when a glacier or other ice-field has rapidly shrunk away from the old moraine, have been taken sometimes to indicate an active glacier, the breaking-away of the ice being attributed to its forward movement into the lake, as occurs in case of the northern glaciers which discharge into the ocean. It is very doubtful whether any of the Colorado instances noticed are due to such a cause. It seems impossible, considering the depth and slope of the ice-fields and the shallowness of the lakes. I have found such icebergs in lakes at the foot of consolidated snow, which showed no evidence whatever of motion, as well as at the foot of *névé*-fields where the motion was surely not sufficient to produce such results. In the winter the waters of the shallow lakes freeze to the bottom, and the snow by drifting builds a steep snow-drift extending far out into the lake. Some melting goes on throughout the winter, the resulting water percolating into the snow and freezing, so that in the early summer the bank of snow is thoroughly consolidated. The lake exposes a flat surface to the summer sun and receives its full midday rays, while the steep ice-bank receives the sun's rays at a low angle during the hottest part of the day. Hence, while the ice-bank remains unmelted the lake ice is melted, the water is raised considerably above the freezing point and undermines the ice which projects out into it, by melting and by wave erosion, until it breaks off. In case of *névé* the breaking is often perhaps facilitated by former crevasses which have not been well healed, so that in such cases the motion has some influence upon the production of the bergs, but even in such cases the bergs would often form without crevasses.

Phenomena of Glaciated Regions

For the recognition of the work of extinct glaciers there are other phenomena. Among the principal ones applicable to our mountain region are the following:

U-shaped Valleys.—The typical valley caused by stream erosion is V-shaped. Glaciers did not create our glaciated canyons, but greatly modified pre-existing stream-cut canyons.[1] In case of the stream, lateral erosion is going on all the while that the stream is cutting deeper. Alternate freezing and thawing break down the cliffs on both sides and furnish the stream with a large quantity of material which it must remove, thus hampering its work of deepening the channel. Hence, the valley is usually widened at the top more rapidly than it is deepened. When a glacier fills the valley, the side walls are protected from alternate freezing and thawing by the body of ice, which preserves a fairly uniform freezing temperature. At the same time the whole mass of the ice is scouring away the rocks. The greatest weight rests along the sides of the canyon at the bottom, so

[1] Endlich, F. M., "Report on the Geology of the White River District," *Tenth Ann. Rept. U.S. Geol. and Geog. Surv. Terr.*, for 1876, p. 116, 1878; Cross, Whitman, and Howe, Ernest, "Geography and General Geology of the Quadrangle," *Silverton Folio No. 120, Geologic Atlas of the United States, U.S. Geol. Surv.*, p. 24, 1905.

that it widens the valley rapidly at the bottom while doing but little work at the top, thus changing the V-shape to U-shape.

Roches Moutonnées.—These are knobs of rock rounded by the glacier, so called from their resemblance to the backs of sheep.

Polished and Scratched Surfaces.—The ice, dragging sand and boulders along its bottom, moves over the rocks, often giving them a beautiful polish, and fluting, grooving and scratching them. The *roches moutonnées* still stand out prominently in the upper parts of our Colorado glaciated valleys, vegetation not yet having gotten enough soil for a foothold, and in a few places polished surfaces and scratches are visible, though the character of the rock in some places is such that the latter are not well preserved, the surface of the granites and gneisses weathering rapidly.

Moraines.—Moraines afford the best evidence of glaciation usually, in the regions examined by me, as they are so unmistakable and so universally present, although in some places probably the rapid retreat of glaciers has prevented the deposition of such moraines.[1]

Lakes.—Glaciers in their retreat in mountain regions have usually left behind them two kinds of lake basins—true rock basins, scoured out by the ice in softer rock lying back of harder zones, and basins dammed by moraines. Lakes of both types are abundant in most of our glaciated valleys, but rare or wanting in some.

Hanging Valleys.—Hanging valleys are lateral valleys whose beds where they enter the main valley are above the bed of the main valley. They have been usually attributed to glaciers,[2] but may occur from causes not associated with glaciers.[3] Such valleys are common in our glaciated regions.

Cirques and Benches.—Our glaciated mountain valleys head in amphitheaters called cirques, and are usually terraced. The cirque structure has often been looked upon as a cause, rather than an effect, of glaciation, forming, as it does, a natural reservoir for the accumulation of snow. Only recently have the cirques and terraces,

[1] LEE, WILLIS T., "Note on the Glacier of Mount Lyell, California," *Journ. Geol.*, Vol. XIII, p. 358, 1905.

[2] DAVIS, W. M., "Hanging Valleys in General," *Science*, N.S., Vol. XXV, pp. 835–36, 1907.

[3] UPHAM, WARREN, "Fjords and Hanging Valleys," *Amer. Geol.*, Vol. XXXV, pp. 312–15, 1905; CROSBY, W. O., "The Hanging Valleys of Georgetown, Colorado," *Amer. Geol.*, Vol. XXXII, pp. 42–48, 1903.

or so-called benches, been at all satisfactorily explained, as the result of "sapping" at the bottom of crevasses and the *bergschrund*. Johnson suggested in 1899[1] that the ice protects the bottom from changes in temperature except where crevasses and the *bergschrund* reach the bottom. So at the bottom of these openings disintegration of the rocks by freezing and thawing would be going on rapidly, while elsewhere this important geological agency would be inoperative. Thus, the moderate change in grade which caused a crevasse would be developed into a sub-glacial cliff and the *bergschrund* would also form a cliff. Surface water dropping into the openings and flowing away under the ice greatly facilitates the work by direct erosion, as well as by carrying off the débris from the disintegration of the rock. These cliffs slowly recede up stream, those formed by the crevasses making the characteristic benches, and that formed by the *bergschrund* developing into a cirque. This idea is accepted by most geologists[2] and enlarged upon, though it is objected to by some,[3] especially in Europe, partly because of a supposition that the ice on both sides of crevasses would prevent much change in temperature. In examining the *bergschrund* of small glaciers in Colorado, I have been convinced, however, that this does go on and is an immensely potent factor in the sculpturing of our mountains. With this idea in mind, one cannot view the crest of the Continental Divide in Colorado without being impressed with the importance of this agency.

Snow-Bank Talus Ridges.[4]—Ridges composed of angular rock, simulating moraines in form, are common in the higher mountains,

[1] JOHNSON, WILLARD D., "The Work of Glaciers in High Mountains," *Science*, N.S., Vol. IX, pp. 112–13, 1899.

[2] MATTHES, FRANÇOIS E., "Glacial Sculpture of the Big Horn Mountains, Wyoming," *Twenty-first Ann. Rept. U.S. Geol. Surv.*, for 1899–1900, Part II, pp. 173–90, 1900; DALY, REGINALD A., "The Accordance of Summit Levels among Alpine Mountains: The Fact and Its Significance," *Journ. Geol.*, Vol. XIII, pp. 118–19, 1905; GILBERT, G. K., "Systematic Asymmetry of Crest Lines in the High Sierra of California," *Journ. Geol.*, Vol. XII, pp. 579–88, 1904; CROSS, WHITMAN, and HOWE, ERNEST, "Geography and General Geology of the Quadrangle," *Silverton Folio, No. 120, Geol. Atlas of the United States*, U.S. Geol. Surv., p. 24, 1905; RUSSELL, ISRAEL C., "Glaciers of Mount Rainier," *Eighteenth Ann. Rept. U.S. Geol. Surv.*, for 1896–97, Part II, p. 382, 1898.

[3] BONNEY, T. C., Presidential Address, British Association for the Advancement of Science, *Science*, N.S., Vol. XXXII, pp. 323–35, 1910. See also DAVIS, W. M., "Glaciation of the Sawatch Range, Colorado," *Bull. Museum Compar. Zoöl.*, Vol. XLIX, pp. 6–7, 1905.

[4] HOWE, ERNEST, *Land Slides in the San Juan Mountains, Colorado*, U.S. Geol. Surv., Prof. Paper, No. 67, pp. 35–36, 1909.

but are easily distinguished. A bank of snow and ice forms at the foot of a cliff, sometimes extending some distance up the cliff. Rocks broken from the cliff by frost slide down over the bank all the spring and early summer and accumulate at its foot. Then the snow and ice melt away and leave it standing out from the cliff as a ridge which does not contain the fine glacial mud mentioned elsewhere. It may

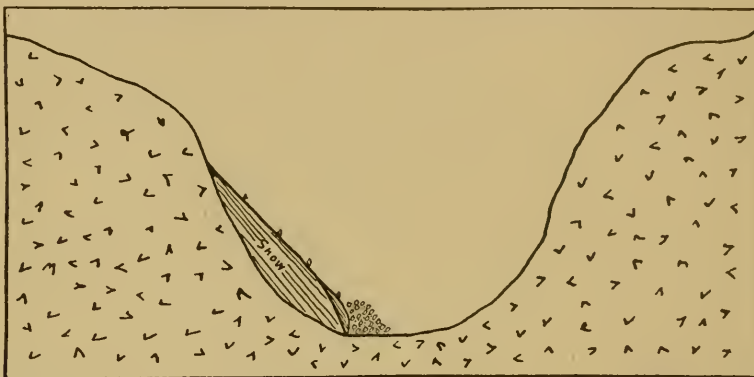

FIG. 1.—Showing origin of snow-bank talus ridges, resembling moraines.

contain mud composed of wind-blown sand, small rock fragments and fragments of vegetation, but that is readily distinguished from glacial mud.

Conditions Limiting Glacial Formation

Types of Glaciers.—It is probable that all of our Colorado glaciers, both ancient and existing, are of the alpine type, which may be subdivided into cliff glaciers (those hanging upon steep cliffs) and valley glaciers (those originating on the cliffs of cirques and extending down valleys). Except Arapahoe, the existing glaciers of the state are cliff glaciers.

Glacial Climates.—It is commonly supposed that very severe climate is necessary to produce glaciers, and glacial epochs have been frequently referred to as periods of maximum cold. Glaciers result from the relation of snowfall to temperature, hence either an increase of annual snowfall or a decrease of mean annual temperature, especially a decrease in the mean summer temperature, may produce a glacier without the climate becoming severe. A marked increase in the snowfall on our mountains would at once initiate another extension of glaciers down the valleys. As it is, they are slowly retreating and a very slight decrease in the snowfall would soon destroy them. Only observations carried on a great many years can really determine whether or not the present recession is permanent, or only represents a short cycle of disadvantageous conditions.

Limiting Conditions.—The reasons there are glaciers or *névé* on some of our high mountains are various and topographic. Although Pike's Peak, for instance, is higher than Arapahoe and her adjoining peaks, on the latter the glaciers have been much more important, because of differences in topography, probably causing greater precipitation on Arapahoe, though records are lacking. The general limiting factors are: (*a*) Size of catchment area. (*b*) Direction of exposure of places into which the wind drifts the snow with reference to protection from the sun. (*c*) Precipitation. (*d*) Temperature. (*e*) Character of the ground in the direction of the prevailing winds.

Altitude.—The altitude at which conditions permitted the formation of glaciers in the Rocky Mountains differed greatly. In the Big Horn Mountains, Wyoming, an altitude from 9,500 to 11,500 feet was necessary to initiate glaciers, and they extended in some instances down to 6,500 feet, the maximum depth of ice being 1,500 feet.[1] In Wasatch Mountains, Utah, the necessary altitude was from 8,000 to 9,000 feet, and many extended down to from 5,000 to 6,000 feet, the largest ones and those reaching the lowest altitudes in their extension being on the west side of the range.[2] In the Uinta Mountains, Utah, most of the catchment areas were 10,000 feet or more above the sea, but a few were between 9,000 and 10,000 feet. The longest was 27½ miles in length and several exceeded 20 miles, the lowest altitude reached being 6,600 feet.[3]

In Colorado probably few glaciers originated at altitudes less than

[1] Salisbury, R. D., "Glacial Geology," *Geology of the Big Horn Mountains*, U.S. Geol. Surv., Prof. Paper, No. 51, pp. 72–73, 1906.

[2] Salisbury, R. D., "Glacial Work in the Western Mountains in 1901," *Journ. Geol.*, Vol. IX, pp. 725–27, 1901.

[3] Salisbury, *op. cit.*, pp. 728–29.

11,000 feet, and in many places they did not extend much below 8,000 feet, though some are known to have reached about 6,000 feet. In length they ranged from less than a mile to over 70 miles and usually reached a depth of 500 to 600 feet, though numbers reached 1,000 feet, a few 1,500 feet, and some even more.

Characteristic Features of the Glaciated Area.—The glaciers occupied the upper portions of canyons and valleys, which now abound in such evidence of the former action of ice as U-shaped valleys (to the exclusion of V-shaped), moraines, cirques, transverse terraces, *roches moutonnées*, polished, fluted and striated surfaces, etc.

Economic Relations

All who are familiar with glacial phenomena are aware that glacial geology has considerable economic importance. This has long been recognized in the area covered by the great Continental Glacier. It is equally true in our mountains. In various parts of Colorado, glacial gravels have been worked as placer claims.[1] As will be seen by examining the localities reported upon, many of the important metal mining districts are partly covered by glacial débris, which may cover valuable ore deposits and thus prevent prospecting or make exploration less profitable. Miners unfamiliar with glacial phenomena have often found "float" upon the surface of moraines which came from miles away, and have wasted much time and money in sinking shafts or running tunnels in the hope of disclosing the veins from which the ore came. In other cases attempts have been made to dig through moraines of great depth for bedrock upon which to place reservoir dams for irrigation and power purposes, in the supposition that they were thin, superficial deposits of stream-laid materials.

Most of the natural lakes of our upper mountain valleys which are now being used for storage of water for irrigation, power or domestic use, are glacial lakes, and they form one of Colorado's greatest assets.

[1] Endlich, F. M., "Report upon the Geology of the San Luis District," *Seventh Ann. Rept. U.S. Geol. and Geog. Surv. Terr.*, for 1873, p. 347, 1874; Stevenson, John J., "Geology of a Portion of Colorado Explored and Surveyed in 1873," *Geog. and Geol. Explor. and Surv. W. of 100th Meridian*, Vol. III, p. 431, 1875; Lakes, Arthur, "Glacial Placer Beds on the Flanks of the Mosquito Range, South Park, Colorado," *Mines and Minerals*, Vol. XXII, p. 469, 1902; Salisbury, Rollin D., "Glacial Work in the Western Mountains in 1901," *Journ. Geol.*, Vol. IX, p. 731, 1901; Capps, S. R., *Pleistocene Geology of the Leadville Quadrangle, Colorado*, U.S. Geol. Surv., Bull. No. 386, p. 15, 1909.

Much of the water of our mountain streams is from remnants of glaciers and *névé*, and from snow-banks which form and are protected in old glacial cirques. In a semi-arid region which is so dependent upon irrigation, it is quite important to know whether the banks of "perpetual snow" may be depended upon for the distant future, as it may make a difference in the planning of extensive works. In times geologically recent, the whole Southwest has become less humid than formerly, and there are strong reasons for believing that the desiccation is still in progress. Inherent difficulties in the use of weather records for the determination of this question, even if they covered a long enough period, make necessary more reliable methods, which would be furnished by series of observations upon glacial remnants and *névé*, carried through many years with records accurately preserved by measurements and photographs taken from the same points, with the same camera and lens, on the same day of each year, preferably the last of August or first of September, for purposes of comparison.

Historical

It was long after the exploration and settlement of Colorado began that the general glaciation of the higher mountains came to be recognized. As late as 1872, Dr. Foster[1] said that the mountains nowhere exhibit *roches moutonnées* or other glacial phenomena and that lakes are very rare. His travels must have been limited indeed, for almost everywhere above 11,000 feet *roches moutonnées*, and moraines are abundant and glacial lakes almost as common. Dr. Bliss,[2] replying to Foster, could give but very few examples of the hundreds now known. Nine years later Geikie[3] in his brief summary of Rocky Mountain glaciation does not mention the existence of such phenomena in Colorado, though a number of papers discussing the subject had appeared long before. Endlich, Stevenson, Hayden, Marvine, King, Peale, and perhaps others, between 1873 and 1878, published reports in the publications of the several western surveys, describing glacial

[1] Foster, J. W., "The Mountains of Colorado," *Amer. Naturalist*, Vol. VI, pp. 73–75.

[2] Bliss, Richard, Jr., "Glaciers in the Rocky Mountains," *Amer. Naturalist*, Vol. VI, pp. 310–12, 1872.

[3] Geikie, Archibald, "The Ancient Glaciers of the Rocky Mountains," *Amer. Naturalist*, Vol. XV, pp. 1–7, 1881.

phenomena in various portions of Colorado. More recent reports by various geologists have appeared in the publications of the United States Geological Survey and the *Journal of Geology*, so that now the existence of glacial phenomena on a very large scale is well known, and some progress has been made even in the determination of two or more distinct periods of glacial extension and retreat. It would be expected that recognition of actually existing glaciers of small extent would be still more tardy. Miss Dartt,[1] now Mrs. Nathan D. Thompson, who lived in Boulder at one time and was familiar with Arapahoe Peak at least from a distance, wrote in 1879: "For reasons belonging to the province of physical geography, we have no glaciers, and the perpetual snows of our lofty mountains are gathered into vast fields or banks in places where the rocks or contours of the ground protect them from the warm west winds." Russell[2] in 1885 said: "No true glaciers have been discovered south of Wyoming."

In 1886 Comstock[3] wrote: "Existing glaciers in the Wind River Mountains and in the San Juan Mountains enable us to witness the actual production of these peculiar effects," but he gives us no further information concerning them or their exact location.

The first definite description that I have been able to find of a still active glacier or glacier-like body in the state is in 1887, when Stone[4] described the ice-field known as Hallett Glacier. This led to Emmons' discussion[5] in which he concludes that it "is most probably the last remnant of the *névé* of this glacier, and could hardly be called a living glacier with strict regard for scientific exactness."

The present decade has been much more prolific. Fenneman and Lee have described Arapahoe, Mills has reported several active glaciers in the neighborhood of Long's Peak and northward, and Siebenthal has described two in the Sangre de Cristo Range. One

[1] DARTT, MARY, *On the Plains and among the Peaks; or How Mrs. Maxwell Made Her Natural History Collection*, Claxton, Remsen & Heffelfinger, Philadelphia, p. 159, 1879.

[2] RUSSELL, ISRAEL C., "Existing Glaciers of the United States," *Fifth Ann. Rept. U.S. Geol. Surv.*, for 1883–84, p. 344, 1885.

[3] COMSTOCK, THEO. B., "Some Peculiarities of the Local Drift of the Rocky Mountains," *Science*, Vol. XX, pp. 925–26, 1886.

[4] STONE, G. H., "A Living Glacier on Hague's Peak, Colorado," *Science*, Vol. X, pp. 153–54, Sept., 1887.

[5] EMMONS, F. S., "On Glaciers in the Rocky Mountains," *Proc. Colo. Sci. Soc.*, Vol. II, pp. 211–27, 1887.

of Mills's books[1] is especially useful because of the accompanying map which gives the location of the principal mountain peaks and named ice-fields of the region north and northwest of Long's Peak. This map names Hallett, Tyndall, Sprague and Andrew Glaciers.

Extinct Glaciers of Colorado

Age.—Colorado was not within the area covered by the Pleistocene Continental Glacier. The Denver Basin deposits once designated glacio-natant drift[2] and the loess are not of glacial origin. In Montana the relations of deposits from the Continental ice-sheet to those from mountain glaciers indicate that the latter were not earlier than the Iowa epoch, and probably as late as the Wisconsin.[3] In Utah seven glaciers reached the shores of ancient Lake Bonneville and the remains of three were partly buried on or near the shore by either fluviatile or lacustrine deposits. There were at least two epochs, and the latest advance was late in the history of Lake Bonneville.[4] Though the Montana, Utah, Wyoming, and Colorado glaciers were likely contemporaneous, they were probably not actually connected, owing to unfavorable intervening topography and altitudes. Theoretically the same conditions would in part be required to produce glaciers in our mountains and to produce extensive lakes in the Great Basin of the Southwest—excess of precipitation over dissipation. Those ancient lakes had two periods of maximum extension, just as the mountain glaciers had. In Wyoming, also, there were two glacial epochs, the latest probably of Wisconsin age or later.[5]

In the Leadville, San Luis and San Juan districts of Colorado,

[1] Mills, Enos A., *The Story of Estes Park and a Guide Book*, Outdoor Life Pub. Co., Denver, 1905.

[2] Emmons, S. F., "Pleistocene Geology," *Geology of the Denver Basin*, U.S. Geol. Surv., Mon., Vol. XXVII, pp. 265–66, 274, 1896.

[3] Salisbury, Rollin D., "Glacial Work in the Western Mountains in 1901," *Journ. Geol.*, Vol. IX, p. 720, 1901.

[4] Salisbury, Rollin D., *op. cit.*, pp. 725–27; Gilbert, G. K., *Lake Bonneville*, U.S. Geol. Surv., Mon., Vol. I, p. 92, 1890; Russell, Israel C., *Geological History of Lake Lahonton, a Quaternary Lake of Northwestern Nevada*, U.S. Geol. Surv., Mon., Vol. XI, 1885; Atwood, Wallace W., *Glaciation of the Uinta and Wasatch Mountains*, U.S. Geol. Surv., Prof. Paper No. 61, pp. 68, 92, 1909.

[5] Salisbury, Rollin D., "Glacial Geology," *Geology of the Big Horn Mountains*, U.S. Geol. Surv., Prof. Paper No. 51, pp. 71, 86–87, 1906.

two epochs of glacial extension have also been recognized.[1] Though quite likely most, if not all, of the Colorado glaciation yet recognized was of Wisconsin age, as Cross and Howe, Siebenthal and Hole say, the direct evidence is meager, and evidence of still earlier glaciation may have been obliterated by more recent advances. In any event, Hayden's statement[2] that the glacial period extended "back farther into the past in the Rocky Mountains than geologists have accredited it in other regions," and began in the Pliocene, seems unsupported by evidence. The freshness of glacial phenomena, continued existence of glaciers and *névé* and other evidence show that the glacial epoch extended down to the present time in Colorado and northward, and that the retreat of the glaciers is still in progress. Though the older glacial phenomena have been considerably affected by erosion in places, especially by the removal of glacial débris and the cutting through of moraines, the upper parts of the glaciated valleys have as a rule been little affected by post-glacial erosion.

Former Extent.—The area of Colorado is about 103,925 square miles. It is difficult to say how much of it was once covered by glaciers, as only an infinitesimal portion of the glaciated area has been accurately mapped. Glaciers were confined to the crests of the higher mountain ranges and the higher mountain valleys, seldom extending up over the lateral divides. Along the crests of the ranges many of the *névé*-fields united. Hence a map of the ancient glaciers and their *névé*-fields would occupy a strip several miles wide along the greater part of the crests of the several ranges whose peaks exceed 12,000

[1] EMMONS, S. F., "Abstract of Report on Geology and Mining Industry of Leadville, Lake County, Colorado," *Second Ann. Rept. U.S. Geol. Surv.*, for 1880–81, p. 229, 1882; *Geology and Mining Industry of Leadville, Colorado*, U.S. Geol. Surv., Mon., Vol. XII, p. 30, 1886; EMMONS, S. F., and IRVING, J. D., *The Downtown District of Leadville, Colorado*, U.S. Geol. Surv., Bull. No. 320, p. 13, 1907; CAPPS, S. R., and LEFFINGWELL, E. D. K., "Pleistocene Geology of the Sawatch Range, Near Leadville, Colorado," *Journ. Geol.*, Vol. XII, pp. 698–702, 1904; WESTGATE, LEWIS C., "The Twin Lakes Glaciated Area, Colorado," *Journ. Geol.*, Vol. XIII, pp. 285–312, 1905; CROSS, WHITMAN, and HOWE, ERNEST, "Geography and General Geology of the Quadrangle," *Silverton Folio No. 120, Geologic Atlas of the United States*, U.S. Geol. Surv., p. 24, 1905; HOWE, ERNEST, and CROSS, WHITMAN, "Glacial Phenomena in the San Juan Mountains, Colorado," *Bull. Geol. Soc. Amer.*, Vol. XVII, p. 267, 1906; HOWE, ERNEST, "Glacial Phenomena in the San Juan Mountains," *Science*, N.S., Vol. XXIII, pp. 306–7, 1906; SIEBENTHAL, C. E., "The San Luis Valley, Colorado," *Science*, N.S., Vol. XXXI, p. 746, 1910; CAPPS, S. R., *Pleistocene Geology of the Leadville Quadrangle, Colorado*, U.S. Geol. Surv. Bull. No. 386, 1909; HOLE, ALLEN D., "Glacial Geology," *Engineer Mountain Folio No. 171, Geologic Atlas of the United States*, U.S. Geol. Surv., p. 68, 1910.

[2] HAYDEN, F. V., "Report of F. V. Hayden, U.S. Geologist," *Seventh Ann. Rept. U.S. Geol. and Geog. Surv. Terr.*, for 1873, p. 53, 1874.

feet in altitude, with lobes of ice extending off on each side down the valleys for several miles, affecting about one-half of the counties of the state. It seems probable that from 10 to 20 per cent of the state was once covered with glacial ice and *névé*. The total area of existing glacial ice and *névé* definitely reported would not exceed ten square miles.

Maps.—Owing to their small scale and the lack of definite data, the accompanying maps (Figs. 2 and 3) are very much generalized, so as to give only a very general idea of the distribution of the glaciers. Most reports are indefinite and nearly all are unaccompanied by maps. The shaded outlines indicating glaciated regions necessarily include ridges and other areas which were not covered by ice, and other areas covered by the glaciers are not included. Only a large, detailed map, based upon much more field work, could correctly represent even the known facts, and extensive areas are wholly unreported and unknown.

Northern Front Range and Medicine Bow District.—This whole region was covered with glaciers for a breadth of about 16 miles. The southern Medicine Bow glaciers extended down to the edge of North Park, large ones extended down both branches of the Cache la Poudre and Big Thompson, one reaching an altitude of about 6,500 feet, and some on the west side of the range reaching the foothills of Middle Park.[1] The South St. Vrain and associated glaciers extended down to an altitude of about 9,000 feet,[2] leaving a fine series of moraines within a few hundred yards of Ward. Just west of Ward the glaciers overrode the hills and the débris indicates a depth of ice of probably at least 300 to 400 feet. The main glacier is not quite extinct and is elsewhere described as Isabel Glacier. Albion Glacier, north of Arapahoe, has likely retreated very recently, glacial polish and striae still showing on rocks which are of such character as to weather readily. It is still represented by crevassed *névé* at the head of Albion Gulch. North Boulder Glacier, represented by

[1] King, Clarence, "Systematic Geology," *U.S. Geol. Surv. 40th Parallel*, Vol. I, pp. 467, ff; Cooper, William S., "Alpine Vegetation in the Vicinity of Long's Peak, Colorado," *Botanical Gazette*, Vol. XLV, pp. 320–24, 1908; Orton, Edward, Jr., "The Mills Moraine, with Some General Remarks on the Glaciation of the Long's Peak Region of Colorado," *Science*, N.S., Vol. XXIX, pp. 751–52, 1909.

[2] Ramaley, Francis, and Robbins, W. W., "Redrock Lake, Near Ward, Colorado," *Univ. Colo. Studies*, Vol. VI, pp. 135–68, 1909.

the existing Arapahoe Glacier,[1] once extended down the valley for a distance of perhaps over eight miles, with a depth of 600 feet or more in places.

Middle Boulder Glacier at its greatest extension probably reached a little below Nederland, though the evidence is not as clear below as above. Its last retreat apparently long anteceded the recession of the North Boulder Glacier. I believe that North Boulder Park,

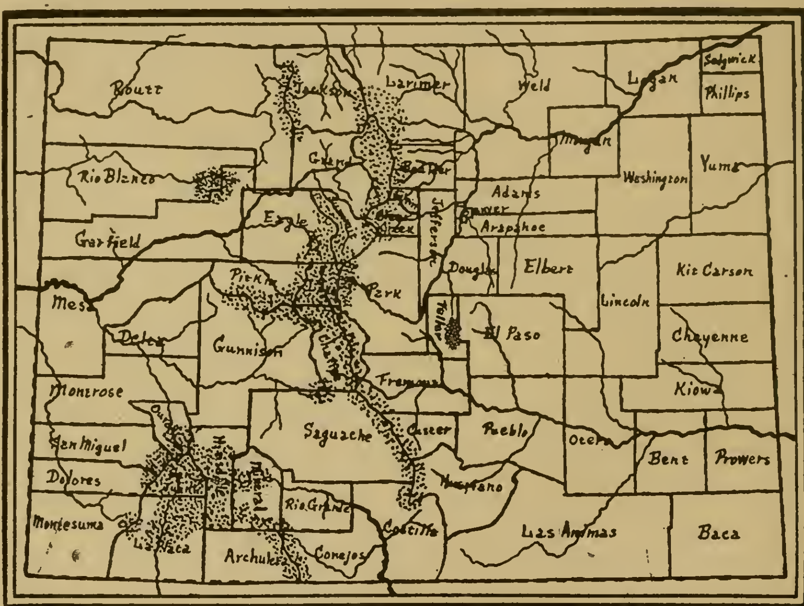

FIG. 2.—Map showing approximate general distribution of ancient glaciers in Colorado.

Middle Boulder Park and South Boulder Park are all filled-up beds of ancient glacial lakes, perhaps representing the earlier glacial extension. Just such lakes are now being rapidly filled up and drained all over the glaciated region, where their glacial origin is undoubted. Unlike most of the gulches of this region, Middle Boulder does not now contain lakes and the upper part has never had such extensive lakes as North Boulder, Albion Gulch, the South St. Vrain etc.

[1] FENNEMAN, H. M., "The Arapahoe Glacier in 1902," *Journ. Geol.*, Vol. X, pp. 840–42, 1902.

South Boulder Glacier extended down to a point just below Tolland (about 8,500 feet) and was at least from 300 to 400 feet in depth as indicated by perched boulders.[1]

All of the gulches on both sides of the range throughout this region which reach the crest of the range were filled with glaciers. Grand Lake is a glacial lake and Gray's Peak, Torrey's Peak and Mount McClellan are glaciated. Large portions of Georgetown and Central

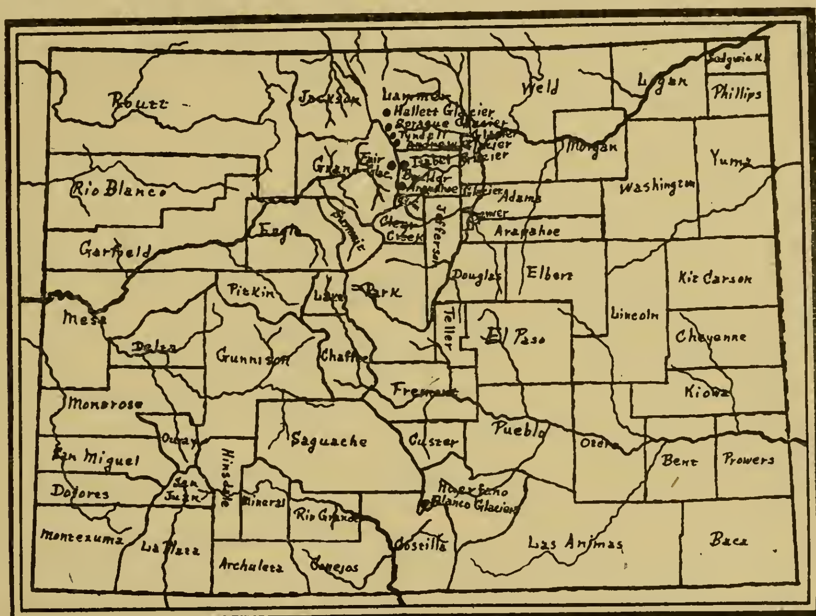

FIG. 3.—Map showing approximate distribution of known existing glaciers in Colorado.

City Quadrangles are glaciated, but there is but little evidence of it in the Lower Clear Creek area covered by Underhill.[3]

Pike's Peak Region.—This peak stands out in front of the Front Range, not producing as great a mountain mass as the grouped peaks

[1] RAMALEY, FRANCIS, "Remarks on Some Northern Colorado Plant Communities with Special Reference to Boulder Park (Tolland, Colorado)," *Univ. Colo. Studies*, Vol. VII, pp. 234–35, 1910.

[2] MARVINE, ARCH. R., "Report of Arch. R. Marvine, Assistant Geologist Directing the Middle Park Division," *Seventh Ann. Rept. U.S. Geol. and Geog. Surv. Terr.*, for 1873, pp. 148, 159, 1874.

[3] UNDERHILL, JAMES, "Areal Geology of the Lower Clear Creek, Colorado," *Proc. Colo. Sci. Soc.*, Vol. VIII, pp. 104–5, 1906; *Univ. Colo. Studies*, Vol. III, p. 265, 1906.

of other parts of Colorado, and hence was not as favorably situated for the production of large glaciers. However, some reached a length of at least three or four miles.[1] Moraine Lake and Seven Lakes are of glacial origin. Cross[2] considered the rounded boulder and gravel deposits of the smooth, grassy country about Divide and Summit glacial drift.

Northern Part of Park Range.—King[3] maps the glaciated area of this northern region on a small scale, and says that it is about 60 miles in length, with an average width of 10 miles. The glaciers came down to the level of North Park, ending at 7,600 or 8,000 feet, portions of the foothills being composed of morainal deposits.

White River Region.—Endlich[4] found no evidence of glaciation in the White River drainage, but believed there were glaciers on the Grand River side of the White River Plateau. I found abundant evidence of glaciers in the upper part of the North White River Valley down as far as Buford, and on Marvine Creek, and have reason to believe the same would be found true of the South Fork.[5]

Leadville District.—The entire region about Leadville including the northern part of Park Range, Sawatch (Saguache) Range, Mosquito Range, Elk Mountains, Upper Arkansas Valley, Blue River, Eagle River etc., is heavily glaciated. The region, especially the Upper Arkansas Glacier, has been much discussed, and its tributary, Lake Creek (Twin Lakes area), has become classic ground to glacialists.[6] Capps and Leffingwell examined 250 square miles of glaciation

[1] STONE, GEORGE H., "Remarks on the Glaciation of the Rocky Mountains," *U.S. Geol. Surv., Mon.*, Vol. XXXIV, pp. 348–49, 1899.

[2] CROSS, WHITMAN, *Pike's Peak Folio, No. 7, Geologic Atlas of the United States*, U.S. Geol. Surv., p. 5, 1894.

[3] KING, CLARENCE, "Systematic Geology," *U.S. Geol. Surv. 40th Parallel*, Vol. I, p. 468, Plate V.

[4] ENDLICH, F. M., "Report on the Geology of the White River District," *Tenth Ann. Rept. U.S. Geol. and Geog. Surv. Terr.*, for 1876, p. 86, 1878.

[5] HENDERSON, JUNIUS, "Scientific Expedition to Northwestern Colorado in 1909; Itinerary, Topography and Geology," *Univ. Colo. Studies*, Vol. VII, pp. 110–11, 1910.

[6] HAYDEN, F. V., "Report of F. V. Hayden, U.S. Geologist," *Seventh Ann. Rept. of U.S. Geol. and Geog. Surv. Terr.*, for 1873, pp. 48–54, 1874; "Report of F. V. Hayden, United States Geologist," *Eighth Ann. Rept. U.S. Geol. and Geog. Surv. Terr.*, for 1874, pp. 47–68, 1876; EMMONS, S. F., "Geology and Mining Industry of Leadville, Colorado," *U.S. Geol. Surv., Mon.*, Vol. XII, pp. 40–42, 1886; *Tenmile Folio, No. 48, Geologic Atlas of the United States*, U.S. Geol. Surv., p. 2, 1898; *Geology of the Aspen Mining District*, U.S. Geol. Surv., Mon., Vol. XXXI, pp. 244–47, 1898; EMMONS, S. F., and IRVING, JOHN D., *The Downtown District of Leadville, Colorado*, U.S. Geol. Surv., Bull. No. 320, 1907; STONE, GEORGE H., "Remarks on the Glaciation of the Rocky

and noted evidence of two epochs, the ice of the last covering the larger part of the surface of the mountains. The glaciers originated at 11,000 feet usually and descended to 9,000 or less, the larger ones reaching a depth of 1,000 feet. Emmons, in the Leadville Monograph (pp. 94–95), says the Platte Glacier must have been about 2,000 feet thick. All the main streams of the Mosquito Range head in glacial cirques. Some, ten miles long, extended down into South Park, according to Stone. Buckskin and Mosquito Gulches are worthy of special mention. Tenmile Glacier extended some distance down Eagle River. A lateral moraine at Clinton Gulch has been tunneled to a distance of 300 feet without reaching solid rock, according to Emmons (*Tenmile Folio*, p. 2). The southern part of Park Range shows glaciation everywhere. According to Hayden (*Seventh Ann. Rept.*, p. 54) the Lake Creek Glacier was 1,500 feet in thickness. There are great moraines everywhere along both east and west sides of the Sawatch Range (Hayden, *Seventh Ann. Rept.*, p. 51). Roches Moutonnées Creek has been made famous as an illustration of glacier-rounded rock knobs by Hayden and Dana. Hayden (*Seventh Ann. Rept.*, pp. 72, 76) also reports moraines and cirques as common in the Blue River Range, and "great masses of snow, like glaciers." The Elk Mountains are also heavily glaciated (Hayden, *Seventh Ann. Rept.*, p. 67).

This great mountain mass, consisting of several ranges centering near Leadville, abounds in cirques separated by serrated ridges, as in the Northern Front Range region. The general elevation of the Sawatch Range for 60 miles or more is from 13,000 to 14,000 feet.

The Elk Mountains were heavily glaciated. Emmons[1] says: "Glacial drift is found over the whole district, although often stripped off by more recent erosion. . . . . On top of Smuggler Mountain, which is 10,000 feet high, the thickness of moraine . . . . is about

Mountains," *U.S. Geol. Surv., Mon.*, Vol. XXXIV, pp. 338–54, 1899; Westgate, Lewis, C., "The Twin Lakes Glaciated Area, Colorado," *Journ. Geol.*, Vol. XIII, pp. 285–312, 1905; Davis, W. M., "Glaciation of the Sawatch Range, Colorado," *Bull. Mus. Compar. Zoöl.*, Vol XLIX, pp. 1–11, 1905; "Glacial Erosion in the Sawatch Range, Colorado," *Appalachia*, Vol. X, pp. 392–404, 1904; Capps, S. R., and Leffingwell, E. D. K., "Pleistocene Geology of the Sawatch Range, Near Leadville, Colorado," *Journ. Geol.*, Vol. XII, pp. 698–706, 1904.

[1] Emmons, S. F., *Geology of the Aspen Mining District, Colorado*, U.S. Geol. Surv., Mon., Vol. XXXI, pp. 244–47, 1898.

400 feet. . . . . The ice sheet overrode all the hills and valleys in this district. . . . . If this [Roaring Fork] valley were as deep at the time when this great glacier existed as at present, the thickness of the ice must have been at least 3,000 feet." Stone[1] says the Roaring Fork Middle Branch Glacier was 15 miles long, one of its moraines forming the dam of Lake Ivanhoe, and glaciers from the west slope of the mountains extended down Rock Creek 12 miles.

San Juan Region.—This great mountain mass covering an immense area in the southwestern part of the state, during the whole of the glacial epoch, as at present, presented the first high mountains to intercept the warm moist currents from the Gulf of California. Hence we find here, as would be expected, abundant evidence of the former action of enormous glaciers.[2]

The Las Animas Glacier is said by Stone to have been 70 miles long, extending down the river beyond Durango and reaching an altitude of little over 6,000 feet, with a depth at Silverton of 1,000, and five miles below Silverton 1,500 feet. The upper valleys of the Los Pinos, San Juan, Navajo, Chama, and probably all the other streams in the area which headed at the crest of the mountains, contained glaciers. According to Hills the San Juan Mountain glaciers covered "nearly the whole of the habitable portion of Hinsdale, San Juan, Ouray and San Miguel Counties and a large portion of the counties

[1] Stone, George H., "Remarks on the Glaciation of the Rocky Mountains," *U.S. Geol. Surv., Mon.*, Vol. XXXIV, pp. 349–50, 1899.

[2] Endlich, F. M., "Ancient Glaciers in Southern Colorado," *Ninth Ann. Rept. U.S. Geol. and Geog. Surv, Terr.*, for 1875, pp. 216–26, 1877; Hills, R. C., "Extinct Glaciers of the San Juan Mountains, Colorado," *Proc. Colo. Sci. Soc.*, Vol. I, pp. 39–46, 1883; *Amer. Journ. Science*, 3d Ser., Vol. XXVII, pp. 391–96, 1883; Howe, Ernest, "Glacial Phenomena in the San Juan Mountains," *Science*, N.S., Vol. XXIII, pp. 306–7, 1906; *Land Slides in the San Juan Mountains, Colorado*, U.S. Geol. Surv., Prof. Paper No. 67, 1909: Howe, Ernest, and Cross, Whitman, "Glacial Phenomena in the San Juan Mountains, Colorado," *Bull. Geol. Soc. Amer.*, Vol. XVII, pp. 251–74, 1906; Cross, Whitman, and Spencer, Arthur Coe, "Description of the La Plata Quadrangle," *La Plata Folio, No. 60, Geologic Atlas of the United States*, U.S. Geol. Surv., p. 6, 1899; Cross, Whitman, and Howe, Ernest, "Geography and General Geology of the Quadrangle," *Silverton, Folio No. 120, Geologic Atlas of the United States*, U.S. Geol. Surv., p. 20, 1905; "Topography and Geology," *Needle Mountain Folio, No. 131, Geologic Atlas of the United States*, U.S. Geol. Surv., pp. 1–12, 1905; "Geography and General Geology of the Quadrangle," *Ouray Folio, No. 153, Geologic Atlas of the United States*, U.S. Geol. Surv., pp. 7–15, 1907; Cross, Whitman, "General Geology," *Telluride Folio, No. 57, Geologic Atlas of the United States*, U.S. Geol. Surv., pp. 9–15, 1899; Spencer, Arthur Coe, "Erosion of the Rico Dome and Recent Geologic History," *Twenty-first Ann. Rept. U.S. Geol. Surv.*, for 1899–1900, Part II, p. 159, 1900; Salisbury, Rollin D., "Glacial Work in the Western Mountains in 1901," *Journ. Geol.*, Vol. IX, p. 731, 1901; Stone, George H., "Remarks on the Glaciation of the Rocky Mountains," *U.S. Geol. Surv., Mon.*, Vol. XXXIV, pp. 338–45, 1889; "The Las Animas Glacier," *Journ. Geol.*, Vol. I, pp. 471–75, 1893.

of La Plata, Dolores and Rio Grande." The Conejos and Archuleta County (Endlich, p. 220) glaciation should be included in the list. He also says the greatest lateral glacier flowing into the Rio Grande Valley was Clear Creek, and that the Lost Trail and Timber Hill country was all glaciated. Stone says every cirque of the tributaries of the Las Animas above Silverton contained glaciers connecting with the main one. In La Plata Quadrangle, according to Cross and Spencer, "the only deposit of distinctly glacial material which has been recognized is a small terminal moraine across the valley of the La Plata at old Parrott City." Salisbury reports small glaciers on the north side of Spanish Peaks. Many glaciers existed in the tributaries of the Gunnison (Stone). In Uncompahgra Valley the lowest moraine is between Ridgway and Dallas, altitude 7,000 feet, eight miles beyond the mountains—a terminal moraine 400 feet high and over two miles long (Stone and Howe and Cross). In San Miguel Valley, the North Fork Glacier reached Keystone, about five miles west of Telluride. The glaciers of Ophir and Trout Lake basins on South Fork were probably less than eight miles long (Stone). On Bridalveil Creek a thickness of 2,000 feet of ice is indicated (Cross and Howe, *Ouray Folio*, p. 15). The "Great Amphitheater" was ascribed by Endlich to the sinking of the floor of the valley for more than 2,000 feet, but Cross (*Telluride Folio*, p. 9) found no evidence of such subsidence and believes that it was formed "by the same agents of erosion that produced all the other basins of the region." In the Rico Mountains "all the facts available point to the very local nature of the glaciation . . . . and to the short duration of glacial conditions" (Spencer). Glaciers occurred in Silver Creek Valley and its tributaries, Deadwood Gulch, and on the tributaries of Scotch Creek.

Sangre de Cristo Range.—Endlich[1] saw "small indications of local glacial action . . . . .in some of the canyons of the Sangre de Cristo Range," and was not certain as to their glacial character. Stevenson[2] described Grape Creek Glacier on the east slope. Sieben-

[1] Endlich, F. M., "Ancient Glaciers in Southern Colorado," *Ninth Ann. Rept. U.S. Geol. and Geog. Surv. Terr.*, for 1875, p. 220, 1877.

[2] Stevenson, John J., "Geology of a Portion of Colorado Explored and Surveyed in 1873," *Geog. and Geol. Explor. and Surv. W. of 100th Meridian*, Vol. III, pp. 434-35.

thal[1] says the glaciers on the west side of the range just reached down to the alluvial slopes of San Luis Valley, and that most of the streams heading against the crest of the range on both sides held glaciers. He especially refers to Black Canyon, Willow Creek, South Zapate, Middle Creek and Bear Creek. The glaciers of this range formerly descended to 9,000 or 9,500 feet.

Existing Glaciers of Colorado

Arapahoe Glacier.—Lee published the first account of this glacier in 1900.[2] The summer of 1902 being an unusually favorable season for observation, I visited it late in August with Dr. N. M. Fenneman and Mr. H. F. Watts, and we made a careful survey and study of the ice and the general glaciation of the region.[3] Since then I have made observations on September 1 of almost every year, to ascertain to what extent, if any, it was receding, and in 1904 and 1905 Mr. Watts and I measured the rate of motion.[4]

This, though small, is a typical alpine glacier, having all the characters of the great alpine glaciers of the world, and is the most important ice-body yet discovered in Colorado. It is perhaps the only one whose title may not be disputed by some glacialists. Possibly it has only been within recent years that the snow line has receded in summer far enough to disclose its real character. A search for old photographs which might settle this point has been fruitless.

It is situated in the cirque on the east side of the Arapahoes, at the head of North Boulder Canyon, in plain sight from Boulder. The chief source of the ice is the south cliff at the head of the cirque or amphitheater. It moves first northward, then eastward and finally southward. Only a portion is seen from Boulder and mostly with a side view, which minimizes the impressiveness of the sight. The

[1] Siebenthal, C. E., "The San Luis Valley, Colorado," *Science*, N.S., Vol. XXXI, pp. 744–46, 1910; "Notes on Glaciation in the Sangre de Cristo Range, Colorado," *Journ. Geol.*, Vol. XV, pp. 15–22, 1907; *Geology and Water Resources of the San Luis Valley, Colorado*, U.S. Geol. Surv., Water-Supply Paper No. 240, p. 46, 1910.

[2] Lee, Willis, T., "The Glacier of Mt. Arapahoe, Colorado," *Journ. Geol.*, Vol. VIII, pp. 647–54, 1900.

[3] Fenneman, N. M., "The Arapahoe Glacier in 1902," *Journ. Geol.*, Vol. X, pp. 839–51, 1902.

[4] Henderson, Junius, "Arapahoe Glacier in 1903," *Journ. Geol.*, Vol. XII, pp. 30–33, 1904; "Arapahoe Glacier in 1905," *Journ. Geol.*, Vol. XIII, p. 556, 1905; "A Colorado Glacier," *Harper's Monthly*, Vol. CXII, pp. 609–14, 1906.

bergschrund and the crevasses are exceedingly fine when viewed in late August and early September. Exaggerated stories have been current as to the depth of the ice and the depth of the crevasses. The contours of the cirque indicate plainly that the greatest depth of the ice can be scarcely, if any, more than 100 feet. I have examined nearly all of the larger crevasses upon repeated visits late in the season when they were free from snow and most accessible, and have found them to run from 30 to possibly 60 feet in depth—though I have not yet measured any which reached the latter depth—and many of them quite evidently reach the bed of the cirque in places, showing that the ice has no such depth as is commonly supposed.

The moraine at the foot of the ice-tongue is found each season covered with fine glacial mud mingled with rock fragments of all sizes. The streams issuing from beneath it, and the first lake below, are milky white with "rock-flour." As the water flows through successive lakes the sediments gradually settle and the color disappears long before the water reaches Silver Lake. The ice has the granular structure of typical glacier-ice.

The stratification of Arapahoe has been described by Fenneman. The blue bands are finely seen in some of the crevasses. On the surface of the ice little ridges caused by unequal melting of alternate bands catch the dust blown upon the ice, and thus make the banding appear even more prominent than it is.

To determine the rate of motion, Mr. Watts and I set a line of ten zinc tablets across the face of the ice on August 30, 1904, tying them accurately to bench marks upon the granite walls of the cirque and upon the terminal moraine, by triangulation and direct observation with instruments. Zinc tablets were used because they at once melt into the ice and thus avoid sliding. No. 1 was placed 300 feet from the northeast edge of the ice; from No. 1 to No. 2, 89 feet; No. 2 to No. 3, 51.7 feet; No. 3 to No. 4, 58.6 feet; No. 4 to No. 5, 65.4 feet; No. 5 to No. 6, 82.8 feet; No. 6 to No. 7, 84.4 feet; No. 7 to No. 8, 73.8 feet; No. 8 to No. 9, 97.2 feet; No. 9 to No. 10, 114.4 feet; making the last tablet 1,017.3 feet from the north edge of the ice, nearly at the center. On August 30, 1905, we again visited the place and made accurate measurements, ascertaining that No. 1 had moved 11.15 feet; No. 2, 11.9 feet; No. 3, 13 feet; No. 4, 15.9 feet; No. 5, 16.75 feet; No. 6, 18.5 feet; No. 7, 20.6 feet; No. 8, 20.45 feet; No. 9, 21.7 feet; No. 10, 27.7 feet.

The main body of the glacier covers an area of somewhat more than one-half a square mile. This does not include the southern lobe, which is now almost separated from the northern by a moraine and is quite distinct in its origin. The southern lobe is now practically dead, though it still shows a distinct *bergschrund* in the upper part.

As is the case with all glaciers and *névé* remnants in the Southern Rockies, the present size of the glacier represents but a small fraction of its former extent and depth.

Nearly all glaciers everywhere are now shrinking. Arapahoe is no exception. Covering a small portion of the foot of the ice and dammed back by a portion of the moraine is a small lakelet, showing recent recession of the ice from that part of the moraine. This lake was present eleven years ago, but has steadily enlarged. When first observed and long afterward, it contained clear water from the surface of the ice, showing that compact ice still covered the bottom and prevented the mingling of silt-laden water from beneath with the clear water which formed the lake. In 1910 the water had become almost milky white and rocks which had projected considerably above the surface of the water, apparently resting upon the underlying ice, up to 1906, have now entirely disappeared, probably owing to the melting of the ice from beneath them. Since the survey of 1902, two incipient valleys which then existed in the ice, one west of the center of the ice-tongue, and one east of the lake, have deepened perhaps twenty feet or more and become very pronounced valleys, with steep sides. At the same time the center of the ice-tongue itself has shrunken away over ten feet down the moraine, and along the lateral moraine on the northeast side the shrinkage has been over twenty feet. The ice within the moraine, noted by Fenneman, has much of it since melted out. The smaller prongs at the head of the main glacier and along the sides of the *névé* have scarcely changed in either shape or size since the original survey, as is demonstrated by our fine series of photographs. The *névé* of the dead south lobe and one narrow intermediate lobe of ice and snow between the two *névés* have shrunken markedly since 1906. This general shrinkage must not be confused with annual shrinkage and recuperation, but is the sum of the annual differences between shrinkage and recuperation. As long as shrinkage and recuperation are exactly balanced, the front at the same time of each year will appear about the same, but when one overbalances the other, a change in the position and shape of the front must be expected. Shrinkage at the head of the *névé* is even more important than shrinkage at the foot of the glacier, for if the *névé* cannot hold its own it will soon lose the power of sending down ice each year to check the shrinkage at the foot of the ice. To make them available for comparison, our photographs are taken on September 1 of each year. The best time to see the details of our mountain glaciers is late August and early September, after the preceding winter's snow is about gone from the ice and before the next winter's snows have begun to cover it.

Isabel Glacier.—This glacier is located in a cirque with extremely precipitous walls at the head of the South St. Vrain, west of Ward, Boulder County, Colorado, a short distance above Isabel Lake. It was discovered by Mr. Fred A. Fair in about 1908, and on September 17, 1910, I went with him to examine it. Unlike most glacier remnants in Colorado, this is in a cirque facing southeastward. It is about 2,500 feet wide and 1,500 feet long, a very distinct tongue extending out in front of the center and passing beneath the moraine. The moraine forms a ridge rising from 10 to 30 feet above the end of the ice-tongue and bearing little evidence of the deposition of fresh glacial mud, which is to be expected from the fact that the ice passes beneath it. A well-defined *bergschrund* extends across the upper end of the ice, gaping from 5 to 20 feet wide. Below this in the center the surface of the ice flattens out, then passes abruptly into the front with a slope at first of 20°, gradually flattening to 15°, then to 10°, and finally at the end to less than 5°. The shape of the cirque is such that the ice is not crevassed below the *bergschrund*. The *bergschrund* reveals everywhere at least 40 feet of well-consolidated but somewhat snowy ice. The ice in the center must be over 75 feet thick and the lower two-thirds of the ice-field is certainly hard, compact glacier-ice. The motion is likely slow, owing to the contours, and the water from beneath is only slightly whitened with rock-flour. This and the next seem to me better entitled to the name glacier than any of the other ice-fields of Colorado, except Arapahoe.

Fair Glacier.—This ice is on the west side of the Front Range, directly opposite and not far from Isabel Glacier. It was also discovered by Mr. Fair, and I have given it his name partly because of the fact that there are no well-known local names in the neighborhood which can be applied to it, and partly because of a wish to recognize his enthusiasm in the exploration of that difficult region. In our limited time on September 17, 1910, we could not get down to the surface of the ice, which is situated in a very difficult cirque, but were close to it and examined it with excellent field-glasses. We estimated it to be 1,500 feet wide and 2,000 feet high. The *névé* is very steep. The *bergschrund* is well defined and about one-third of the way down from the upper part of the *névé* to the end of the glacier. Some distance below this the ice flattens, then passes down abruptly into the front, which has a slope of probably 45°, and exposes fine series of stratification lines bent into a double loop, indicating two lines of maximum movement. The cirque faces the north. The recessional moraines indicate recent rather rapid retreat. The water of the lake just below the terminal moraine is very milky with the rock-flour from beneath the glacier.

Hallett Glacier.—This ice-field is so named because Mr. W. L. Hallett, of Colorado Springs, in about 1883, stepped through a layer of thin snow into a crevasse and narrowly escaped a serious accident, which suggested the glacial character of the ice. In 1887 it was visited by Chapin and Stone.[1] Stone says it is on the east face of the north spur of Hague's Peak, in a small cirque hardly one-fourth of a

[1] Chapin, Frederick H., *Mountaineering in Colorado*, W. B. Clarke & Co., Boston, pp. 97, 118, 3d ed., 1893; Stone, G. H., "A Living Glacier on Hague's Peak, Colorado," *Science*, Vol. X, pp. 153–54, 1887; "Remarks on the Glaciation of the Rocky Mountains," *U.S. Geol. Surv., Mon.*, Vol., XXXIV, p. 351. See also Mills, Enos A., "Canyon in Ice," *Outdoor Life*, December, 1898; *Estes Park, Colorado* (a small pamphlet); *The Story of Estes Park and a Guide Book*, Outdoor Life Pub. Co., 1905; *Wild Life in the Rockies*, Houghton Mifflin Co., pp. 234, 243, 1909; Burlington Route, *Estes Park, Colorado*, (folder with map and pictures).

mile in diameter, at the head of a glaciated valley which drains into the Big Thompson. The ice had recently shrunken from the latest moraine, leaving a lake "rather less than one hundred yards in diameter, upon which floated small icebergs." The moraine then rose fifty feet or more above the level of the ice. "The material of the ice-field though somewhat granular on the surface, is not a mass of snow, but a clear and compact ice." "The principal crevasse is curved so as to be nearly parallel with the shore of the lakelet, and is not far from one hundred feet back from it." Perhaps this is the *bergschrund*.

The lower parts of the crevasses were filled with broken icicles, ice stalagmites, etc., so that only from twenty to thirty feet can be seen. How much deeper the crevasses really are, is not known; but, from the size and shape of the ice-field, it does not seem probable that the greatest depth of ice exceeds fifty or seventy-five feet. Above the main crevasse were two others large enough to be seen through the recent snow.

The ice in its movement converges to the lakelet. The width is greater than the length.

On the north side of the valley the ice reaches about two hundred feet further down the valley (eastward) than on the south side, and it has also extended a tongue of ice southward across the outlet of the lake, so that the outlet is by a sub-glacial channel. This tongue of ice is nearly one hundred feet wide, and rises six or eight feet above the lake. . . . . The slopes of the ice are everywhere steep. . . . . I saw no evident moraines and only two small pieces of rock on the ice anywhere. The cliffs around the head of the glacier are nowhere very high, in places rising only a few feet above the ice, and they are surprisingly bare of loose fragments. . . . . Some of the boulders in the lake come near the surface, and may be a recent terminal moraine. Perhaps a careful examination when the ice is bare of recent snow may reveal moraines now forming; but, if so, they must be small, since there is so little moraine-stuff being cast upon the ice. There are several other "snow-fields" in the vicinity of Long's Peak which show some signs of glacial flow. . . . . They are all ice rather than snow.

The foregoing sketch is condensed from Stone's account. Emmons[1] immediately objected to the designation of this ice-mass as a glacier, justly saying, in brief, that *névé* looks more like ice than snow and that "the other characters are decidedly those of the *névé*-field rather than of the glacier." Emmons is wrong, however, in urging that a lake

[1] Emmons, S. F., "On Glaciers in the Rocky Mountains," *Proc. Colo. Sci. Soc.*, Vol. II, pp. 222–26, 1887

at the end of the ice shows that an ice-field cannot be a glacier, for certainly a recession of any alpine glacier may temporarily form a lake back of its terminal moraine. The absence of moraine itself may result simply from rapid retreat of a glacier.[1] In the present instance, Stone[2] seems to have been himself in doubt as to the propriety of applying the term glacier to the Hallett ice, for in 1889, twelve years after his first report, he says: "It is *plainly sliding, if not flowing*, down the mountain side. *It appears so much like a true glacier* that I have named it Hallett Glacier, after the discoverer." The italics are mine.

Chapin's interesting account does not add much that is not noted by Stone. He indicates that the length of the ice was about 1,000 feet and its width about a quarter of a mile. He thought the icebergs were formed by the ice moving forward and breaking off along the lines of the crevasses, as in case of the large arctic glaciers which extend into the sea. A very different origin of such icebergs is suggested elsewhere in the present paper. LeConte,[3] in the latest edition of his *Elements of Geology*, uses a photograph of this ice-field, borrowed from Chapin, to illustrate the unequal weathering of a wind-rippled surface.

Mills attempted to measure the rate of motion of this ice in 1904, and under date December 20, 1904, wrote: "The glacier was moving in the center and at the northern end at the rate of 1.1 inches in 24 hours." On January 25, following, he added:

> In lining for measurements I used nail-pointed stakes. Considering that the summer of 1904 was cool and snowy, a movement of 1.1 inch per day for the Hallett is pretty swift. My figures possibly may be slightly wrong, but I believe them correct. . . . . Though I have neither figures nor photographs to verify, yet I feel sure that the glacier has become much smaller since I first saw it in 1895. . . . . The *bergschrund* (September, 1904) seemed wider than usual, but the crevasses were completely cemented with recent snow and ice.

[1] Lee, Willis, T. "Note on the Glacier of Mount Lyell, California," *Journ. Geol.*, Vol. XIII, pp. 358, 1905.

[2] Stone, G. H., "Remarks on the Glaciation of the Rocky Mountains," *U.S. Geol. Surv., Mon.*, Vol. XXXIV, p. 351, 1899.

[3] LeConte, Joseph, *Elements of Geology*, 4th ed., D. Appleton & Co., 1901, p. 52.

The use of stakes is not the best method for accuracy, and in order to get accurate results the observations should be carried on for quite a number of days or weeks. However, the rate given, when compared with that of similar ice-masses, considering the time of the year, is not abnormal and may be quite accurate.

Andrew Glacier.—This ice-field is located on Mills's map just south of Mt. Hallett and about five miles northwest of Long's Peak. I have no other information concerning it.

Tyndall Glacier.—Chapin[1] described this ice-field without naming it. Mills informs me that it now passes under the foregoing title. It is between Mt. Hallett and Flat Top (Chapin's "Table Mountain"). Chapin says:

> It hangs like a true glacier to a steep ridge connecting the peak with Table Mountain [p. 72]. . . . . There were no actual crevasses, but the snow was ridged and serrated. The center of the field seemed to be solid ice, and there was a miniature *bergschrund* next the upper rocks bordering on the ice [p. 86]. . . . . The snow fills an amphitheater over a quarter of a mile in width at the lower rim, with walls a thousand feet high. The general slope is northeast. The position in width is northwest to northeast. A magnificent terminal moraine locks in the ice, and the meltings from the snow escape under the rocks of the moraine at least fifty feet below the top. . . . . The greater part of the moraine was undoubtedly formed when the body of the snow was much greater than it is now, not in area, but in depth; yet I think the work of carrying down stones is still going on [p. 89].

He made the mistake of trying to measure the rate of movement by driving stakes into the ice, which, of course, instead of settling with the melting of the ice, simply melted out and were found lying on the surface upon the next visit, so that the results are entirely worthless (pp. 90–93).

Sprague Glacier.—On September 23, 1905, Mr. Enos A. Mills wrote in answer to my inquiry: "I was there ten years ago and estimated its height [length] at eleven hundred feet, and its width at fourteen hundred. Its slope is much steeper than that of Hallett Glacier. My barometer showed its bottom to be just twelve thousand feet above sea level." It is southwest of what is now called Stone's Peak, about twelve miles west of Estes Park postoffice.

[1] CHAPIN, FREDERICK H., *Mountaineering in Colorado*, W. B. Clarke & Co., Boston, pp. 69–96, 3d ed., 1893.

Sierra Blanca Glaciers.—"The valley of the Huerfano, heading on the northeast side of Blanca Peak, is distinguished from the others by the presence of living glaciers—small, it is true, but characteristic," under the steep north face of Blanca Peak. The width of the north glacier is

about 800 feet and its greatest length is about 1,000 feet, although the ice probably extends a considerable distance farther beneath the terminal moraine. The glacier lies in a pocket on the mountain side, and the ice is probably quite thick. A prospecting tunnel, starting in the moraine below the edge of the visible ice, went horizontally in the clear ice for a distance of 115 feet without reaching rock, which, taking into account the slope of the surface, demonstrates a vertical thickness of over 80 feet. The slope of the ice surface is very steep, about 42°. . . . . Two embryonic terminal morainic ridges are visible, the lower and larger one some 400 feet below the present edge of visible ice. The ice . . . . shows the characteristic upturned dirt-bands looped concentrically about the point of supply, and the surface of the lower half of the glacier is for the most part covered with fine black gravelly dirt, residual from the dirt-bands. Many small longitudinal rivulets have cut gullies down the otherwise notably smooth surface of the ice, exposing the banded ice beneath the dirt covering. The ice itself displays characteristic *gletscherkörne* about one-tenth inch in diameter. Because of the conformation of the pocket in which the ice accumulates, the production of crevasses is impossible, with the exception of a definite *bergschrund* which marks the line where the upper edge of the ice pulls away from the rock wall in the wasting season. . . . . The Blanca glaciers possess an added interest in being the southernmost existing glaciers yet reported in the Rocky Mountains, and, so far as known to the writer, the southernmost in the United States. Their latitude is 37° 35′ N., their longitude 105° 28′ W., and their elevation about 12,000 feet.[1]

Unnamed Ice-Masses.—Cross[2] reports a "remnant of crevassed *névé* ice, of a bluish color," on the north slope of a high ridge east of Dallas Peak, in Telluride Quadrangle. Cross and Howe[3] repeat the statement concerning *névé* ice in Telluride Quadrangle, and say that "small glaciers are known at several places in the Front Range, northeast of Denver," thus tacitly recognizing the validity of the designa-

[1] SIEBENTHAL, C. E., "Notes on Glaciation in the Sangre de Cristo Range, Colorado," *Journ. Geol.*, Vol. XV, pp. 18–22, 1907.

[2] CROSS, WHITMAN, "General Geology," *Telluride Folio, No. 57, Geologic Atlas of the United States*, U.S. Geol. Surv., p. 15.

[3] CROSS, WHITMAN, and HOWE, ERNEST, "Geography and General Geology of the Quadrangle," *Silverton Folio, No. 120, Geologic Atlas of the United States*, U.S. Geol. Surv., p. 25, 1905.

tion of other ice-fields besides Arapahoe as glaciers. Hills[1] also mentions *névé* in the San Juan district.

In an east-facing cirque on the northeast side of the north spur of Arapahoe Peak, just over a sharp ridge from Arapahoe Glacier, is a body of well-stratified and crevassed ice, estimated to be 1,500 feet wide and 800 feet long, showing undoubted evidence of movement, but my impression was, while on the ground, that it was sliding as a mass, rather than with the motion of a glacier. It does not now seem to be building a moraine nor to be discharging fresh glacial mud into the terminal lake. Icebergs in the lake are likely produced by undermining as explained elsewhere in this paper, rather than by the forward movement of the ice. Half a mile or so further north in the head of Albion Gulch is a similar body of ice, showing slight evidence of movement. Numerous smaller ice-masses in the region show crevasses when the fresh snow is all melted off in a dry, hot season, but I do not consider them glaciers.

Possibly the Andrew, Sprague and Tyndall glaciers should be classed as *névé* rather than as glaciers, if not, indeed, the Hallett also, but I have visited none of them. Certainly from the evidence the title of the first three is shaky, and if they are to be accepted, then the North Arapahoe and Albion Gulch ice-bodies and many others must be added to the list, which I do not believe should be done.

Comstock, as hereinbefore noted, refers to existing glaciers in the San Juan Mountain district, Hayden reports "great masses of snow, like glaciers," in the Blue River Range, and Siebenthal has informed the writer that glaciers probably exist on Mount Massive, near Leadville. These statements, coupled with the facts that there are many wild portions of our higher mountains which have not been explored in search of glaciers; that they are more apt to exist in secluded cirques at heads of gulches, with very steep walls, uninviting to the average traveler; that Arapahoe Glacier, in plain sight from several large towns and cities, was not recognized as a glacier until within a few years; and that the Isabel and Fair glaciers, though within a few miles of a mining camp and only a day's journey on horseback from

[1] Hills, R. C., "Extinct Glaciers of the San Juan Mountains, Colorado," *Proc. Colo. Sci. Soc.*, Vol. I, pp. 39–46, 1883.

Boulder, have just been discovered; all suggest that there are numbers of other glaciers tucked away in the more inaccessible mountain fastnesses of Colorado—perhaps some which are larger and more interesting than the largest thus far discovered. However, let us hope that the name may not be applied to *névé* remnants such as are now popularly called glaciers in various localities.

Bibliography

This bibliography includes all the papers known to the author which bear directly upon glacial phenomena in Colorado. As an aid to students a number of important papers discussing glacial phenomena in general and especially existing glaciers outside of Colorado in North America have been added, including all papers cited in the text of the present report. Information concerning omitted papers would be gratefully received, to be incorporated in some future supplement.

Agassiz, J. L. R., *Système Glaciaire*, 1847; *Etudes sur les Glaciers*, 1840.

Atwood, Wallace W., *Glaciation of the Uinta and Wasatch Mountains*, U. S.Geol. Surv., Prof. Paper No. 61, 1909.

Ball, Robert, *The Cause of an Ice Age*, London.

Bliss, Richard, Jr., "Glaciers in the Rocky Mountains," *Amer. Naturalist*, Vol. VI, pp. 310–12, 1872.

Bonney, T. C., Presidential Address, British Association for the Advancement of Science, *Science*, N.S., Vol. XXXII, pp. 321–36, 353–63, 1910. [Discusses climate, production of cirques and benches and erosion of valleys by glaciers, etc.]

"Burlington Route," Estes Park, Colorado. A recent folder with the best map of the whole region and pictures of Hallett glacier.

Capps, S. R., *Pleistocene Geology of the Leadville Quadrangle, Colorado*, U.S. Geol. Surv., Bull. No. 386, 1909.

Capps, S. R., and Leffingwell, E. D. K., "Pleistocene Geology of the Sawatch Range, Near Leadville, Colo.," *Journ. Geol.*, Vol. XII, pp. 698–706, 1904.

Chamberlin, Thomas C., "An Ignored Theory of the Ice Age," *Science*, N.S., Vol. XXIV, pp. 531–32, 1906.

Chamberlin, Thomas C., and Salisbury, Rollin D., *Geology*, Vol. I, 1905.

Chapin, Frederick H., *Mountaineering in Colorado*, W. B. Clarke & Co., Boston, 3d ed., 1893. [Describes Hallett and other ice-fields.]

Comstock, Theo. B., "Some Peculiarities of the Local Drift of the Rocky Mountains," *Science*, Vol. XX, pp. 925–27, 1886. [Mentions existing glaciers in Colorado.]

Cooper, William S., "Alpine Vegetation in the Vicinity of Long's Peak, Colorado," *Botanical Gazette*, Vol. XLV, pp. 319–37, 1908. [Discusses glacial phenomena.]

CROSBY, W. O., "The Hanging Valleys of Georgetown, Colorado," *Amer. Geol.*, Vol. XXXII, pp. 42–48, 1903; *Tech. Quart.*, Vol. XVI, pp. 41–50, 1903.

CROSS, WHITMAN, *Pike's Peak Folio, No. 7, Geologic Atlas of the United States*, U.S. Geol. Surv., 1894.

———, "General Geology," *Telluride Folio, No. 57, Geologic Atlas of the United States*, U.S. Geol. Surv., pp. 13–15, 1899. [Reports *névé*.]

———, See also under Howe and Cross.

CROSS, WHITMAN, and HOWE, ERNEST, "Geography and General Geology of the Quadrangle," *Silverton Folio, No. 120, Geologic Atlas of the United States*, U.S. Geol. Surv., pp. 1–25, 1905.

———, "Topography and Geology," *Needle Mountain Folio, No. 131, Geologic Atlas of the United States*, U.S. Geol. Surv., pp. 1–12, 1905.

———, "Geography and General Geology of the Quadrangle," *Ouray Folio, No. 153, Geologic Atlas of the United States*, U.S. Geol. Surv., pp. 1–15, 1907.

CROSS, WHITMAN, and SPENCER, ARTHUR COE, "Description of the La Plata Quadrangle," *La Plata Folio, No. 60, Geologic Atlas of the United States*, U.S. Geol. Surv., pp. 1–12, 1899.

DALY, REGINALD A., "The Accordance of Summit Levels among Alpine Mountains: The Fact and Its Significance," *Journ. Geol.*, Vol. XIII, pp. 105–25, 1905. [Discusses sculpturing of mountains by glaciers.]

DARTT, MARY, *On the Plains and among the Peaks: or, How Mrs. Maxwell Made Her Natural History Collection*, Claxton, Remsen & Heffelfinger, Philadelphia, 1879.

DAVIS, W. M., "Glacial Erosion in the Sawatch Range, Colorado," *Appalachia*, Vol. X, pp. 392–404, 1904.

———, "Glaciation of the Sawatch Range, Colorado," *Bull. Mus. Compar. Zoöl.*, Harvard Coll., Vol. XLIX, pp. 1–11, 1905.

———, "Hanging Valleys in General," *Science*, N.S. Vol. XXV, pp. 835–36, 1907. [Contains bibliography of papers on main-valley troughs "regarded as the results of glacial erosion," and especially refers to La Plata Peak, Colorado.]

EMMONS, SAMUEL FRANKLIN, "Abstract of Report on Geology and Mining Industry of Leadville, Lake County, Colorado," *Second Ann. Rept. U.S. Geol. Surv.*, for 1880–81, pp. 203–87, 1882.

———, *Geology and Mining Industry of Leadville, Colorado*, U.S. Geol. Surv., Mon., Vol. XII, 1886.

———, "On Glaciers in the Rocky Mountains," *Proc. Colo. Sci. Soc.*, Vol. II, pp. 211–27, 1888.

———, "Pleistocene Geology," *Geology of the Denver Basin, in Colorado*, U.S. Geol. Surv., Mon., Vol. XXVII, pp. 255–74, 1896.

———, *Tenmile Folio, No. 48, Geologic Atlas of the United States*, U.S. Geol. Surv., 1898.

Emmons, Samuel Franklin, *Geology of the Aspen Mining District, Colorado*, U.S. Geol. Surv., Mon., Vol. XXXI, 1898.

Emmons, Samuel Franklin, and Irving, John Duer, *The Downtown District of Leadville, Colorado*, U.S. Geol. Surv., Bull. No. 320, 1907.

Endlich, F. M., "Report upon the Geology of the San Luis District," *Seventh Ann. Rept. U.S. Geol. and Geog. Surv. Terr.* (Hayden Survey), for 1873, pp. 305–51, 1874. [Says glacial phenomena observed in but one locality and of small extent (p. 350).]

———, "Report of F. M. Endlich, S.N.D.," *Eighth Ann. Rept. U.S. Geol. and Geog. Surv. Terr.* (Hayden Survey), for 1874, pp. 181–240, 1876. [See especially pp. 192–220, Animas region.]

———, "Ancient Glaciers in Southern Colorado," *Ninth Ann. Rept. U.S. Geol. Surv. Terr.* (Hayden Survey), for 1875, pp. 216–26, 1877.

———, "Report on the Geology of the White River District," *Tenth Ann Rept. U.S. Geol. Surv. Terr.* (Hayden Survey), for 1876, pp. 63–131, 1878. [See especially pp. 86–88, 115–16.]

Fenneman, N. M., "The Arapahoe Glacier in 1902," *Journ. Geol.*, Vol. X, pp. 839–851, 1902.

Forbes, J. D., *Travels through the Alps of Savoy*, 1843.

———, *Norway and Its Glaciers.*

———, *Occasional Papers on the Theory of Glaciers.*

Foster, J. W., "The Mountains of Colorado," *Amer. Naturalist*, Vol. VI, pp. 65–75, 1872. [Reports no glacial phenomena and rarity of lakes.]

Geikie, Archibald, "The Ancient Glaciers of the Rocky Mountains," *Amer. Naturalist*, Vol. XV, pp. 1–7, 1881. [Fails to note any glacial phenomena in Colorado.]

Geikie, James, *The Great Ice Age and Its Relation to the Antiquity of Man.*

Geinitz, F. E., "Die Eiszeit," *Die Wissenschaft: Sammlung naturwissenschaftlicher und mathemaiischer Monographien*, Heft 16, Braunschweig: Friedrich Vieweg und Sohn, 1906.

Gilbert, Grove Karl, *Lake Bonneville*, U.S. Geol. Surv., Mon., Vol. I, 1890. [Discusses connection of lake and glaciers.]

———, "Systematic Asymmetry of Crest Lines in the High Sierra of California," *Journ. Geol.*, Vol. XII, pp. 579–88, 1904. [Discusses glacial sculpturing of mountains.]

———, "Glaciers and Glaciation," *Harriman Alaska Expedition*, Vol. III, pp. 1–231, Doubleday, Page & Co., 1904.

Hayden, F. V., "Report of F. V. Hayden, U.S. Geologist," *Seventh Ann. Rept. U.S. Geol. and Geog. Surv. Terr.* (Hayden Survey), for 1873, pp. 17–81, 1874. [Reports glaciation in various parts of Colorado, on pp. 44, 45, 48, 51, 52, 55.]

HAYDEN, F. V., *Geological and Geographical Atlas of Colorado and Portions of Adjacent Territory*, U.S. Geol. and Geog. Surv. Terr. (Hayden Survey), Plates XII, XIII, XIV, XV, XVI, 1877. Includes some then known moraines.

———, "Report of F. V. Hayden, U.S. Geologist," *Eighth Ann. Rept. U.S. Geol. and Geog. Surv. Terr.*, for 1874, pp. 1–68, 1876.

HENDERSON, JUNIUS, "Arapahoe Glacier in 1903," *Journ Geol.*, Vol. XII, pp. 30–33, 1904.

———, "Arapahoe Glacier in 1905," *Journ. Geol.*, Vol. XIII, p. 556, 1905.

———, "Extinct Glaciers of Colorado," *Univ. Colo. Studies*, Vol. III, pp. 39–44, 1905.

———, "A Colorado Glacier," *Harper's Monthly*, Vol. CXII, pp. 609–14, 1906. Reviewed in *Review of Reviews*, March, 1906, p. 375.

———, "Scientific Expedition to Northwestern Colorado in 1909. I. Itinerary, Topography and Geology" *Univ. Colo. Studies*, Vol. VII, pp. 101–12, 1910. [See especially pp. 110–11.]

HILGARD, E. W., "The Causes of the Glacial Epoch," *Tenth Intern. Congr. Geol. Mexico session*, pp. 431–36, 1907; *Science*, N.S., Vol. XXV, pp. 350–54, 1907.

HILLS, R. C., "Extinct Glaciers of the San Juan Mountains, Colorado," *Proc. Colo. Sci. Soc.*, Vol. I, pp. 39–46, 1883; *Amer. Journ. Sci.*, 3d ser., Vol. XXVII, pp. 391–96, 1883.

HOLE, ALLEN D., "Glacial Geology," *Engineer Mountain Folio, No. 171, Geologic Atlas of the United States*, U.S. Geol. Surv., pp. 62–69, 1910.

HOWE, ERNEST, "Glacial Phenomena in the San Juan Mountains," *Science*, N.S., Vol. XXIII, pp. 306–7, 1906.

———, *Land Slides in the San Juan Mountains, Colorado*, U.S. Geol. Surv., Prof. Paper No. 67, 1909. [Explains some deposits resembling glacial deposits.]

———, See also under Cross and Howe.

HOWE, ERNEST, and CROSS, WHITMAN, "Glacial Phenomena in the San Juan Mountains, Colorado," *Bull. Geol. Soc. Amer.*, Vol. XVII, pp. 251–74, 1906.

IRVING, JOHN DUER. See under Emmons and Irving.

JOHNSON, WILLARD D., "The Work of Glaciers in High Mountains," *Science*, N.S., Vol. IX, pp. 112–13, 1899.

KING, CLARENCE, *Systematic Geology*, *U.S. Geol. Surv. of 40th Parallel* (King Survey), Vol. I, 1878. [Especially pp. 467–69.]

LAKES, ARTHUR, "Glacial Placer Beds on the Flanks of the Mosquito Range, South Park, Colorado," *Mines and Minerals*, Vol. XXII, p. 469, 1902.

LECONTE, JOSEPH, *Elements of Geology*, 4th ed., D. Appleton & Co., New York, 1901. [Contains photo of Hallett Glacier, borrowed from Chapin.]

LEE, WILLIS T., "The Glacier of Mount Arapahoe, Colorado," *Journ. Geol.*, Vol. VIII, pp. 647–54, 1900.

LEE, WILLIS T., "Note on the Glacier of Mount Lyell, California," *Journn Geol.*, Vol. XIII, pp. 358–62, 1905. [Discusses rapidity of retreat in relation to moraine.]

LEFFINGWELL, E. D. K. See under Capps and Leffingwell.

MARVINE, ARCH. R., "Report of Arch. R. Marvine, Assistant Geologist directing the Middle Park Division," *Seventh Ann. Rept. U.S. Geol. and Geog. Surv. Terr.* (Hayden Survey), for 1873, pp. 83–192, 1874. [Especially pp. 157, 159–61.]

MATTHES, FRANÇOIS E., "Glacial Sculpture of the Big Horn Mountains, Wyoming," *Twenty-first Ann. Rept. U.S. Geol. Surv.*, for 1899–1900, Part II, pp. 173–90, 1900. [Important paper on crevasses and *bergschrund* in production of benches and cirques.]

MILLS, ENOS A., "Canyon in Ice," *Outdoor Life*, December, 1898. [Figures Hallett Glacier.]

———, *Estes Park, Colorado.* [A small pamphlet with photos of Hallett and Sprague Glaciers.]

———, *The Story of Estes Park and a Guide Book*, Outdoor Life Pub. Co., Denver, 1905.

———, *Wild Life on the Rockies*, Houghton Mifflin Co., Boston and New York, 1909. [Especially pp. 234, 243.]

MUIR, JOHN, *The Mountains of California*, The Century Co., 1901. [Especially pp. 20–35.]

ORTON, EDWARD, JR., "The Mills Moraine, with Some General Remarks on the Glaciation of the Long's Peak Region of Colorado," *Science*, N.S., Vol. XXIX, pp. 751–52, 1909. [Paper read by title and only brief abstract published containing little information.]

PEALE, A. C., "Report of A. C. Peale, M.D., Geologist of Middle Division," *Eighth Ann. Rept. U.S. Geol. Surv. Terr.* (Hayden Survey), for 1874, pp. 73–180, 1876.

RAMALEY, FRANCIS, "Remarks on Some Northern Colorado Plant Communities with Special Reference to Boulder Park (Tolland, Colorado)," *Univ. Colo. Studies*, Vol. VII, pp. 223–36, 1910. [Briefly discusses glaciation.]

RAMALEY, FRANCIS, and ROBBINS, W. W., "Redrock Lake, Near Ward, Colorado," *Univ. Colo. Studies*, Vol. VI, pp. 135–68, 1909. [Discusses a glacial lake from a botanical point of view.]

REID, HARRY FIELDING, "The Mechanics of Glaciers," *Journ. Geol.*, Vol. IV, pp. 912–28, 1896. [Discusses chiefly form, flow and variation.]

———, "The Stratification of Glaciers" (abstract), *Science*, N.S., Vol. VIII, p. 463, 1898; *Amer. Geol.*, Vol. XXII, p. 249, 1898.

———, "Stratification and Banded Structure of Glaciers," (abstract), *Science*, N.S., Vol. XI, pp. 103–4, 1900.

REID, HARRY FIELDING, "The Variation of Glaciers," VI, *Journ. Geol.*, Vol. IX, pp. 250–54, 1901; VIII, *ibid.*, Vol. XI, pp. 285–88, 1903; IX, *ibid.*, Vol. XII, pp. 252–63, 1904; X, *ibid.*, Vol. XIII, pp. 313–18, 1905; XI, *ibid.*, Vol. XIV, pp. 402–10, 1906; XII, *ibid.*, Vol. XVI, pp. 46–55, 1908; XIII, *ibid.*, Vol. XVI, pp. 664–68, 1908; XIV, *ibid.*, Vol. XVII, pp. 667–71, 1909. [These papers contain brief statements concerning Arapahoe and Hallett Glaciers.]

———, "The Flow of Glaciers and Their Stratification," *Appalachia*, Vol. XI, pp. 1–6, 1905.

RUSSELL, ISRAEL C., "Existing Glaciers of the United States," *Fifth Ann. Rept. U.S. Geol. Surv.*, for 1883–1884, pp. 303–55, 1885.

———, *Geological History of Lake Lahontan, a Quaternary Lake of Northwestern Nevada*, U.S. Geol. Surv., Mon., Vol. XI, 1885.

———, "Glaciers of Mount Rainier," *Eighteenth Ann. Rept. U.S. Geol. Surv.*, for 1896–97, Part II, pp. 349–415, 1898.

———, *Glaciers of North America*, Ginn & Co., 1901.

SALISBURY, ROLLIN D., "Glacial Work in the Western Mountains in 1901," *Journ. Geol.*, Vol. IX, pp. 718–31, 1901.

———, "Glacial Geology," *Geology of the Big Horn Mountains*, U.S. Geol. Surv., Prof. Paper, No. 51, pp. 71–90, 1906.

———, See also under Chamberlin and Salisbury.

SCHOEBERLE, J. M., "An Ignored Theory of the Ice Age," *Science*, N.S., Vol. XXIV, pp. 439–40, 1906.

SHERZER, WILLIAM HITTELL, "Glacial Studies in the Canadian Rockies and Selkirks," *Smithsonian Misc. Coll.*, Pub. No. 1567, Vol. XLVII, pp. 453–96, 1905; "Glaciers of the Canadian Rockies and Selkirks," *Smithsonian Contrib. to Knowl.*, Pub. No. 1692, Vol. XXXIV, pp. 1–135, 1907. [Discusses stratification, dirt-bands, etc.]

SIEBENTHAL, C. E., "Notes on Glaciation in the Sangre de Cristo Range, Colorado," *Journ. Geol.*, Vol. XV, pp. 15–22, 1907.

———, "The San Luis Valley, Colorado," *Science*, N.S., Vol. XXXI, pp. 744–46, 1910.

———, *Geology and Water Resources of the San Luis Valley, Colorado*, U.S. Geol. Serv., Water-Supply Paper No. 240, 1910.

SPENCER, ARTHUR COE, "Erosion of the Rico Dome and Recent Geologic History," *Twenty-first Ann. Rept. U.S. Geol. Surv.*, for 1899–1900, Part II, pp. 152–65, 1900.

———, See also under Cross and Spencer.

STEVENSON, JOHN J., "Geology of a Portion of Colorado Explored and Surveyed in 1873," *U.S. Geog. Explor. and Surv. W. of 100th Meridian* (Wheeler Survey), Vol. III, 1875. [Especially pp. 426–71.]

STONE, GEORGE H., "A Living Glacier on Hague's Peak, Colorado," *Science*, Vol. X, pp. 153–54, 1887. [Describes Hallett Glacier.]

———, "The Las Animas Glacier," *Journ. Geol.*, Vol. I, pp. 471–75, 1893.

———, "Remarks on the Glaciation of the Rocky Mountains," *U.S. Geol. Surv., Mon.*, Vol. XXXIV, pp. 338–54, 1899.

TARR, RALPH S., "The Advancing Malaspina Glacier," *Science*, N.S. Vol. XXV, pp. 34–37, 1907.

TRUE, H. L., *The Cause of the Glacial Period*, The Robert Clarke Co., 1902.

TYNDALL, JOHN, *The Glaciers of the Alps*, 1860.

———, *The Forms of Water, in Clouds and Rivers, Ice and Glaciers*, 1872.

UNDERHILL, JAMES, "Areal Geology of the Lower Clear Creek (Colorado)," *Univ. Colo. Studies*, Vol. III, pp. 263–376, 1906; *Proc. Colo. Sci. Soc.*, Vol. VIII, pp. 103–122, 1906.

UPHAM, WARREN, "Fjords and Hanging Valleys," *Amer. Geol.*, Vol. XXXV, pp. 312–15, 1905, and papers cited therein.

WESTGATE, LEWIS C., "The Twin Lakes Glaciated Area, Colorado," *Journ. Geol.*, Vol. XIII, pp. 285–312, 1905.

WRIGHT, G. FREDERICK, *The Ice Age in North America*, D. Appleton & Co., 1890.

Fig. 4.—Map of Arapahoe Glacier (*Journal of Geology*).

Fig. 5.—General view of Arapahoe Glacier (*Journal of Geology*).

FIG. 6.—Arapahoe Glacier, terminal lake and moraine (*Journal of Geology*).

FIG. 7.—Glacial lakes below Arapahoe Glacier (*Journal of Geology*).

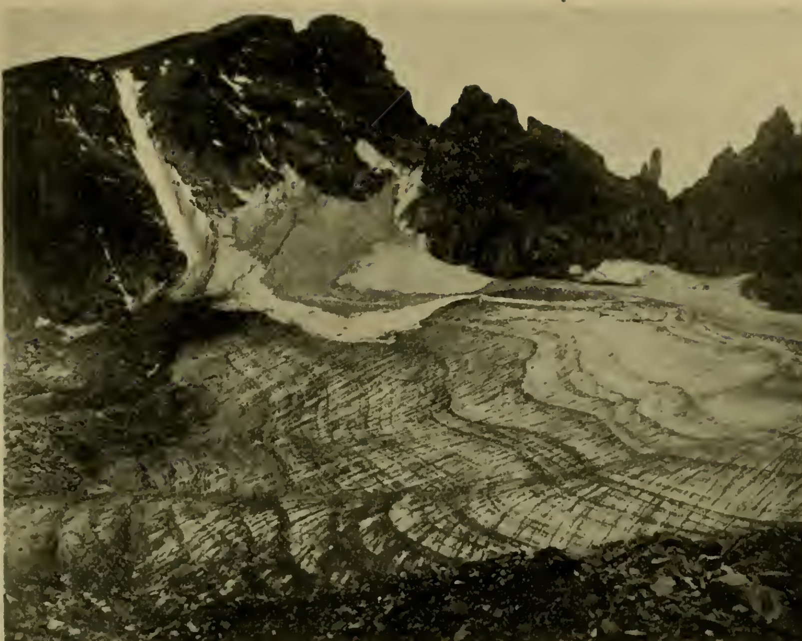

FIG. 8.—Isabel Glacier.

FIG. 9.—Fair Glacier.

FIG. 10.—Hallett Glacier (Mills).

FIG. 11.—Albion Gulch, a typical glaciated valley.

FIG. 12.—Morainal lake in North Boulder Canyon.

FIG. 13.—Terminal moraine of Arapahoe Glacier, showing fine mud mixed with boulders of various sizes.

FIG. 14.—Perched glacial boulder, North Boulder Canyon.

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CONTENTS

NEED OF A STATE TAX COMMISSION IN COLORADO

By John Burton Phillips

In the last few decades there has been a great expansion of state activity. The statesmen in whose hands the direction of modern government is placed have awakened to the fact that there are many fields in which the state can take the initiative and render great service to the citizens. Society is complex, and the times demand an increase in specialization. By employing experts, therefore, the government may place at the disposal of its citizens the benefits resulting from the latest scientific achievements. It is the recognition of this possibility, and the desire to further, as rapidly as possible, the progress in well-being, that have induced the governments of all modern states to enlarge their activities and very largely abandon the old and narrow *laissez-faire* theory as to the limits of state action. We find accordingly a host of modern officials concerned with the administration of new laws on such subjects as pure food, milk supply, compulsory school attendance, child-labor, bake-shop and laundry inspection, etc. Again, on the side of education, we have huge government bureaus, such as the Bureaus of Chemistry and of Animal Industry in the Department of Agriculture at Washington. Work of similar scientific character is also being done in many of the state executive departments. The results of scientific investigations carried on by these government agencies are printed and distributed gratuitously in the state's endeavor to advance the well-being of its citizens.

These various state activities are expensive and, in order that they be successfully carried on, it is necessary to secure an increase in the state's revenue. In proportion as the state undertakes to do more and more those things which, under the early theory of industrial liberty, it was supposed the individual would do for himself, it is necessary to call for a larger per capita tax. This is what has happened. The per capita tax is increasing rapidly in the United States. Kansas is a fair example. In that state the per capita tax[1] has increased as follows:

1880	$5.72	1900	$ 9.38
1885	7.01	1905	11.57
1891	9.47	1907	12.41
1895	9.76		

The need of greater revenue by modern states and the appreciation of the increasing burden of taxation are forcing greater attention to be given to tax problems. To get an ever-increasing revenue demands deeper study of the sources from which taxes are drawn than was the case at an earlier date when government needs were less and opportunities for making money were greater.

The principal problems in getting a greater revenue are the attitude of the individual toward state activities, and the improvement of the existing system of taxation. The attitude of the taxpayer toward state activities is greatly influenced by the keenness with which he feels the tax burden. New reforms are opposed when he is frightened by a possible increase of his tax.

When great skill is used in devising a tax system, it is possible to collect very heavy taxes and still preserve in the taxpayer a sympathetic attitude toward the additional activities constantly undertaken by modern states. Germany is perhaps the best example of this. That nation has employed her men of science to devise a tax system with the result that taxation there is claimed by impartial writers to have attained a higher degree of perfection than anywhere else in the world. It is a favorite saying of German writers on finance that, if taxes be scientifically levied, they will not become any special burden, just as a soldier's knapsack, if scientifically adjusted, will be carried without fatigue. From the ease with which high taxes are collected from all classes, and the little evasion which exists there, it appears that the Germans have in large measure established the truth in the above comparison.

The system of taxation in general use in the United States is

[1] *Special Report, Kansas State Tax Commission*, 1909, p. 6.

known as the general property tax. Briefly this may be described as the system whereby the assessor is directed to ascertain how much property of every description is owned by each individual, and to appraise such property at its true cash value. The total value of the property thus ascertained of each person forms the basis upon which his tax is computed.

The assessor is a local officer generally elected by the voters in the county, township, city or district. The valuation of the property for taxation in the assessment district is determined by the local assessor. The valuations of the various districts are added together to form the valuation of the state. On this sum as a basis, the per cent of tax levy for the state is determined. The amount of state tax to be paid by the taxpayers in each county or local assessment district is determined by finding what proportion the total assessed value of such district is of the total assessed value of the state. It is therefore clear that if the local assessor can establish for the inhabitants of his county a record for poverty and, by underassessment of property of all kinds, keep the valuation low, the proportion of state tax borne by the taxpayers in that county will be much below what it should be. Taxes will be lowered and such an assessor will be popular. There is, therefore, a constant tendency to overlook property and underestimate its value in making assessments.

The above general property tax system is weakest in its attempts to secure the assessment of personal property. Such a method of taxing real estate is believed to be correct in theory and the objections to it come from defects in administration. However, the application of the general property tax system to personal property is condemned by all writers on finance, and has been abandoned by practically all civilized countries except the United States. The reason for its failure is the absolute impossibility of finding intangible property, such as moneys, credits, stocks, bonds, etc. Numerous illustrations showing how personal property escapes the assessor might be given. The following from the Ohio Special Tax Commission of 1893 is significant:

In 1866 the valuation of the city of Cincinnati was: realty $66,454,602; personalty, $67,218,101; the personal property was greater than the amount of real estate by $800,000.

In 1892, twenty-five years later, the real estate of Cincinnati had increased to $144,208,810; while the personal property decreased to $44,735,670.

The amount of money returned for taxation in the state in 1866 was nearly $3,000,000 more than it is today (1893).

In 1866, the amount of money returned for taxation in Hamilton County (containing Cincinnati) was nearly five times what it was in 1892; the amount of credits was nearly double what it is today. The amount of bonds and stocks was $30,000 more than it was in 1892.

These are the fiscal results. The social results are thus summarized by the commission:[1]

The system as it is actually administered results in debauching the moral sense. It is a school of perjury. It sends large amounts of property into hiding. It drives capital in large quantities from the state. Worst of all, it imposes unjust burdens upon various classes in the community.

. . . . This inequality of taxes weighs most heavily upon those whose thrift and prudence have resulted in affording to themselves or their children a competence. It is evident that this burden rests with peculiar force upon those persons whose scrupulous honesty induces them to make full and complete returns of all their property.

The Ohio State Tax Commission of 1906 says:[2]

The value of all credits returned was $34,000,000 less in 1906 than it was in 1890, and $16,000,000 less than it was in 1870. The value of all stocks and bonds was $2,575,000 less in 1906 than it was in 1880, and the value of all intangible property including moneys, credits, stocks and bonds, as returned for taxation, was nearly $8,000,000 less in 1906 than it was in 1890.

This was in spite of the tax inquisitor law passed in 1882, by which inquisitors might be selected by county auditors to search for personal property not listed for taxation, and to place such property, when discovered, on the rolls, with a penalty of 50 per cent of the tax due each year for the preceding five years. The inquisitor received 20 per cent and the auditor 4 per cent of such additional taxes collected. From the above report of the Special Tax Commission, it

[1] *Report of the Ohio Special Tax Commission of 1893.*

[2] *Report of the Ohio Tax Commission of 1906.*

is plain that this drastic law did not enable the assessors to find more personal property in Ohio.

The chief result of this law was to drive wealthy citizens out of the state. It is said[1] that millions of capital left the city of Cleveland and that "the value of high-class residential property on Euclid Avenue and in its vicinity depreciated 40 or 50 per cent."

At the National Civic Federation Conference on Taxation, Buffalo, May 23, 25, 1901, Hon. James R. Garfield condemned this law in the following words:

> The practical effect of the law has been to drive away millions of property which otherwise would have been returned for at least a partial valuation.
>
> The experience of Ohio shows the utter uselessness of attempting to reach personal property by individual returns, and the tax inquisitor law, instead of affording a remedy, has driven millions of capital away from the state, and has brought the state into disrepute.

In 1904 this law was declared unconstitutional. The Ohio Special Tax Commission Report of 1908 further[2] says:

> The widespread concealment of intangible property, increasing in amount year by year, is the most convincing proof of the failure of the general property tax. It shows that after more than fifty years of experience, with all conceivable methods in the way of inquisitor laws, severe penalties and criminal statutes, designed to force the owners of moneys and credits, stocks and bonds, to put their holdings upon the tax duplicate, not only is the percentage of such property less than ever before, but public sentiment seems to be more and more openly approving an evasion of the law. Such a condition of affairs is so manifestly wrong and so inimical to good government, that its longer continuance is a grave injury to the state.

A number of special tax commissions appointed by various states during the past two decades have, almost without exception, made reports generally similar to those of the Ohio commissions above quoted.

It thus appears that those who have had the greatest opportunities for studying the working of the general property tax are united that, for personal property at least, it is not likely to be successfully

[1] Bullock, "General Property Tax in the United States," *Boston Transcript*, January 13, 20, 27, 1909.

[2] *Report of Ohio Tax Commission*, 1908.—Quoted in *Report of the Committee of the International Tax Association on the Causes of the Failure of the General Property Tax*, p. 8.

administered. A large part of the personalty in all states where this tax prevails escapes the assessor. Realty is also assessed greatly below its cash value.

It was pointed out above that the assessor is anxious to keep the valuation of his county or local unit low, so as to avoid high state taxes for his constituents. At the same time the taxpayer is interested in making himself out as poor in this world's goods as possible, to avoid paying a high tax. Hence the assessor and the taxpayer himself are both unduly interested in making low valuations. The result is such as might be expected so long as the asssessor is practically certain that his assessment will not be disturbed by any meddlesome board of review, and thus far little has been done to correct underassessments in Colorado or elsewhere by the ordinary nominal board of review or equalization. Underassessment has therefore become the rule. Let us see how this has developed in Colorado.

By way of introduction, the following quotation is worthy of note. It is from the report[1] of a committee of the county assessors appointed to investigate variations of assessment in the different counties.

> We find that most of the assessors in the agricultural counties have their best land assessed far too low in proportion to present cash value, and too low in proportion to the value placed upon other property. In their assessed values they have not kept pace with the rapidly increasing cash values of the past few years. Their values might have been high enough under the conditions that existed a few years ago when they were placed, but in our opinion, this class of property demands the most thorough equalizing of any single account in the state.
>
> There are hundreds of acres of agricultural and fruit lands in the state, having a market value of from $10 to $1,500 per acre, that have been given a valuation for assessment purposes of from 5 to 30 per cent of their market value. On the other hand, we find thousands of acres of grazing land that is assessed at its full cash value, bringing about a very unequal state of assessed valuation.

In 1904 an estimate of the true value of the real property and improvements of the state of Colorado was made by the Census

[1] *Report of the Committee of County Assessors of Colorado*, 1906, p. 4.

Bureau of the United States. By comparing this estimated value with the value as determined by the local assessors, the amount and percentage of undervaluation in different counties becomes at once apparent. It is clear that there is little uniformity in the work of local assessing officers. This is revealed by the following table:

TRUE AND ASSESSED VALUES OF CERTAIN COUNTIES IN COLORADO, 1904*

	Estimated True Value of Real Property and Improvements Taxed†	Assessed Value of Real Property and Improvements Taxed†	Percentage Assessed of True Valuation
State	$530,892,880	$214,519,074	40.4
Arapahoe	6,179,510	3,089,755	50.0
Archuleta	1,748,024	379,181	21.1
Boulder	23,144,732	7,937,180	34.2
Denver	169,100,150	84,550,075	50.0
El Paso	40,934,525	16,373,810	40.0
Fremont	13,887,431	3,644,995	26.2
Jefferson	11,985,169	3,654,015	30.4
Larimer	14,653,005	4,884,335	33.3
Las Animas	12,534,710	6,267,355	50.0
Pueblo	35,869,676	17,934,838	50.0
Teller	25,993,120	6,483,280	24.9
Weld	25,095,752	7,721,770	30.7

* *Census*, 1900, "Wealth, Debt and Taxation," p. 90.

† Exclusive of railroads, street railroads, telegraph and telephone, privately owned waterworks and privately owned electric light and power stations.

According to the above table, real estate is assessed at from 21 per cent to 50 per cent of its true value. This lack of uniformity on the part of the local assessors is unjust to the residents of those counties in which property is valued more highly. For example, owners of real property and improvements having a true cash value of $5,000 in Denver County in 1904 paid twice as much state tax as the owners of the same amount of the same kind of property in Teller County, and nearly 2½ times as much as those in Archuleta County.

Great variations in the valuation of livestock are easily discovered. There is apparently no agreement among the local assessors as to the average value to be placed on domestic animals. Each assessor fixes this for himself. In the State Auditor's report may be found the number of domestic animals of each kind in each county, and the total valuation of such property as determined by the assessor. By division the average value may be found. In this way the following table was made.

AVERAGE ASSESSMENT OF LIVESTOCK IN CERTAIN COUNTIES OF COLORADO, 1908

County	Horses	Mules	Cattle	Sheep	Swine
Adams	$39.17	$43.73	$13.53	$1.49	$3.59
Arapahoe	35.60	53.47	15.77	2.00	4.60
Archuleta	25.10	26.66	7.74	1.52	3.15
Baca	18.80	26.50	9.70	1.50	2.31
Boulder	32.10	31.30	11.15	1.00	3.25
Custer	21.70	30.00	9.05	2.41	2.78
Chaffee	20.78	25.00	7.00	....	4.00
Cheyenne	16.55	21.38	11.17	1.50	5.00
Denver	47.10	54.22	28.00	2.69	5.87
El Paso	25.40	29.50	9.78	1.45	4.00
Garfield	23.60	19.65	8.27	1.50	2.26
Huerfano	26.80	36.10	12.90	2.00	3.90
Lake	38.80	8.22	15.90	1.18	....
Larimer	29.70	36.50	8.90	1.63	3.04
Montezuma	40.10	87.97	12.10	2.00	5.00
Morgan	31.90	57.69	8.85	1.50	2.81
Otero	31.40	42.70	9.96	1.33	3.21
Park	15.01	16.43	7.00	1.50	2.18
Pueblo	32.30	47.78	9.99	1.87	4.05
Weld	39.35	54.60	10.99	1.63	4.50

This table shows that, in the opinion of the assessor, domestic animals vary greatly in value according to the county in which they are kept. No one will assume that these figures of average valuations show differences in the quality of the stock in the various counties. They represent simply the personal equation of the assessor. Why, for instance, should horses be valued at $15.01 each in Park County, $38.80 in Lake County, $39.35 in Weld and $47.10 in Denver? There are, to be sure, more expensive carriage horses in Denver County, but this will not account for all the difference. The same lack of uniformity in valuation is seen in the average values of the other domestic animals; mules $8.22 in one county, $87.97 in another; cattle $7.00 in Park and Chaffee counties and from two to four times this amount in others. Sheep and swine are valued about two and a half times as high in some counties as in others.

Livestock is not only undervalued, but also overlooked by the assessor. This appears from the following table in which the number of domestic animals as ascertained by the United States Census for 1900 is compared with the number of such animals reported by the assessors for the same year:

LIVESTOCK* IN CERTAIN COUNTIES OF COLORADO—UNITED STATES CENSUS ENUMERATION AND NUMBER ASSESSED, 1900

	Arapahoe	Boulder	Larimer	Mesa	Otero	Weld	State
Horses—							
Actual No.	26,105	8,234	14,926	4,580	9,512	24,241	236,546
No. Assessed ...	21,006	7,061	9,538	4,480	6,611	15,602	199,894
Cattle—							
Actual No.	82,522	20,825	77,495	43,310	82,922	70,830	1,433,318
No. Assessed....	46,254	13,798	46,075	20,861	24,251	48,891	828,396
Sheep—							
Actual No.	135,841	1,328	12,617	25,426	60,787	81,021	2,044,814
No. Assessed....	76,350	2,127	13,252	5,158	37,019	125,035	1,278,075
Swine—							
Actual No.	11,491	3,144	4,242	3,307	5,817	11,585	101,198
No. Assessed....	4,643	1,009	862	1,244	1,950	3,247	33,480

* Roy G. Blakey, Manuscript Thesis for degree of M.A., University of Colorado, June, 1910, p. 36.

The above table shows that in the year 1900, with a few exceptions in the case of sheep, the number of domestic animals found by the assessor in his search for the true cash value of the personal property in his county was greatly below the reality—from $\frac{1}{3}$ to $\frac{5}{6}$ of the actual number. It is true that certain domestic animals, as sheep, for instance, are taken from one county to another for grazing, and this might account for the larger number assessed in certain counties, as the census enumeration and local assessment were not made at the same time. But it is certainly not probable that there occurred any such a migration of domestic animals from the state of Colorado as is indicated by the last column of the above table. Swine appear to be especially elusive, and it may be that the evil spirit of the tax system enters into them at the assessor's approach and, like those of biblical times, they disappear over a precipice—if not into the sea, at least out of reach of the assessor. Other livestock does not escape the contagion.

Stocks of merchandise as assessed in Colorado exhibit curious fluctuations. The following table shows from the assessor's returns the succession of riches and poverty among the mercantile class during a period of three years. The peculiarities of this exhibit render comment unnecessary.

ASSESSED VALUE OF MERCHANDISE IN CERTAIN COUNTIES IN COLORADO,* 1906-7-8

Counties	1906	1907	1908
Adams	$ 170,670	$ 37,341	$ 123,690
Denver	7,563,830	......	8,001,950
Douglas	19,125	20,350	211,285
Elbert	18,850	26,460	......
Gilpin	135,376	150,588	107,350
La Plata	395,255	390,215	480,175
Teller	367,785	13,185	25,520

* Blakey, *Assessment of Property for Taxation*, p. 55.

The failure of the assessors to reach intangible property is shown by the following tables:

ASSESSMENT OF INTANGIBLE PROPERTY IN COLORADO, 1890-1900

	Money and Credits	Bank Stock or Shares in Any Bank, or Stock or Shares in Any Corporation or Company	Total Assessed Value of Intangible Property in State
1890	$2,530,320	$2,598,807	$5,129,127
1891	2,213,382	3,792,353	6,005,735
1892	4,798,350	4,727,982	9,526,332
1893	5,023,516	1,838,531	6,862,047
1894	2,078,701	3,341,594	5,420,295
1895	1,994,637	4,547,548	6,542,185
1896	4,617,794	3,140,175	7,757,969
1897	4,011,496	2,474,759	6,486,255
1898	4,224,320	2,396,262	6,620,582
1899	5,012,825	2,353,971	7,366,796
1900	5,776,825	2,639,428	8,416,253

ASSESSMENT OF INTANGIBLE PROPERTY IN COLORADO, 1901–1908

	Money, Credit Book Acc'ts and Other Acc'ts not Evidenced by Writing	Cash Value Promissory Notes, Bonds, Debentures and All Other Written Evidence of Indebtedness	Special Privileges and Franchises not Included in Other Items	Cash Value of Bank Deposits in State.	Cash Value of Bank Deposits out of State	Bank Stock or Shares in Any Bank	Stock or Shares in Any Corporation Doing Business in State	Total Assessed Value of Intangible Property in State
1901..........	$11,137,978	$1,698,330	$762,352	$1,275,927	$27,423	$5,939,536	$964,392	$21,805,938
1902..........	7,426,513	352,370	875,300	669,490	3,410	4,969,032	306,105	14,602,220
1903..........	4,706,003	239,272	959,815	386,322	6,745	5,167,720	911,287	12,377,164
1904..........	4,500,776	144,887	722,310	283,975	22,170	5,235,465	169,073	11,078,656
1905..........	4,597,138	166,655	629,660	442,620	12,245	5,592,702	219,152	11,660,172
1906..........	3,867,523	164,930	478,240	405,111	00,000	5,534,916	179,120	10,629,840
1907..........	4,024,255	116,810	345,850	599,492	00,000	5,450,443	93,910	10,630,760
1908..........	3,748,369	133,370	384,370	406,980	200	5,947,947	110,470	10,731,706

Previous to 1901 intangible property was divided into but two groups for assessment purposes, money and credits, and shares in corporations. In 1901 the present tax law classifying such property into eight groups came into operation.

The tables show what is shown by the statistics of other states, namely, the impossibility of assessing intangible property at its true value. While the new law brought about an increase in the assessment in 1901, since that time there has been a great decline. What proportion of the true value is represented by the assessment it is impossible to say except in the matter of bank stock and bank deposits. These items may be checked with the *Report of the Comptroller of the Currency*. In 1908 when bank stock was assessed at $5,947,947 the Comptroller reported the capital stock of national, state, stock savings and private banks and loan and trust companies in Colorado as $13,869,479.[1] The following table shows the proportion of bank deposits assessed:

PROPORTION OF BANK DEPOSITS ASSESSED IN COLORADO*

Year	Assessed Value of Bank Deposits	Actual Individual Deposits in State, Savings, Private Banks, Loan and Trust Companies and National Banks, from *Report of Comptroller of the Currency*, 1908, p. 452
1901	$1,275,927	
1902	669,490	
1903	386,322	
1904	283,975	$72,583,621
1905	442,620	83,626,719
1906	405,111	93,242,597
1907	599,492	106,309,307
1908	406,980	101,035,363

* BLAKEY, *Assessment of Property for Taxation*, p. 74.

Since 1901 there has been a general decline in the assessment of bank deposits. Comparison of the assessors' returns of bank deposits in the state with the reports of the Comptroller of the Currency shows that in 1908, while the assessors found $406,980, the actual amount was $101,035,363. Less than $\frac{1}{200}$ part was assessed. In

[1] *Report of the Comptroller of the Currency*, 1908, p. 419.

such counties as Denver and Pueblo, no one was assessed on his money on deposit in banks. In 1908, bank deposits were assessed only in eleven counties as follows:

COUNTIES ASSESSING BANK DEPOSITS IN COLORADO, 1908

Counties	Bank Deposits Assessed	Counties	Bank Deposits Assessed
Adams	$ 5,850	Phillips	$17,900
Arapahoe	13,325	Prowers	7,780
Clear Creek	2,000	Rio Blanco	225
El Paso	303,910	Sedgwick	1,900
Jefferson	17,195	Teller	1,980
Lake	34,915		

The evidence of the above tables is sufficient to show clearly that property in Colorado is both underassessed and overlooked by the local assessors, notwithstanding the law directs them to place it on their rolls at its true cash value. The general property tax system has thus far failed in this state, as elsewhere, in securing a true valuation of the property which should be taxed. The following is the percentage of assessed to true valuation as determined by the United States Census since 1870:

Year	1870	1880	1890	1900	1904
Percentage	85.6	30.7	19.2	23.1	28.3

One of the serious effects of under valuationis the loss of revenue needed for state institutions. In Colorado, as in a number of other states, it is the practice of the legislature to provide the revenue for various state institutions by the imposition of a certain fractional mill tax on each dollar of assessed valuation. It was the opinion of the legislature that a provision of this kind would guarantee a suitable revenue for these institutions which would increase as the wealth of the state increased, and thus meet the requirements of their expanding needs. In this way there would be no necessity for constant lobbying for appropriations. This plan has, however, failed to produce satisfactory results. By the zeal of the local assessors for the underassessment of property, the total assessed valuation of the state increases but slowly, or even remains stationary, and the revenues of the state institutions become wholly inadequate. In this way the action of the local assessor, in refusing to assess property at its true cash value as the law directs, is able to defeat the will of the legislature and cripple the progress of the state by limiting the amount of money available for the maintenance of state institutions. To a considerable extent, then, it comes about that, as far as the state institutions are concerned, the local assessors, rather than the legislature, determine how much financial support they shall receive.

The demand for the abolition of the general property tax as a means of taxing intangible property has been made for many years by students of tax problems and writers on public finance. The last recommendation for its abolition was made by a committee of the International Tax Association, appointed in 1909. This committee, composed of distinguished students of public finance and attorneys of large experience in matters of taxation, made its report at the Fourth International Conference on State and Local Taxation, at Milwaukee, September 1, 1910. Among the conclusions[1] are the following:

> That the general property tax system has broken down.
>
> That it has not been more successful under strict administration than where the administration is lax.
>
> That the failure of the general property tax is due to the inherent defects of the theory.
>
> That even measurably fair and effective administration is unattainable, and that all attempts to strengthen such administration serve simply to accentuate and to prolong the inequalities and unjust operation of the system.

This report was adopted by the International Tax Association and its conclusions are therefore those of the only association of tax experts in America.

If the general property tax, in its present form, is abolished, some other tax or taxes must be found to take its place, or a different plan of assessment must be devised. Various plans have been offered.

[1] *Report of the Committee on Causes of the Failure of the General Property Tax*—International Tax Conference, Milwaukee, 1910, p. 15.

Among these are the substitution of the habitation tax or the income tax, or the separation of the sources of the state and local revenue.

The habitation tax is a tax on rents. It is recommended as a substitute for the tax on personal property. It is urged that a tax on rent would be easily levied, as the rent which everyone pays is well known. By making the tax a lien on the property, its payment would be guaranteed. By exempting rents below a certain amount, and by making special exemptions in the case of families with a large number of children as is done in Tasmania, the tax can be so arranged as not to bear heavily on the poor or discriminate against large families. Whatever the theoretic possibilities of this tax, it is apparent that, in the present state of public opinion, it is not likely to be adopted in the United States.

The income tax is not generally believed by American writers to be suited to the use of the states as a means of getting revenue. It is disliked by our people on account of its inquisitional features, and the ease of migration here would tend to make capital leave states where the tax was well enforced. Attempts at rigorous enforcement can at best be but partially successful, as it is necessary to take the taxpayer's word as to the amount of his income in probably the majority of cases. In England, where the income tax is relied on for a large part of the total revenue, the taxpayer's statement is taken for 59 per cent of the total income tax revenue. While these difficulties might be overcome, the adoption of this tax by our states must await a long period of financial education.

Another plan by which it is proposed to escape the evils of the general property tax, and particularly the injustice of underassessment, is what is known as the separation of sources of state and local revenue. By this plan the same objects would not be taxed for state and also for local purposes. For example, the state would derive its revenue from taxes on corporations, mortgages, stock transfers, liquor licenses and the like, while the local units would secure a revenue by using the general property tax. In this way, the assessment made by the local assessor would not be used as a basis according to which the state tax would be apportioned to that county or local unit; hence there would not be the same inducement for the local assessors to undervalue the real and personal property of their districts, as such property would not be taxed for state purposes.

It was at first thought that the merits of this plan were sufficiently great to warrant its general adoption. A number of states so amended their revenue laws as to secure a state revenue without taxing local real estate and personalty under the general property tax system. New York, Connecticut and Pennsylvania were among the first states to employ this system. It has now had several years' trial and is found to be defective. Its chief defects are: (1) The state revenue is inelastic and may in some years greatly exceed the needs of the state; in other years the revenue may fall short of the needs. (2) The voter, relieved from paying a direct state tax, loses interest in state affairs. There is accordingly a tendency to extravagance on the part of the legislature. Under this system in New York expenditures increased in fifteen years from $12,984,000 to $34,589,000, and in Connecticut they increased so rapidly that last year the plan was abandoned, and a state tax was imposed on general property. Connecticut officials state that the extravagance was caused by the abolition of a direct state tax.[1]

There is another plan for the separation of the sources of state and local revenue which deserves to be mentioned. This scheme was brought forward many years ago by Allen Ripley Foote, president of the International Tax Association. It has been accepted by eminent students of taxation, and adopted by the state of Oregon. The plan provides that the amount of state tax to be paid by each county shall be determined, not by the assessed valuation, but according to the expenditures of such county. That is, the ratio which the expenditures of each county bears to the total expenditures of all counties in the state shall be the ratio according to which the share of state tax to be borne by each county shall be determined.

While this scheme has certain advantages, such as the absence of interest in underassessment, local freedom in taxation, tendency to

[1] Bullock, *Quarterly Journal of Economics*, May, 1910, p. 456.

check local extravagance through fear of higher state taxes and the lack of necessity for state boards of equalization, it is open to the objection that it might emphasize too forcibly the interest of the taxpayer in the county expenditure. It is claimed also that desirable expenditures in progressive communities would be checked by the addition to the local taxes of a penalty in the shape of an increased state tax. If improvements were not checked, progressive communities would be taxed for the benefit of unprogressive.

The results of this plan of separation of state and local taxation will be watched with interest. It does not go into operation in Oregon till 1912, so that as yet nothing is known of its practicability. The novelty of the plan will delay its adoption till its success or failure is established. Opinion against it seems to be developing. In the *Quarterly Journal of Economics* (May, 1910), Professor Bullock vigorously attacks the plan.

The general property tax has failed as a means of taxing intangible personal property because of the attitude of the public toward the vigorous enforcement of the law. The reason why public opinion does not condemn the evasion of the tax on money, credits and securities is to be found in the sense of justice. The general property tax presumes to tax all kinds of property at the same rate, and assumes that by this means the burden will be equally distributed. However, it is impossible by such a tax to distribute evenly the burden between all classes of property. A tax rate of 1½ per cent on the value of real estate can be borne without serious difficulty, but a tax of like amount on money, credits and securities works grievous injustice. The tax on real estate is capitalized and subtracted from the price by the purchasers and in consequence the burden is not felt. But in case of securities the tax must, as a general rule, be paid by the owner, and hence his income from investments of this kind is greatly reduced. As money, credits and securities do not generally yield a return of more than 6 per cent, a tax of 1½ per cent on these kinds of wealth is equivalent to an income tax of 25 per cent—a most unheard-of thing. The British income tax at the present time is 12 pence in the pound, or 5 per cent. The experience of civilized nations in the matter of an income tax has established the principle that such a tax may be successful at a rate anywhere from 2 to 6 per cent, but beyond 6 per cent the rate is regarded by the taxpayer as confiscatory and the evasions are so great that the amount of revenue derived is smaller than can be obtained when the tax is imposed at a lower rate. It thus appears that public opinion regards the assessment of intangible property at its full value by the general property tax as confiscatory and accordingly does not frown on the evasion of the law in the assessment of this class of property.

A practical remedy for this wholesale evasion of taxation of intangible wealth has been proposed. This is to tax intangible property as a special class and at lower rate than other property is taxed. In this way the injustice of the confiscatory nature of the present tax may be done away with and the support of public opinion enlisted in the efforts to bring to light all intangible wealth. Thus the revenue from such taxes is increased.

This has been the case in Pennsylvania. In that state, since 1879, there has been a tax of 4 mills on the dollar of intangible property. The result has been a great increase in the valuation of intangible property locally assessed.

INTANGIBLE PROPERTY LOCALLY ASSESSED IN PENNSYLVANIA*

1885	$145,300,000	1900	$ 722,900,000
1888	429,800,000	1903	847,100,000
1891	575,300,000	1906	932,900,000
1894	613,900,000	1907	1,014,000,000
1897	673,700,000		

* Bullock, "General Property Tax in the United States," *Boston Transcript*, January 13, 20, 27, 1909. Reprinted by the International Tax Association, Columbus, Ohio.

The annual average yield of the tax on corporate loans alone was $300,000 for the period 1886 to 1890, and $1,500,000 for the period 1900 to 1905. This remarkable increase shows clearly the advantage of assessing intangible property at a lower rate than the general property tax presumes to do.[1]

[1] Bullock, *op. cit.*

The table above shows a great increase in intangible property in the state. Its valuation for purposes of assessment has increased faster than real estate, and it now equals one-half of the total assessment of real property. "In other states it varies from 1 to 12 per cent of the assessed value of the realty."[1]

Since 1896 Maryland has placed certain securities in a special class and limited the rate of tax which cities may levy on them. The local rate may not exceed 3 mills, and the state rate averages about 1.6 mills, the total levy therefrom approximating 4.6 mills. It is said this legislation has been vigorously supported by public opinion, and that evasion of assessment is frowned upon. At any rate the assessed valuation of this class of property has greatly increased.

ASSESSED VALUE OF SECURITIES TAXED IN THE CITY OF BALTIMORE *

1896	$ 6,000,000	1902	$ 89,900,000
1897	55,000,000	1903	94,300,000
1898	55,000,000	1904	85,900,000
1899	61,900,000	1905	104,200,000
1900	65,800,000	1906	120,400,000
1901	68,900,000	1907	150,900,000

* BULLOCK, *ibid.*

From the above table it appears that the new law taxing intangible property at a lower rate has brought out of hiding an amount of property sufficiently large to yield a greater revenue than was possible under the old general property tax law taxing such property at 20 mills on the dollar.

Uniformity and equality in taxation does not mean that all kinds of property shall be taxed in the same manner and at the same price. Constitutional provisions providing for uniformity in taxation do not preclude the possibility of classifying property and taxing it at different rates. The Supreme Court of the United States in the case of the Pacific Express Company v. Seibert[2] says:

This court has repeatedly laid down the doctrine that diversity of taxation, both with respect to the amount imposed and the various species of property

[1] BULLOCK, *ibid.*

[2] 142 U.S. 351.

selected either for bearing its burdens or from being exempt from them, is not inconsistent with a perfect uniformity and equality of taxation in the proper sense of those terms; and that a system which imposes the same tax upon every species of property, irrespective of its nature or condition or class, will be destructive of the principle of uniformity and equality in taxation and of a just adaptation of property to its burdens.

In many states there are constitutional objections to thus classifying intangible personal property and taxing it at a different rate from other property, but in Colorado this objection does not exist, as the constitution permits the classification of property for the purposes of taxation.

In any scheme for the reform of the present tax system the absence of radical changes is a strong point. Changes for the betterment of a financial system are rarely made by wholesale. On the contrary, they come slowly, and only by small increments at a time. It is for this reason that we cannot hope for the sudden abolition of the general property tax and the substitution of some one of the numerous academic schemes for fiscal reform. The general property tax system we

PERMANENT STATE TAX COMMISSIONS*

State	No. of Commissioners	How Chosen	Length of Term	Salary
Alabama........	3	By Governor	4 years	$2,400†
Connecticut.....	1	" "	4 "	3,000
Indiana.........	3	" "	4 "	3,000
Kansas.........	3	" " and Senate	4 "	2,500
Massachusetts...	1	" "	3 "	5,000
Michigan.......	3	" " and Senate	6 "	2,500
Minnesota.......	3	" "	6 "	4,500
New Jersey......	5	" "	5 "	3,500‡
New York.......	3	" "	3 "	5,000
North Carolina...	3	By popular vote	6 "	3,000
Ohio...........	3	By Governor and Senate	3 "	5,000
Washington.....	3	" "	4 "	3,000
West Virginia....	1	" " and Senate	6 "	4,000
Wisconsin.......	3	" " " "	8 "	5,000

* *Special Report, State Tax Commission, Kansas*, 1909, p. 55.
† The chairman is paid $3,000 in Alabama.
‡ The chairman is paid $5,000 in New Jersey.

now have, which is so vigorously condemned by financial writers, has grown up with our industrial and political fabric and cannot be either quickly abandoned or suddenly and radically changed. It would therefore seem wise for us to consider first moderate and reasonable plans for improving it. While we are not able to remove all the injustice inherent in the present system, we can at least improve its administration. It is for this reason that the suggestion of a supervisory agency or state tax commission is more likely to engage the attention of the legislators than are the more radical schemes of reform. The most obvious need appears to be pressure on the local assessors by a superior power to secure uniformity in assessments. This power can be obtained by means of a state tax commission.

Permanent state tax commissions exist in fourteen states, as shown by the table on page 101. These commissions are charged with a general supervision of the work of the local assessors. Among their duties may be mentioned the following:

1. To visit each county of the state and advise assessing officers.

2. To hold an annual conference with assessors.

3. To publish and distribute to assessors a book of instructions for use in making valuations of both real and personal property.

The instruction books provided by the Kansas commission and the State Board of Commerce of Ohio are especially valuable.

4. To make a study of the tax system and report criticisms and recommendations for new legislation to the legislature.

5. To perform the duties of the state board of equalization or assist such board by furnishing data and advice.

The principal powers of a state tax commission are:

1. To classify property for the purposes of taxation.

2. To remove or recommend the removal of a local assessor.

3. To order a reassessment of property in any district where there is reason to believe property has been omitted or underassessed.

4. To add to the local assessment roll any property which may have been omitted by the assessor.

5. To raise or lower the assessed valuation as determined by the local assessor of any individual or corporation.

6. To prescribe the form of maps and blanks to be used in the assessment of property, and compel their use by assessing officers.

The power of a state tax commission to classify property for taxing purposes does not mean the power to impose different taxes on different classes of property as discussed above.

While a state commission should not have the power to change the rate, it may perform a very useful service by bringing about more nearly uniform valuations of certain classes of property by the assessing officers. This can be done by dividing property into certain classes, and requiring the return of such classified property with the amount of value placed on each unit of each class. For instance, real estate should be classified by a central authority for purposes of assessment. The committee on uniform classification of real estate recommended the following classification to the International Tax Association:

1. Cultivated land. Includes meadows.
2. Arable land. That not under cultivation, but capable of being plowed.
3. Orchard land. All land covered by fruit trees.
4. Timber land.
5. Mineral land. That containing coal, iron or other minerals in paying quantities.
6. Quarry land. Containing stone.
7. Oil and gas land.
8. Waste land. All not included in above classification.

This classification has the merit of increasing the attention the assessor must devote to real estate, and it seems probable that the valuations placed on land thus separated into classes will be more accurate than those made by assessors not required to classify real estate. Hence the state tax commissions by prescribing the classes of real estate and compelling the assessors' returns to show the valuation of property in each class will greatly increase the uniformity and accuracy of assessment.

In the assessment of certain kinds of personalty, it is possible to make use of a classification. Livestock may be classified to a considerable extent. Horses may be classified as to age, under one year, one year and under two, and two years and over. Similar classification may be used in assessing other domestic animals, and the result would seem to be a far greater approach to accuracy than is possible under the present haphazard methods of local independence in assessment. What is needed is a central power to adopt the classification and compel its use by the local assessors.

The usefulness of permanent state tax commissions has been thoroughly established by their work in other states. A brief summary of the results obtained by state supervision of assessments of property for taxation in Kansas, Michigan, West Virginia, Washington and Wisconsin is given below:

Kansas

A state tax commission was organized in 1907. The increase in the total valuation of the state, as result of the work of the commission, is as follows:[1]

Year	Assessed Valuation
1907	$ 425,281,214
1908	2,414,320,127
1909	2,511,260,285

After correcting inequalities in various districts, the assessment of 1908 bears the following relation to the assessment of 1907:

Property	Increase
Land	6.32 times assessment of 1907
Town lots	4.64 " " " "
All real estate	5.84 " " " "
Personal property	6.01 " " " "
Public-service corporations	5.23 " " " "
Railroad property	5.13 " " " "

$213,591,148 of personal property which had never before been assessed was added to the rolls in 1908.[2]

Michigan

The state board of tax commissioners was organized in 1899. The commission's work begins to show in the assessment for 1900, and by 1902 the results are very apparent.[3]

[1] *First Biennial Report of Tax Commission of Kansas*, 1908, p. 335; *Second Report*, 1909, p. 77.

[2] *First Biennial Report of Tax Commission*, 1908, p. 14.

[3] *Report of State Board of Tax Commissioners and State Board of Assessors*, 1902, pp. 118, 128, 133, 136, 138.

ASSESSED VALUES OF STATE

Year	Real Property	Percentage of Increase	Personalty	Percentage of Increase	Total	Percentage of Increase
1899..	$ 825,858,711	....	$142,330,376	....	$ 968,189,087	....
1902..	1,086,816,327	31.6	331,435,531	132.85	1,418,251,858	46.5

In fifty-three counties the value of real property had declined $56,997,312 during the period from 1886 to 1899, while in fifty-nine counties personal property declined $10,647,216 during the same period.[1] In 1899 personalty paid 14.6 per cent of the total tax, but in 1907 after several years' labor by the commission, personal property paid 22 per cent.[2]

West Virginia

A state tax commissioner was established in 1904. The new law was in full operation in 1906. The effect is shown in the following table of the assessed valuation of the state.[3]

Year	Realty	Assessed Valuation: Personalty	Public Utility Property
1904..................	$168,480,150	$ 80,306,209	$ 30,043,300
1905..................	169,026,710	126,281,620	36,052,845
1906..................	475,174,841	193,573,192	209,093,726
1907..................	489,274,675	199,264,834	242,696,766
1908..................	490,715,670	204,166,662	251,354,364
1909..................	579,085,888	221,125,930	263,036,033

From the above table it appears that in five years the total taxable wealth of the state had increased 3.81 times; real estate 3.43 times; personalty 2.74 times.[4]

Washington

A state board of tax commissioners was established in 1905. While not endowed with as great powers as some of the commissions in other states, it has nevertheless proven effective. The result of

[1] *Report of State Board of Tax Commissioners and State Board of Assessors* (1902), p. 114.

[2] *Report of State Tax Commission*, 1907–8, p. 65.

[3] *Second Biennial Report State Tax Commissioner*, 1907–8, p. 370.

[4] Address of T. C. Townsend, state tax commissioner of West Virginia, before the Fourth International Tax Conference on State and Local Taxation, at Milwaukee, Wisconsin, August 31, 1910.

the work of this board first appears in the assessment of 1906. The table shows a considerable increase as the effects of state supervision.[1]

	Valuation of All Property in State	Percentage of Increase
1905	$328,542,525	.....
1906	530,209,882	61.30
1907	573,070,528	.....
1908	748,593,942	.....

The increase of the real property assessment for 1906 over 1905 was $183,612,350, and the personalty $18,046,905, or 30 per cent.

Wisconsin

The state tax commission was created in 1899, and the effect of its labors is apparent in the assessment of 1901. The table shows that in that year the assessment of real estate had increased 135.53 per cent and personal property 97.87 per cent.

STATE ASSESSMENT*

Year	Realty	Percentage of Increase	Personalty	Percentage of Increase
1899	$ 505,263,975	....	$119,736,025	....
1900	503,690,767	−.31	126,309,232	5.49
1901	1,186,349,139	135.53	249,934,861	97.87
1902	1,226,376,973	3.37	277,969,027	11.22
1903	1,309,504,464	6.78	443,667,536	59.61
1904	1,422,621,485	8.63	420,219,515	−5.28
1905	1,513,335,382	6.37	439,364,618	4.55
1906	1,671,142,204	10.42	453,657,796	3.25

Year	Total Assessed Valuation	Percentage of Increase over Previous Year
1899	$ 625,000,000	....
1900	630,000,000	.80
1901	1,436,282,000	127.98
1902	1,504,346,000	4.74
1903	1,753,172,000	16.54
1904	1,842,841,000	5.11
1905	1,952,700,000	5.96
1906	2,124,800,000	8.81

* *Report of State Tax Commission*, 1907, pp. 19, 22, 24.

[1] *Report State Board of Tax Commissioners*, 1906, p. 193; *ibid.*, 1908, pp. 53, 95.

It appears from the work of state supervision in the above states that as soon as a state tax commission is invested with real power over assessment by local officers the assessed valuation of the state has been greatly increased. With an increased assessed valuation and no change in the tax limit law, it would be possible to increase greatly the amount of taxes to be paid. At the present time most local governments are levying taxes up to the per cent of the assessed valuation allowed by law, and would levy larger amounts if they could. Therefore, when new legislation makes it certain that there will be a great increase in the assessed valuation, it has been found necessary to safeguard the taxpayer by passing an act to limit the amount of taxes that may be collected under the new law. Thus in Kansas[1] it was provided that no officer or board might make a tax levy that would produce an amount greater than 102 per cent of what would have been produced by applying the maximum levy to the valuation of 1907.

A similar act was passed in Ohio (June, 1910) when it was decided to place property on the rolls at its full cash value. This act provides that the present maximum rate of levy shall be so reduced that if levied on the total valuation in each taxing district it would not produce in 1911 and 1912 and any year thereafter a greater amount of taxes than if levied on the total taxable property for 1910,

plus the additions provided for in Sec. 2 which are "an amount equal to the aggregate amount of taxes levied in such district for the year 1909 plus 6 per cent thereof for the year 1911, 9 per cent for the year 1912, and 12 per cent thereof for any year thereafter." Any minimum rate required by law to be levied for any purpose is hereby reduced in like proportion that the maximum rate is herein reduced.[2]

At the special session of the legislature of West Virginia in 1904, when the act was passed which directed that instead of at its "fair cash value" property should be assessed at its "true and actual value," it was found necessary to limit the rate of tax levy for different purposes. This act was amended in 1905, again in 1907 and

[1] *Laws of 1908*, chap. 78.

[2] FOOTE, "Taxation Work and Experience in Ohio," paper read at Fourth International Conference on State and Local Taxation, Milwaukee, August 30 to September 1, 1910.

again in 1908 as the valuation of the state increased under the effective administration of the new law.

The great value of limiting the tax levy is of course the guaranty to the taxpayer that he will be protected under the increased valuation demanded by the new legislation. When the taxpayer is thus assured of protection from the increased valuation, he will the more readily co-operate in the efforts to secure the assessment of property at its true cash value.

APPENDIX

Average Assessed Value of Land, Livestock and Certain Other Personalty in the Counties of Colorado

The following tables were prepared by Mr. Herbert C. Fairall, Secretary of the State Board of Equalization. They are based on the assessment of 1910 and show the average assessed value of land, livestock and other tangible personal property in each of the various counties. The counties are arranged in groups of contiguous territory with somewhat the same topography. These figures, like those of 1908, show great variations in the assessment of the same kind of property in the different counties.

TABLE I

AVERAGE ASSESSED VALUE PER ACRE OF LAND IN COLORADO, 1910

County	Fruit Land	Irrigated Land	Natural Hay Land	Dry Farming Land	Grazing Land	Productive Coal Land	Non-productive Coal Land	Oil Land	Other Mineral Land
Adams	.....	23.81	.....	3.00	1.56	.....	.....	.....	.....
Arapahoe	.....	34.83	.....	5.25	1.50	.....	.....	.....	.....
Boulder	.....	22.02	11.83	....	3.10	31.50	.....	28.21	16.48
Douglas	.....	15.00	5.00	3.00	1.75	.....	.....	.....	.....
Jefferson	.....	28.52	.....	....	1.72	.....	12.24	.....	.....
Larimer	60.00	20.33	5.00	6.58	1.28	.....	.....	.....	6.40
Logan	.....	17.17	.....	2.73	1.63	.....	.....	.....	.....
Morgan	.....	16.11	12.12	5.36	1.98	.....	.....	.....	.....
Weld	.....	21.34	15.80	4.91	2.25	26.84	10.96	.....	.....
Cheyenne	.....	.....	.....	....	1.91	.....	.....	.....	.....
Elbert	.....	.....	5.00	5.00	1.30	.....	.....	.....	.....
El Paso	.....	18.00	.....	4.00	1.50	51.65	.....	.....	.....
Kiowa	.....	.....	.....	2.50	1.25	.....	.....	.....	.....
Kit Carson	.....	.....	.....	1.79	1.79	.....	.....	.....	.....
Lincoln	.....	.....	.....	....	1.50	.....	.....	.....	.....
Phillips	.....	.....	.....	2.59	....	.....	.....	.....	.....
Sedgwick	.....	12.10	6.00	3.36	2.17	.....	.....	.....	.....
Washington	.....	15.00	5.00	....	1.98	.....	.....	.....	.....
Yuma	.....	8.00	.....	3.10	1.20	.....	.....	.....	.....
Baca	.....	.....	.....	1.56	1.56	.....	.....	.....	.....
Bent	.....	20.43	.....	....	1.88	.....	.....	.....	.....
Fremont	151.99	15.61	8.10	....	1.50	29.93	.....	17.97	5.00
Huerfano	.....	9.74	.....	....	1.21	94.78	4.84	.....	.....
Las Animas	.....	10.50	6.87	5.50	1.55	37.86	17.04	.....	.....
Otero	36.22	25.63	.....	....	1.80	.....	.....	.....	.....
Prowers	.....	15.05	8.00	....	2.02	.....	.....	.....	.....
Pueblo	.....	24.44	.....	....	1.42	.....	.....	.....	.....
Grand	.....	.....	5.00	....	1.00	.....	.....	.....	.....
Jackson	.....	.....	5.00	....	1.30	.....	5.50	.....	.....
Rio Blanco	.....	9.00	.....	3.50	1.32	.....	10.00	2.50	30.00
Routt	.....	10.00	.....	4.89	2.12	20.00	10.00	.....	5.89
Clear Creek	.....	.....	.....	....	2.52	.....	.....	.....	.....
Eagle	.....	13.74	.....	....	1.86	.....	.....	.....	.....
Gilpin	.....	.....	.....	....	1.25	.....	.....	.....	5.00
Lake	.....	.....	.....	....	3.45	.....	.....	.....	.....
Park	.....	.....	7.00	....	1.07	.....	6.00	.....	.....
Pitkin	.....	13.91	.....	....	1.98	16.34	.....	.....	.....
Summit	.....	5.00	.....	....	1.25	.....	.....	.....	.....
Teller	.....	.....	5.00	5.00	1.50	.....	.....	.....	7.75
Chaffee	20.00	11.93	.....	....	1.22	.....	.....	.....	.....
Gunnison	.....	8.44	.....	....	1.53	37.42	.....	.....	.....
Archuleta	.....	7.00	.....	....	1.00	10.00	10.00	.....	.....
Conejos	.....	8.47	.....	....	1.50	.....	.....	.....	.....

TABLE I—*Continued*

County	Fruit Land	Irrigated Land	Natural Hay Land	Dry Farming Land	Grazing Land	Productive Coal Land	Non-productive Coal Land	Oil Land	Other Mineral Land
Costilla......	.....	5.63	4.00	....	1.20	.....	.....	.....	2.00
Custer.......	8.00	.....	10.00	....	1.25	.....	.....	.....	10.00
Mineral......	.....	.....	3.01	....	1.54	.....	.....	.....	.....
Rio Grande..	.....	9.96	.....	....	1.87	.....	.....	.....	.....
Saguache....	.....	8.66	.....	....	1.20	.....	.....	.....	.....
Dolores......	.....	6.00	.....	....	1.25	.....	10.00	.....	10.00
La Plata.....	35.00	16.00	.....	6.20	1.25	20.00	20.00	.....	.....
Montezuma..	10.00	9.70	.....	....	1.25	10.00	.....	.....	.....
San Miguel ..	.....	8.15	.....	....	1.57	.....	10.00	.....	.....
Delta........	75.00	41.25	.....	1.00	1.25	50.00	20.00	.....	.....
Garfield.....	30.00	18.50	.....	....	1.68	50.00	20.48	.....	7.52
Mesa........	82.50	21.50	.....	....	3.00	20.00	.....	.....	.....
Montrose....	65.00	14.13	.....	....	2.25	.....	.....	.....	.....
Ouray.......	.....	12.52	.....	5.44	1.30	.....	8.00	.....	.....
San Juan....	.....	.....	.....	....	2.80	.....	.....	.....	.....
Hinsdale.....	.....	.....	.....	....	1.64	.....	.....	.....	.....
Denver......	.....	251.90	.....	.....	....	.....	.....	.....	.....

TABLE II

AVERAGE ASSESSED VALUE OF LIVESTOCK IN COLORADO, 1910

County	Horses	Mules	Asses	Range Cattle	Dairy Cattle	Sheep	Swine	Goats
Adams	36.55	47.18	.....	10.04	18.00	1.50	5.51	.....
Arapahoe	37.30	41.67	.....	10.15	23.60	1.50	6.65	.....
Boulder	32.85	34.35	.....	9.97	15.55	1.01	4.76	.....
Douglas	37.00	40.00	.....	12.50	.....	1.50	6.00	.....
Jefferson	27.40	31.00	.....	8.14	15.66	1.63	3.68	1.00
Larimer	31.64	37.67	.....	9.70	15.00	1.06	4.94	.....
Logan	32.97	34.37	.....	10.00	14.96	1.37	4.82	.....
Morgan	32.00	41.50	100.00	10.00	16.00	1.13	2.80	.....
Weld	40.36	53.47	.....	9.93	17.68	1.56	4.74	.....
Cheyenne	25.31	32.77	4.60	10.34	.....	1.46	6.96	.....
Elbert	28.95	36.76	.....	9.21	15.00	1.50	5.00	.....
El Paso	25.80	27.78	.....	9.00	18.10	1.60	5.27	.....
Kiowa	20.00	28.00	.....	10.00	.....	1.24	3.38	.....
Kit Carson	27.57	35.72	189.13	8.53	13.00	1.50	4.85	1.31
Lincoln	26.95	35.00	.....	8.32	.....	1.50	4.12	.....
Phillips	20.00	20.00	.....	8.09	10.23	.66	4.00	.....
Sedgwick	25.41	31.29	.....	8.44	14.00	1.50	4.55	.....
Washington	32.04	44.67	.....	8.39	.....	1.50	4.50	.....
Yuma	27.00	29.00	138.60	7.95	.....	1.20	4.99	.....
Baca	24.00	32.70	1.66	8.89	13.16	1.50	2.28	.....
Bent	30.30	33.98	.....	7.07	15.57	1.14	3.58	.....
Fremont	26.79	30.00	.....	7.94	18.64	.....	3.40	....
Huerfano	33.24	3.96	5.00	39.25	12.84	1.53	4.23	1.67
Las Animas	25.15	31.80	45.82	11.06	24.50	1.57	4.68	2.00
Otero	31.06	37.77	.....	11.00	.....	1.42	3.15	.....
Prowers	23.86	26.28	.....	6.44	15.00	1.17	2.55	.....
Pueblo	35.94	46.26	.....	13.52	28.20	1.57	5.53	.....
Grand	20.00	23.00	.....	9.00	.....	1.40	5.00	.....
Jackson	28.10	24.00	.....	8.28	.....	1.40	2.40	1.30
Rio Blanco	25.43	23.50	.....	11.15	.....	2.00	3.00	.....
Routt	32.26	31.73	.....	10.92	.....	2.00	5.01	.....
Clear Creek	27.24	25.00	10.00	13.63	.....	.....	.....	.....
Eagle	27.00	20.00	.....	10.14	.....	1.50	5.00	.....
Gilpin	25.00	25.00	....	15.00	.....	.....	.....	.....
Lake	30.15	.....	10.30	.....	18.64	.....	.....	.....
Park	18.87	23.80	3.00	8.00	12.00	1.50	3.00	1.50
Pitkin	27.05	26.66	7.69	8.95	.....	1.50	4.13	.....
Summit	24.00	20.00	5.00	.....	12.34	2.00	5.00	.....
Teller	27.61	47.73	10.00	8.55	22.00	.....	4.26	2.50
Chaffee	17.70	23.00	5.00	7.29	14.60	1.40	4.14	.....
Gunnison	21.83	27.74	.....	8.16	.....	2.00	4.83	.....
Archuleta	29.75	41.05	.....	7.66	10.66	1.50	3.10	1.00
Conejos	19.89	28.00	.....	8.95	15.00	1.25	5.00	.....
Costilla	29.50	46.00	5.00	10.00	20.00	1.50	3.50	2.00

TABLE II—*Continued*

County	Horses	Mules	Asses	Range Cattle	Dairy Cattle	Sheep	Swine	Goats
Custer	29.95	15.00	.....	10.00	.....	2.02	4.70	.....
Mineral	21.14	50.00	.....	9.14	.....	1.50	.....	.....
Rio Grande	41.85	55.53	.....	8.15	13.00	1.50	3.75	.75
Saguache	30.40	45.66	.....	8.33	.....	1.75	4.50	.....
Dolores	26.12	33.46	2.50	8.55	15.00	.....	3.00	.....
La Plata	35.71	33.00	6.00	8.16	15.00	1.83	3.61	1.00
Montezuma	40.86	58.67	.....	10.00	20.00	1.73	3.84	1.22
San Miguel	32.71	35.54	10.00	8.78	.....	1.90	3.80	2.00
Delta	32.17	37.70	.....	9.15	20.00	2.00	4.65	2.00
Garfield	25.44	30.31	.....	8.27	15.00	1.50	2.90	.....
Mesa	25.00	30.00	.....	8.00	15.00	1.50	3.00	.....
Montrose	26.92	21.83	.....	8.77	.....	1.93	3.50	.....
Ouray	25.00	26.90	.....	8.00	12.03	2.00	5.00	.....
San Juan	27.58	21.08	5.00	......	15.00	1.50	.....	1.00
Hinsdale	21.00	24.50	.....	8.60	.....	1.50	.....	.....
Denver	49.02	65.37	.....	.....	33.13	.....	4.40	.....

TABLE III

AVERAGE ASSESSED VALUE OF CERTAIN PERSONALTY IN COLORADO, 1910

County	Bicycles, Motor Cycles	Automobiles	Carriages and Vehicles	Musical Instruments	Clocks and Watches
Adams	13.00	309.00	21.20	44.21	7.20
Arapahoe	20.00	373.00	19.00	63.25	8.65
Boulder	11.25	290.00	18.54	66.46	8.97
Douglas	.....	520.00	14.25	35.00	8.00
Jefferson	.....	148.00	17.81	52.61	10.50
Larimer	50.17	254.00	18.07	50.49	7.62
Logan	14.61	323.00	15.58	63.00	8.37
Morgan	15.00	257.00	12.50	51.00	5.70
Weld	15.67	220.00	18.60	65.00	11.00
Cheyenne	.....	500.00	13.07	39.82	12.90
Elbert	.....	250.00	20.00	20.00	5.00
El Paso	18.67	394.00	23.00	56.00	16.00
Kiowa	4.00	......	9.28	9.57	3.41
Kit Carson	7.89	165.00	16.48	21.49	4.55
Lincoln	.....	231.00	11.00	41.32	8.31
Phillips	.....	279.00	10.00	23.05	4.87
Sedgwick	5.00	181.00	17.00	41.61	5.00
Washington	.....	270.00	12.17	31.18	7.66
Yuma	.....	212.00	13.25	32.65	6.00
Baca	29.80	148.00	8.90	11.30	2.22
Bent	30.41	196.00	17.40	61.05	6.54
Fremont	13.00	208.00	21.12	59.45	10.00
Huerfano	11.63	387.00	25.40	69.65	8.88
Las Animas	24.24	345.00	26.46	78.11	12.81
Otero	16.11	253.00	17.33	57.23	9.10
Prowers	8.20	181.00	9.13	54.79	4.57
Pueblo	16.08	431.00	27.65	59.45	9.33
Grand	.....	......	17.43	44.23	....
Jackson	.....	700.00	14.53	65.50	6.00
Rio Blanco	10.00	......	19.00	63.25	7.00
Routt	.....	250.00	25.39	52.89	8.25
Clear Creek	50.00	600.00	22.22	52.23	....
Eagle	.....	......	21.21	76.80	8.17
Gilpin	.....	......	32.50	75.00	....
Lake	.....	......	33.21	52.25	22.20
Park	.....	285.00	13.88	78.33	6.20
Pitkin	9.42	175.00	18.75	79.07	11.06
Summit	30.00	......	26.00	72.43	15.32
Teller	25.00	160.00	21.00	47.00	14.19
Chaffee	27.00	301.00	21.81	63.00	10.90
Gunnison	13.50	200.00	16.70	44.44	10.00
Archuleta	.....	......	18.07	57.45	5.99
Conejos	30.00	210.00	20.00	37.50	5.25
Costilla	14.00	334.00	28.00	41.00	4.50

TABLE III—*Continued*

County	Bicycles, Motor Cycles	Automobiles	Carriages and Vehicles	Musical Instruments	Clocks and Watches
Custer	.....	......	15.38	36.50	10.30
Mineral	.....	225.00	25.07	57.37	7.50
Rio Grande	.....	236.00	24.00	82.26	6.50
Saguache	.....	315.00	26.00	77.00	5.40
Dolores	.....	......	22.60	36.19	10.15
La Plata	7.00	253.00	23.43	58.10	12.30
Montezuma	.....	250.00	32.36	80.75	11.12
San Miguel	.....	......	30.55	76.10	17.38
Delta	.....	303.00	21.92	96.53	9.56
Garfield	.....	256.00	16.12	47.00	11.00
Mesa	6.00	211.00	15.50	48.50	6.00
Montrose	.....	......	17.82	38.54	6.77
Ouray	.....	......	20.58	45.55	10.80
San Juan	75.00	......	32.11	75.00	18.50
Hinsdale	.....	......	18.65	59.21	9.00
Denver	17.02	414.00	44.16	64.89	16.98

MR. STEPHEN PHILLIPS AS A WRITER OF TRAGEDY[1]

By Fred B. R. Hellems

I

The concord with which Mr. Stephen Phillips was acclaimed a true singer on the publication of his *Poems* was only less striking than the later clashing of polemics over his merits as a writer of tragedy, and even the most hopeful searcher after convincing literary verdicts would rise from the several score reviews on my table with a despairing impression of the futility of criticism. Accordingly, in a rather pessimistic frame of mind, one blustering afternoon in late September, I sat down to read once more *Paolo and Francesca* with *Romeo and Juliet.* Doubtless this comparison has been instituted, more or less carefully, by every lover of poetry; for the features of resemblance are so numerous and striking that they must challenge the attention of even the casual reader.

Both plays belong to the earlier activity of their respective authors; in both the story is frankly drawn from the open treasury of older literature; in the former as in the latter the scene is "the eternal Italy of passion, the time is the deathless spring of young desire"; in either tragedy two youthful beings, who forget the world and all beside, pay the penalty, or win the guerdon, of a lover's death, and the play ends "with a long, deep sigh like the last breeze of an Italian evening"; in short, there is almost as close a parallel as one could hope to find. In following the parallel one must not forget that Mr. Phillips expressly deprecates comparison with the Elizabethans, who sought for multiplicity of effect, whereas he aims at unity; but even over his protest some relative estimate will be made by every devotee of the drama, and, in the right spirit, it is essentially worth making.

[1] Reprinted from the *Atlantic Monthly*, Vol. 102, No. 6, pp. 809–21, by kind permission of the publisher.

How, then, does the *Paola and Francesca* emerge from the experiment? The real answer can come only from the individual reader; but I cannot escape the conviction that if he will read as I did, doing his best to put aside all preconceptions and yielding himself naturally to the pages in his hands and the general impression thereby produced, he will close the two plays with the feeling that if there is not equality of concrete achievement there is at least real kinship of spirit. Nay, I even fancy that not a few readers will feel the tugging at the heartstrings just a little stronger at the last words of Giovanni than at the closing speech of the Prince. If there "never was a story of more woe than this of Juliet and her Romeo," yet by its side may stand the story of Paolo and Francesca, who wooed and loved unwillingly, whom we leave looking like children fast asleep. Naturally, there arises the objection that the experiment would be proposed and the conclusion reached only by a cloistered bookman. In this objection, however, I could not quite acquiesce; for I must believe that a comparison in the theater would lead to no materially different decision. Mr. Irving's production of the modern play I have never heard; but no unprejudiced auditor will ever forget or deny his emotions when Mr. George Alexander, approaching the litter with its bitter lading of youth and beauty, in whose company we have lived a fated hour, says very gently:

> Not easily have we three come to this—
> We three who now are dead. Unwillingly
> They loved, unwillingly I slew them. Now
> I kiss them on the forehead quietly.

In my own experience I noted the same deep and general hush that I had felt shed itself over a Greek audience some six years before, at the not dissimilar close of the *Antigone*, which was presented by the students of the University of Athens. Of course the surface is only the surface; but the heart is the heart, and this tugging at its strings has something to do with judging a tragedy. The farther I followed the thoughts suggested by the comparison, the more I was strengthened in the belief that Mr. Phillips was worth knowing. Shortly afterward the *Faust* was placed in my hands, and I have ventured to make a simple estimate of Mr. Phillips' actual achievements and of the grounds for hope or fear as to his future. With this modest aim before me I have essayed a review of the six plays hitherto published, taking up in order our author's choice of tragic material, treatment of plot and dramatic motive, depiction of character, poetic diction and scenic presentment.

II

If we first cast a general glance over the dramas we find that three of them may be called tragedies of love, one a tragic masque, the fifth a dramatic character study, while the latest is frankly an adaptation of Goethe's masterpiece. In the earliest of the love tragedies Mr. Phillips has gone to Dante for his story and has chosen that aspect of the myriad-faced problem wherein the love of the principal characters appears as a phase of Fate, "that god behind all gods." From the moment when Paolo enters out of sunlight leading Francesca, until in the gloomy hall the bodies are reverently covered over, we feel that in most solemn sooth "his kiss was on her lips e'er she was born." Their love was as inevitable as life or death. Indeed, it was at one with the love in the old Empedoclean or new Haeckelian scheme of the universe, the love that operates from the primordial atom to the enthralling of the earth by the sun, from the lowest protozoon to the loftiest soul of man with its godlike uprushing toward pure truth and pure beauty. Despite our conventions we realize that the love of these twain does raise them above themselves; and the glorious allegorizing of Plato in the *Phaedrus* and *Symposium*, along with Dante's kindred vision, is immediately recalled by the scene in which we hear the glowing prayer of Paolo:

> Let me with kisses burn this body away,
> That our two souls may dart together free.
> I fret at intervention of the flesh,
> And I would clasp you—you that but inhabit
> This lovely house.

Howbeit, love of the spirit with absolutely no fretting intervention of the flesh is as impossible for us in our mortal houses as it is undesirable, until we rise to other levels; and it is strictly in accord with cosmic order, as well as cosmic passion, that youth goes toward youth. For their contravention of our recognized moral order they meet a punishment that is no punishment, but merely one more ground for Heine's decision that "die Liebe mit dem Tode verbunden ist unüberwindlich."

In *The Sin of David* the central conception of love is the same. Thus Lisle says to Miriam in words that still carry an echo from Plato and Dante:

> No! for a revelation breaks from thee,
> Thou hast unlocked the loveliness of earth,
> Leading me through thy beauty to all beauty.
> Thou hast admitted me to mystery,
> Taught me the different souls of all the stars;
> Through thee have I inherited this air,
> Discovered sudden riches at my feet,
> And now on eyes long blinded flames the world.

Here again unquenchable love is brought into conflict with the moral order, this time with the scarlet taint of blood-guiltiness; for Lisle, maddened by Miriam's moonlit beauty, sends her husband to certain death and watches him ride, dying, into the night. Upon this pair of lovers, even after they are sheltered in happy wedlock, breaks a storm of real punishment in the loss of an idolized child. Nemesis with terrible grimness has caught up the earlier words of Lisle, and sending more than mere death, "strikes at his heart, his hope, his home."

In *Herod* the face of love is different. The Judaean soldier-king, who has lived forever half in lightning, half in gloom, is possessed by a consuming passion for his queen, whom he has wooed amid the crashing of cities. Mariamne, however, in whose veins there runs the blood of all the Maccabees, loves her stormy, brilliant husband mainly for his impetuous power:

> Those eyes that dimmed for me flamed in the breach;
> And you were scorched and scarred and dressed in spoils,
> Magnificent in livery of ruin.

Stronger than her love for Herod, although it is of the sort which "not time, absence, or age could ever touch," is the love she bears her brother, who is more than flesh and blood to her, the incarnation of the spirit of her ancient race, the crown of its past and hope of its future:

> O thou art holy, child;
> About thee is the sound of rushing wings,
> And a breathing as of angels thro' thy hair.

So, when Herod, in submission to what seems to be irresistible political need, causes the brother to be slain, her great love is quenched in a greater grief:

> Herod, that love I did conceive for you,
> And from you, it was even as a child—
> More dear, indeed, than any child of flesh,
> For all its blood was as a colour of dreams,
> And it was veined with visions delicate.
> Then came a sudden labour ere my time—
> Terrible travail—and I bring it forth,
> Dead, dead. And here I lay it at your feet.

Then the goads of grief and jealousy skilfully utilized by Herod's scheming mother and sister drive him to the deed which fulfils the astrologer's prediction that Herod should kill the thing that most he loved; for the dead brother demands his sister's death. Finally, beneath the weight of sin and sorrow the king's mind is maddened, and amid the wild foam of insanity he "clasps only this rock, that Mariamne lives." As to wealth and dominion and power he has achieved more than his wildest dreams; but he has "ransomed outward victory with inward loss," and his last words before being bound in catalepsy are a heart-rending cry that he will re-create his beloved out of endless yearning. If Paolo seems to be punished for his love, if the punishment of Lisle is real and heavy indeed, Herod may be numbered with Othello and the few others whose retribution has become a part of the world's moan of pain.

In *Ulysses* we have still another phase of love; but it no longer fills the stage as in the preceding plays. It is true that the storied fidelity of Penelope and the sacred hunger of her soul are sung once more in beautiful lines; and the drama ends effectively with husband and wife in silent embrace by the brightening hearth, while the voice of the minstrel is heard repeating the song:

> And she shall fall upon his breast
> With never a spoken word.

Howbeit, the love of the wanderer for Penelope, deep and abiding though it proves, is not all that Calypso reads into it before she bids the Ithacan leave her island; it is essentially a part of his longing for home, one of the thousand calls ringing in his ears and summoning him across the deep. As to dramatic motive the punishment of the suitors and the portrayal of the character of the wave-worn, steadfast, wily king play quite as large a part as the love between husband and wife.

In *Nero* love is only an incident, the Emperor's relations with Poppaea being treated as a feature of the conspiracy against Agrippina, a part of the policy of "matching the mistress 'gainst the mother—the noon of beauty against the evening of authority." The drama is primarily an exposition of the development of an "aesthete made omnipotent," of a dreamy, pampered youth with a surface of polish and specious intentions who changes into a crazy author-actor-musician with all the world for his theater. In opposition to him is drawn the imperious woman who would give life to even the driest of annals, and if there is a central tragic point in the play it is her murder, which has been acquiesced in rather than promoted by the demented son. For this, however, he pays a wild atonement by giving her flaming Rome for a funeral pyre; and the curtain falls as Nero faints at the conclusion of his apostrophe to her spirit and the flames that appease its rage.

As to *Faust* there is little need of words. Here is matter for the dramatic poets of all ages; each changing era of thought will justify a new presentation of this eternal theme. At some not very distant day we may have a *Faust* almost as different from Goethe's as his was different from the mediaeval puppet show to which we trace its origin. The great new play may be no better; but it will be fundamentally different. If we are honest, we must admit that the sage of Weimar, despite his efforts to convince us that Faust worked out his own salvation, is ultimately driven to "salvation by grace." This solution was proper enough at one stage in occidental development; but it will hardly be acceptable much longer. It is too mediaeval and formal. In our *Faust* of the future, the problem will be the same; but the solution must be along the lines the younger Goethe doubtless intended. On earth the skein is tangled, and on earth, not in heaven, must it be unraveled. This is no presumptuous arraignment of one of the world's greatest classics; it is simply an obvious assertion that man's attitude toward the fundamental moral problems of the universe is not fixed beyond the possibility of movement. In the months intervening since the announcement of Mr. Phillips' new play, I had hoped that he might essay the Olympian task of treating this inexhaustible theme in a new spirit; but he and Mr. Carr have preferred the lowlier, easier work of adding to the innumerable adaptations of the greatest drama in German literature.

Utilizing this brief review to recall the tragedies, we can hardly fail to conclude that in the first three outlined above Mr. Phillips has chosen thoroughly suitable material, unless we are all to desert to Mr. Bernard Shaw and allow the "sentimentalists" to weep alone. In the story of Ulysses there is appropriate and even beautiful material for a tragic masque, which is practically what Mr. Phillips has given us. In Nero, I think, there is stuff for a certain sort of tragedy, although not for the sort our author has written; but of this I shall speak again. The *Faust* treats an undying theme with unlimited possibilities.

III

With this dramatic material our author's treatment of plot is naturally connected very closely. In *Paolo and Francesca*, for instance, in view of the long precedent literary tradition attaching to these names, Mr. Phillips had little room left for choice save as between so-called idealizing and realistic treatments. That he is to be congratulated on choosing the former several critics have denied; but if these had stumbled upon the same chance for a comparison as was thrust upon me by a kindly fortune, I cannot but fancy that a few of them would have modified their decision. It happened by the sheerest luck that the last play I attended in Paris the week before seeing *Paolo and Francesca* presented in London was Marion Crawford's realistic version of the same story. History was adhered to with brain-satisfying accuracy, and Madame Bernhardt, although I had seen her when she appeared to better advantage, acted with genuine power; but the contrast between that presentation and Mr. George Alexander's production of the less historical version by Mr. Phillips would have given pause to the most aggressive advocates of realism. The Parisian play was after all only a tragedy of blood flowing across a picture of muddy passion, which all the witchery of the supremely gifted actress and the magic of the incomparable scenic presentment could not raise above the commonplace; whereas on the London stage was a tragedy of human souls with a background of ineluctable Fate. Even when one admits the existence of certain vulnerable points, this background saves the plot, and the final impression is one of inevitability.

Passing to *Ulysses*, we may borrow from Aristotle:

> A certain man is absent from home for many years; he is jealously watched by Poseidon, and left desolate. Meanwhile his home is in a wretched plight—suitors are wasting his substance and plotting against his son. At length, tempest-tost, he arrives and reveals his true self; he attacks his enemies, destroys them and is himself preserved. This is the essence of the plot; the rest is episode.

Even the play's warmest admirers, Mr. Stephen Gwynne, for instance, are inclined to slight the question of plot and to emphasize other aspects, such as "the beauty of sight and sound, the grace of gesture, the melody of verse, the glory of splendid words"; or, "the fire and force, that lift out of the commonplace a common motive or a common thought." There is a weakness as to impelling and unifying dramatic motive which the noble forms of Athena and Poseidon may cloak but cannot altogether hide; and the weakness may as well be admitted without contention.

As to *The Sin of David* it is safe to assume that any reader will repeat in large part whatever verdict he has passed upon the question of plot in *Paolo and Francesca,* which it resembles in so many ways, although there is one important weakness, which will be considered in connection with the author's treatment of Lisle's character.

When we come to the *Herod,* however, we find ourselves in a position to decide definitely that Mr. Phillips can construct a plot. It is true that he was once more using material from an open source and that other plays had been written on the same subject; but even so there was more room for stretching of the wings, and our poet has achieved a notable flight. Early in the first act the author sets before us the masterful passion of Herod for his bride, which is the central theme; the critical position of Judaea before the all-engulfing tide of Roman conquest; the menace of Aristobulus' existence to Herod's supremacy over a discontented people, whom he alone can save; the almost idolatrous devotion of Mariamne to her brother; and the jealous intriguing of Cypros and Salome. Across the scene there flit the whispered prophecies of a coming king—reminding us of "Christ in Hades"—who shall rule in gentleness and take terror from the grave. For one clear if awful moment we are allowed to pierce the veil of the future, when Cypros repeats the astrologer's prediction:

> Herod shall famous be o'er all the world,
> But he shall kill that thing which most he loves.

Just before the fall of the curtain, when Mariamne discovers that Herod has brought about her brother's death, we see a little more clearly beyond the veil.

In the second act Herod is led by a complex of motives, convincing in the sum, to order the death of the wife whose murdered love he cannot survive. "Fate is upon him with the hour, the word." To make more deeply pathetic his helplessness before Fate and Mariamne we are shown his mastery over the Judaean mob and his promotion by Caesar to undreamed-of power. In the third act, where some ambitious reviewers have complained of a lack of action, the drama "lies in the fateful suspense that hangs over the issue; in the shifting tempestuous movements of the half-mad king's mind, and the echo which they find in the corresponding movements of hope and confidence, alarmed sympathy, consternation, dismay and finally solemn resignation, in the minds of his hearers."

With the whole play before an intelligent reader I do not see how he could possibly dissent from the following verdict of one of the keenest and most open-minded literary judges in England, writing under the *nom de plume* of Senex:

> The plot is so contrived that all the action passes after the manner of French tragedy, and with no great violence done to probability, in a single scene—the hall of audience in Herod's palace in Jerusalem. An Elizabethan breadth and daring of imaginative treatment, with a Greek parsimony of characters and issues, and a French observation of the unities at least of place,—such are the main structural characteristics of the new tragedy; and it is needless to say that they make it from the outset quite unlike any other modern English work of stagecraft.

In *Nero* the plot, to voice a candid personal opinion, is not handled with any real mastery. That a character-study can be made a great play has been shown by *Hamlet* and other examples; but there is almost as much difference between the treatments of Shakespeare and Mr. Phillips as there is between the characters of the Danish prince and the Roman emperor. In the Elizabethan play the drama grows, in the modern it is forced—a feeling from which one rarely escapes, even under the charm of the author's many beautiful passages and skilful scenic auxiliaries. What plot there is must find its center in Agrippina, and perhaps the mere adopting of her name for the drama would have made us less captious in our criticism. Racine was wise enough to call his play on the period *Britannicus;* but in the drama of Mr. Phillips the character-study deals primarily with the eponymous persona, while the plot interest centers about another. If Agrippina had been given just a trifle more prominence and her name had appeared as the title, we should have felt that the play had a beginning, a middle, and an end; whereas even the most friendly critics must confess that the present play hardly fulfils this modest requirement. We are not through with Nero when he apostrophizes burning Rome. In the play of the same name by Mr. Robert Bridges these words are spoken by Seneca:

> If any were to make a tragedy
> Of these events, how would it pass or please
> If Nero lived on at the end unpunished,
> Triumphing still o'er good?

And despite Thrasea's rejoinder that "the god that mends all comes not in pat at his cue, as a machine," we feel that Seneca was right. Pagans or Puritans, we will have Nemesis or the avenging God; we do not ask that virtue be happy, or even that natural evil be chastised; but withal those of us least poetical in our justice do demand that abnormal vice shall not be flaringly triumphant at the end. Moreover, in the case of Nero history has recorded his punishment; and in fact the punishment of such a character in such an environment is inevitable. It would seem that a great tragedy on the picturesque actor-emperor could be written as a sort of Greek play in which all the overweening pride of the Ahenobarbi should be punished in Nero by his fantastic madness and abject death; or that a successful tragedy could be constructed on the lines of a modern drama, half-way between Mr. Phillips' *Nero* and a French study of pathology, terminating on the wild, avenging night that brings death to the tyrant madman, with the truly tragic figure of Acte by his side.

Of the plot of *Faust* we need speak only in so far as Mr. Phillips and his collaborator have modified their original. Much of Goethe's text has long been discarded on the ordinary stage, nor can we make serious complaint about many of the omissions. The manifest striving of our present adapters is toward simplicity and unity.

In the Prologue, on a range of mountains between heaven and earth, Mephistopheles obtains permission to win the soul of Faust if he can. Into the first act are condensed the appearance of the Earth-Spirit, the conversation with Wagner, the phial scene, the invocation of the Spirit of Evil, the compact with Mephistopheles, the latter's conference with the earnest student and the visit to the witches' cavern. In the first scene of Act II the foolery in Auerbach's

Keller is connected with the Margaret episode, the students being represented as friends of Valentine, who is leaving for the wars. From the drinking bout Faust and Mephistopheles go to watch the faithful returning from mass, and they meet Margaret, who has been praying to the Virgin for her brother's safety. The next three scenes follow the old version more closely, although with many omissions and minor changes; also with one unimportant but annoying inconsistency which we have not space to discuss. In the fifth scene Mephistopheles urges Faust to "finish what is begun" and gives him the potion. The sixth scene closes with the entry of Faust into Margaret's dwelling. In Act III the order of events is decidedly modified. From the gossip of the village girls at the fountain, Margaret turns to the church, where she is tormented at her prayers by the mockery of Mephistopheles. Outside the cathedral the student friends converse about Margaret's guilt. Valentine comes proudly in at the head of his troop, to be told of his sister's shame. Faust and his ally appear and the duel occurs, followed by the heart-breaking interview between brother and sister. Act IV contains a brief Brocken scene, wherein Faust is shown Helen, Cleopatra and Messalina. Just as he is yielding, however, the witch who presented the rejuvenating potion in Act I causes him to see Margaret in her misery with her dead babe at her feet. The second scene takes us to the prison cell and deathbed of Margaret.

At this point comes the great departure from Goethe, and, in my humble opinion, an absolutely fatal mistake. No man can ever forget the impressive ending of the first part of *Faust*. The voice from above declares that Margaret is saved; Mephistopheles disappears with Faust; the dying voice from within is heard faintly calling the lover's cherished name. There is final tragedy. But this will not do for Mr. Phillips and Mr. Carr. Faust declares that he will follow his lost love:

> Margaret, Margaret! after thee I come
> And rush behind thee in thy headlong flight.

Then the hero and the arch-fiend argue in four pages of really fine verse about the former's fate. Finally, while Margaret is seen at the feet of Raphael, Mephistopheles claims his wager won; but an angel from the Prologue declares that Faust has been ennobled by a higher, holier love springing from his sin. During his speech "angels are seen bearing the soul of Faust upward toward Margaret." In the last two lines Mephistopheles says with almost touching patness and piety:

> Still to the same result I war with God:
> I will the evil, I achieve the good.

In the name of Life, what mockery is this? When the voice from above declares that Margaret is saved, we believe; because our own hearts had decided that she was no more guilty than a trampled flower; but what about Faust? Goethe tried, at any rate, to make him expiate his sin by service and suffering; bitter years of struggle and writhing upward preceded the end; even the angels admit the limitations of their saving power:

> Wer immer strebend, sich bemüht,
> Den können wir erlösen.

But in so far as the real action of the play goes, our new Faust is transported to heavenly joys after his moment of wild agony and self-reproach, which, for all the evidence before us, is much more likely to be the drunkard's morning misery than the dawning of a new spiritual day within his heart. It is as idle to put the assurance that he hastened his salvation on the authoritative lips of an accredited angel as it is to have it supported by the Devil; we are left absolutely unconvinced and rebellious. This man has chosen the easiest of preys; has dragged a maiden to a grave of shame; has been responsible for the murder of her mother, the drowning of her child, the death of her brother; and he shall be saved because of the nobility of her self-immolation, because of a bitter repentance enduring at least a moment and a grandiloquent declaration that still he fights upward and battles to the skies. It may be transcendent mastery of dramatic effect; it may be exalted emotion-mongering; but it is alien to the best spirit of the age in which we live, it is contrary to the eternal verities. Faust must live and suffer and serve his fellow-men. If the final solution is to be in heaven rather than on earth, if he is to find rest in the unfathomable grace of God, it must be after he has wrought some little alleviation in the groping misery of mankind. And this must be shown to us in the play, not merely left for our credence or divination.

IV

Over the historic question of the relative importance of plot and character we need delay only long enough to note that the great dramatist will make the two interpenetrate and fuse until they become one, and the question disappears. In this welding, I think, we must concede that Mr. Phillips has not betrayed a weak hand. As a matter of fact, it is a shade less difficult to bring about a satisfying union of plot and character if the author chooses to represent the figure we call Fate ever hanging over the stage than if he chooses to insist on the persistent but perishing distinction between tragedies of character and tragedies of Fate and endeavors to dispense with the appearance of this ultimate force.

Mr. Phillips has been true enough to his Greek training to elect in all frankness the former course and has thereby incurred the charge of putting only "wire-controlled" puppets upon the stage. To this charge the obvious answer is that they are no more "wire-controlled" than we are, who prate so soundingly about being masters of our fate. In criticism, as in everyday life, one must adopt a common-sense compromise between an academic freedom of the will and an ironbound determinism. If Francesca, who had just spread out her hands to the warm sun, could have wedded Paolo, they must still have known sorrow, for that is the lot of mortals; but their lives would have been different, to say the least, although they would have been just as truly subject to environment. And in his treatment of Herod Mr. Phillips seems deliberately to suggest his appreciation of the truth that drama must not be a mere study of character, but of the action of time and hap and place upon character fitted for other deeds; for in the purest of Greek irony our author has placed the following passage on the very verge of the catastrophe:

Herod. The towered world;
And we, we two, will grasp it, we will burst
Out of the East unto the setting sun.
Mariamne. Thou art a man.
Herod. With thee will be a god;
Now stand we on the hill in red sunrise.
Mariamne. Now hand in hand into the morning.
Herod. Ever
Upward and upward—ever hand in hand.

Here is the pity of it. This seems a living possibility, which Herod slays by the same stroke with which he slays Aristobulus; and whereas under conceivable circumstances he might have moved into the morning with Mariamne at his side, he is engulfed in a fearsome night, groping vainly for a vanished hand. And yet, even while we see this possibility, we understand that he could not have dwelt in the morning to the end; for his character and his fate were too closely allied.

In *The Sin of David*, on the other hand, one discovers a real weakness, inasmuch as there has been set forth absolutely nothing in Lisle's character or actions to prepare us for his instantaneous conception of a love that he was bound to regard as alike unhallowed and impossible. Here, certainly, plot and character have not been welded. The explanation is probably to be found in the change from David to Lisle, due to the interference of the English arbiter of dramatic morals. If David had been in question we should have been thoroughly prepared for his prompt surrender to his passion; but in the case of Lisle there is a distinct jar, and, since this is the turning point of the whole drama, the defect is a serious one.

In *Faust*, *Ulysses* and *Nero* the problem hardly presents itself; for in the two first named both plot and character are fixed in the hearer's mind before the curtain rises, and the third, as we have said, is essentially a character-study.

On the whole the major personages are adequately depicted. We have neither photographic realism on the one hand nor mere impressionistic adumbration on the other. Miriam, for instance, is a real woman, set before us in clear, essential portraiture, even if we are not told the color of her eyes. She is a daughter of France, born in the sun's lap, transferred to the drear fenland at her father's death and to the guardianship of the benumbing Puritan, who after wedding her without wooing "locks her spirit up and keeps the key." Her misery is faithful to the loathed yoke until the appearance of Lisle. Even after his coming she is willing to struggle; but the ruthless husband, confusing a diligent wife and quiet house with unnatural sacrifice and self-starvation, drives her to her fate. The very hour of surrender is "a deep inheriting, and as the solemn coming to a kingdom." In her new abode, this time a home, she is the spirit of motherhood. All that "wanders in her and is wild," having broken in one wave on Lisle, has been gathered up with all else that is in her to be poured out in love for her child and the father of her child. With the boy's taking off comes rebellion against the causeless theft and a prayer for heaven's ire sooner than heaven's indifference. This is followed by the thought that she is being punished for having rushed into Lisle's arms in headlong passion. Finally her husband confesses his crime, and the wracked heart rebels against his sin and her contagion; the body that wooed him to murder conceived her boy, adjudged to death before his birth. Her agony begets a gradual calm, the calm of hopelessness: "O I am stone to human life henceforth." In this mood she notes in her husband the eyes that shone from her dead boy's face, and Lisle grasps the opportunity to suggest that by the loss of their beloved they have paid the penalty of fleshly sin; that now may begin a marriage everlasting; whose sacrament shall be their deep and mutual wound, whose witnesses the shadowy throngs. Then the same woman we came to know in the first act, craving light and love, clasps the plea he offers and falls on the heart of the man who five years ago had led her from gloom to sunshine. But in the dreary fenland we met her and in a sort of spiritual fenland we bid her farewell; for we know that ever in her heart will be the cry: "I want the little hands and feet of him." About her in the future will flit irrecoverable dreams, with memory and repentance, never deep, confident happiness again. That the character of Lisle is adequately drawn few would maintain; but

Miriam attests that our author can depict a woman. A review of *Herod* would be still more convincing as to his ability to depict a man who is fitted to be a hero of tragedy. In the characters of Miriam and the Judaean king Mr. Phillips was less bound than in the major personages of his other plays, and his success with these must be remembered against his failures. Indeed as to this particular point one finds much encouragement in the Roman play; for the author's treatment of the emperor and of Agrippina shows a touch that is growing in skill, if not in strength.

In the minor characters it can hardly be maintained that he has achieved equal success, although Antinous in his insolence and splendor, Lucrezia with her thwarted woman thoughts, and Poppaea with the merciless calculation of her witching beauty stand forth to challenge any sweeping condemnation. The fact is that Mr. Phillips in his desire to avoid multiplicity of effect has deliberately minimized the importance of his minor personages and has depicted them accordingly, so that with the three characters named above to attest his power it would be thoroughly unsafe to decide that he will not achieve more satisfactory results in the future. That there is room for improvement should be frankly conceded; for our ideal tragedy, without sacrificing the stamp of perfect unity, may include a number of important personages strongly portrayed and contributing to the main action.

V

In entering upon the field of Mr. Phillips' language and verse we find fewest differences of opinion. It is true that an occasional line is dismally prosaic. For instance, in the new play, as a translation of "Schnell und unbegreiflich schnelle," said of the circling earth, we have "Swift, beyond understanding quite," probably because the line has to rhyme with "night," and in the earlier plays it has been easy for the reviewers to point out similar defects. We actually encounter one tall statement that he is "careless and slipshod in his literary methods"; but even the more acrimonious fault-finders concede the faint praise that he is a successful "phrase-maker."

And with that one word who shall quarrel? It is strange to find so often the pseudo-philosophical delusion that limpid language and glowing imagery and polished verse are a small part of poetic drama; yet from many of our critics one would be forced to conclude that these are non-essential trappings, and that Shakespeare, for instance, would still be Shakespeare if stripped thereof. In the nature of things, poetic drama cannot live without these three; for here, at least, the raiment is a part of the body and the more lustrous and luminous the raiment, the greater the body's vitality and beauty.

One criticism, however, is both pertinent and instructive: that he is greater as a poet than as a dramatist. Herein he seems to follow a long line of honorable predecessors from Aeschylus to Shakespeare; for the law of progress seems to be that tragic poets shall be poets before developing into great writers of tragedy. "Their lips must have power to sing before their hands have skill to paint or carve figures from life." In whatever points the author of *Marpessa* might fail when he advanced to the composition of tragedy, he could not fail to write poetry, and from the opening act of the Rimini drama to the closing speech in *Nero* our expectation is not disappointed. In *Faust* some of the translations fall short of our demands. The vigorous curse, for instance, lacks the spear-like penetrating power of the original, and the haunting spinning-wheel song sinks to verse like this:

> Gone is my peace, and with heart so sore
> I shall find it again nevermore.
> If he be not near me, the world is a grave
> And bitter as is the sea-wave.
>
> . . . .
>
> My bosom is aching for him alone—
> Might I make him my very own!
> Might I kiss but his lips till my mouth were fire,
> And then on his kisses expire!

On the whole, however, it would be fair to say that in the latest as in the earlier plays complete lucidity of meaning is expressed in varied beauty of language and verse. It is true that he is most successful in the lyric moments; but he is scarcely less effective in the moments which are otherwise highly impassioned, and his weakness is discovered only in the lighter portions of the dialogue. In other words, while he has not yet achieved complete mastery, he is weak where weakness is least fatal and strong where strength is most indispensable. This general conclusion as to his poetic diction is, I think, indisputable, so we need not bring forward any considerable number of illustrative excerpts. When a metrical passage makes itself a beautiful concomitant of one's thoughts on a great theme, it is safe to speak of it as high poetry, and what one of the readers of our plays will think of the passing of a young life from a sheltered haven to sorrow's sea without recalling such lines as these?

> And yet, Nita, and yet—can any tell
> How sorrow first doth come? Is there a step,
> A light step, or a dreamy drip of oars?
> Is there a stirring of leaves or ruffle of wings?
> For it seems to me that softly, without hand,
> Surely she touches me.

Or who will think of death's part in life without recalling the stimulating rejection by Ulysses of Calypso's offer of immortality?

> I would not take life but on terms of death,
> That sting in the wine of being, salt of its feast.
> To me what rapture on the ocean path
> Save in the white leap and the dance of doom?
> O death, thou hast a beckon to the brave,
> Thou last sea of the navigator, last
> Plunge of the diver, and last hunter's leap.

Again, there are few more poignant exclamations than this of Herod, when his dazed mind half grasps the possibility that there has been mischance to Mariamne:

> I'll re-create her out of endless yearning,
> And flesh shall cleave to bone, and blood shall run.
> Do I not know her, every vein? Can I
> Not imitate in furious ecstasy
> What God hath coldly made? I'll re-create
> My love with bone for bone, and vein for vein.
> The eyes, the eyes again, the hands, the hair,
> And that which I have made, O that shall love me.

In striking contrast to the brokenness of this cry stands Acte's flowing description of Poppaea, which will always be worth quoting once more on the theme of soul-less beauty:

> A woman without pity, beautiful.
> She makes the earth we tread on false, the heaven
> A merest mist, a vapour. Yet her face
> Is as the face of a child uplifted, pure;
> But plead with lightning rather than those eyes,
> Or earthquake rather than that gentle bosom
> Rising and falling near thy heart. Her voice
> Comes running on the ear as a rivulet;
> Yet if you hearken, you shall hear behind
> The breaking of a sea whose waves are souls
> That break upon a human-crying beach.
> Ever she smileth, yet hath never smiled,
> And in her lovely laughter is no joy.
> Yet hath none fairer strayed into the world
> Or wandered in more witchery through the air
> Since she who drew the dreaming keels of Greece
> After her over the Ionian foam.

In the foregoing, and more clearly in several other passages, one catches now and then an echo from some of the great teachers at whose feet our poet has sat in patient learning; but there is absolutely no sign of the mere copyist. Indeed, in this as in his dramatic structure and atmosphere, he represents exactly the laudable attitude described by Swinburne as "that faithful and fruitful discipleship of love with which the highest among workmen have naturally been always the first to study and the most earnest to follow the footsteps of their greatest predecessors." It would be well if this form of discipleship were more widely in vogue with aspiring dramatists, and the serious critic will be little inclined to speak harshly of this feature of our author's style.

VI

As to scenic presentment we need detain our reader only a moment. In the composition of the plays, as has been pointed out, Mr. Phillips wisely kept the actor and the spoken word constantly in mind. In fact, as eminent and kindly a critic of *Herod* as Mr. W. D. Howells said that in reading the play he had an uncomfortable sense as of the presence of a third party, which upon closer examination of his consciousness appeared to be the actor. That this becomes a real defect very few will be convinced. In any event, such a criticism leads us to expect that an author so attentive to the acted play would be strong in scenic presentment. This expectation Mr. Phillips unquestionably justifies. The Italian palazzo, the royal home of Odysseus—perhaps, as actually presented, adhering too faithfully to golden Mycenae to be quite accurate for gaunt Ithaca—the Judaean hall of audience and the imperial scenes at Rome offer a striking spectacle to the eye. The countless presentations of Goethe's *Faust* have naturally made it very easy to achieve stupendous and finished spectacular effects, and the devices in Mr. Phillips' new play at once recall and comply with the injunction of the director in the Prolog im Himmel:

> Drum schonet mir an diesem Tag
> Prospekte nicht und nicht Maschinen.

In *The Sin of David*, too, the original plan would have presented a staging akin to its fellows and fundamentally different from the final form. Throughout the plays, beautiful architecture, rich and tasteful robes, effective grouping of figures, and similar features appeal most winningly to the audience. Mr. Phillips had the initial advantage of a cultured taste and an actor's experience; but he had also the invaluable co-operation of two such masters of stage management as Mr. George Alexander and Mr. Beerbohm Tree, so that comment becomes rather superflouus. The stage effects are invariably as happy and brilliant as modern scenic art and long experience can make them. In truth, the danger is that they may be too successful, and I have fancied that a little of the weakness of *Nero* may be due to scenic temptation.

In passing we may recall that if Mr. Phillips has been fortunate in his stage managers, he has been not less fortunate in having the Benson school of actors to deliver some of his best blank verse. While poor staging may inflict a serious wound on a drama, poor acting deals the death blow, leaving only a corpse for the bookman to galvanize into a merely literary existence. A poetic drama must be well staged and well acted, or, in a certain sense, it remains poetry rather than drama.

VII

Herewith it would seem that this article must conclude without any serious foreboding; for the writer, while emphasizing certain defects, has admitted that Mr. Phillips can choose excellent dramatic material, that he can weave a strong plot, that he can make a character live, that he can write beautiful verse and that he is a thorough master of stagecraft. Manifestly little remains save apparently unimportant details; but it is exactly from these trifles that one's foreboding may spring. For instance, great tragedians have often used some such device as oracle, dream or prophecy to declare the future with unmistakable significance, and the dramatic effect is frequently strong, occasionally tremendous; but Mr. Phillips resorts thereto with dangerous freedom. In *Paolo and Francesca* we have the vaticinations of Angela and the reiterated warnings of Lucrezia; in *Ulysses* we have the decision of the Olympian council; in *Herod*, the prediction of the astrologer; in *The Sin of David*, it is the self-righteous prayer of Lisle after he condemns Joyce to death; in *Nero*, it is again an astrologer. Moreover, in addition to utilizing these more or less general predictions, Mr. Phillips fairly toys with the future at every turn. Thus he drops lurking suggestions such as we find in the avowal of Francesca:

> I have wept but on the pages of a book,
> And I have longed for sorrow of my own.

So Herod hints at his coming fate when he says:

> And I, if she were dead, I too would die,
> Or linger in the sunlight without life.

In the same category belongs the abrupt decision of Ulysses—

> I'd go down into hell, if hell led home!

Most striking instance of all, in an early part of *Faust*, where Valentine is parting from Margaret, he inserts the avowal:

> Beneath War's thunder skies where'er I go
> I'll think of thee the whitest flower of all.

This is followed by a toast drunk with his student friends: "Well then, here's to my sister Margaret; and he who has the worth to win her shall then toast the purest maid in our city." And examples could be multiplied without end. It must be admitted that this tossing about of the ball of the future is always employed skilfully, even artistically; but its constant recurrence in six consecutive plays is not without disturbing significance.

Still more minute points give rise to thought, as the repeated sympathy of atmospheric conditions with the psychological situation, or the fact that Marpessa, Francesca, and Miriam are obviously created by the same hand. Again, Giovanni speaks of a second wedding when Paolo and Francesca are united in death, and Lisle speaks of a second wedding when he and Miriam are reunited after their punishment. One may concede unhesitatingly the non-essentiality of most of these points and still feel that they are discomforting. Inexhaustibility is a large part of the difference between talent and genius, and inexhaustibility is exactly what these detailed considerations do not suggest. That they afford ground for anything more substantial than a foreboding, few would care to maintain; but from the foreboding I, for one, cannot escape. Furthermore, it is disquieting to recall that his earliest play is decidedly his best, even if there are signs of improvement in particular phases. Nor can the failure to essay a new *Faust*, instead of acquiescing in an adaptation, increase the hopefulness of his admirers. That Mr. Phillips has never gone into novel fields for his subjects need not concern us. An author may produce immortal works without seeking the glaringly new or startlingly strange, as Greek tragedy alone would prove; but in each new treatment of an old theme we have a right to expect some profound criticism of life, some lifting of a tiny corner of the great veil. Howbeit, my fears are at bitter war with my hopes; for the future of Mr. Phillips is of real moment for poetic drama, perhaps the highest form of literature.

Since the above was written Mr. Phillips has published *Pietro of Siena*, and my forebodings have been made much more keen and definite. The new play seems to me to be so inferior to the greater of his previous dramas that I do not think I should be justified in asking the reader to follow me in a criticism thereof. But it does not invalidate any of the conclusions I have drawn as to the merits of its stronger predecessors. Let us hope he is only nodding, albeit the nodding that is prolonged through a whole play is decidedly alarming.

SOME CONSIDERATIONS ON MODERN SPANISH FICTION

By S. Griswold Morley

It is a fact that the novels produced in Spain within the last forty years are not well known in America, or even in the rest of Europe, except to specialists, despite the respectable quantity and undeniable quality of the work. French novels seem to have a faculty of penetration frequently out of all proportion to their intrinsic value. It is due in part to the towering position held by France in the intellectual world, and partly to the tendency of French writers to develop in the field of fiction whatever current of thought chances to sweep across Europe at a given moment. Spain, hiding behind the Pyrenees, is wont to meditate her own concerns at leisure, and evolve her own conceptions of art and life. The provinciality which forms at once the barrier and the charm of Spanish letters shuts many from almost unlimited enjoyment. Just as the drama of the seventeenth century in Spain can furnish one interesting reading matter for half a lifetime, so the recent Spanish novel, voluminous and entertaining, can in case of need fill up the other half. Pérez Galdós alone, with forty *Episodios nacionales* and more than forty other novels, could occupy one's mind for a long time, and not much of the pabulum would be mediocre, if not much would be absolutely of the first rank. Spain has only resumed an activity in fiction which was broken off at about 1650.

The novel and the drama are the two branches of literature in which Spain has always excelled. She has never produced a pre-eminent philosopher, essayist or mathematician. In lyric poetry she holds a better place, yet the average student of general literature cannot recall the name of a single Castilian poet. Spain has no Dante nor Milton nor Goethe nor Hugo. Her inferiority is implied when one speaks of the charming poet Bécquer as a Spanish Heine, or of Espronceda as a Spanish Byron. Great original geniuses do not suggest the name of some other genius. Cervantes and Calderón, the two Castilians whose reputation is world-wide, represent the novel and the drama.

In the days when the Spanish monarchy was the greatest of world-powers, there were likewise two divisions of the novel in which Spain set the fashion for the world:[1] the romance of chivalry and the picaresque tale, or "romance of roguery." Amadís of Gaul (or "of Wales," as it seems this hero should be called), who was the prototype of wandering cavaliers, issued from darkness somewhere in the fourteenth century. His innumerable progeny reached down to the time of Don Quijote, at once the perpetuator and the queller of all knights errant. The other and parallel current of fiction was equally old. That mischievous cleric, the Archpriest of Hita, writing about 1350, created characters similar to some later rogues of literature. The famous novel in dialogue form, known as the *Comedia de Calisto y Melibea*, published about 1500, contains picaresque elements of great force. Then came the first real novel of low life, *La Vida de Lazarillo de Tormes* (*ca.* 1550), followed by Mateo Alemán's *Guzmán de Alfarache*, and numerous other romances of the same class. Cervantes, who was interested in all strata of society, wrote some frankly picaresque short stories besides his long novels.

The first half of the seventeenth century saw the publication of a great many *novelas*, called *ejemplares*, after the fashion of Cervantes, and usually anything but exemplary in contents. After that there was a gap of 150 years before Spain again entered the field of the novel. The entire eighteenth century is barren of prose fiction, at least of examples sufficiently important to find their way into the histories of literature. With the exception of this gap the Spanish novel has a history stretching from the Middle Ages to the twentieth century, and it displays few foreign elements. Almost all its valuable characteristics are native to Spain.

In France a wholly different condition will be found. Notwithstanding the high reputation that the French novel enjoys, it appears upon analysis to be the offspring of European currents of thought, or, in many cases, of direct foreign influence. The continuous devel-

[1] The pastoral flourished also for about 100 years, but it originated in Italy.

opment so evident in Spain is wholly lacking. The short stories of the Middle Ages were in verse (*fableaux*) and represented fairly the *esprit gaulois*. Bonaventure des Périers and Rabelais continued the tradition; but it was soon interrupted. The *Heptameron* of Marguerite de Navarre (1558) is derived from Boccaccio. In the seventeenth century various foreign currents flow side by side. D'Urfé's *Astrée* (1607–27) comes from the Italian pastorals; the interminable novels of Mlle. de Scudéry twine the same strand with that of the Spanish romances of chivalry. Sorel and Furetière, Scarron and Lesage recall in greater or less degree the picaresque tales. Mme. de la Fayette, Marivaux and Voltaire wrote some admirable fiction, containing touches of realism and of psychology, but not representing a continuous development.

In like manner, the French novels of the nineteenth century, famous as they are and brilliant in many ways, exemplify a tendency to take up a European theory or current of feeling and develop it to a high degree, without sufficient consideration of the fitness of its application to the particular case. Blind logic is a trait of French character which has often been pointed out, usually in contrast to the practical, unsystematic English habit of mind. The French themselves call it "la raison raisonnante," and recognize in it the cause of the artificial restrictions of their pseudo-classic drama as well as of the excesses of the French Revolution. So, the romantic novel of Chateaubriand and Hugo was merely one offshoot of a general movement in Europe, a movement that produced more valuable results in other forms of literature, as far as France is concerned. The genius of Stendhal and Balzac raised the novel to a plane of permanent value, but it soon slipped back into another rut worse than the preceding. Naturalism, the result of scientific methods more or less unskilfully applied to art, has cast a veil of sordid commonplaceness over much of the work of Flaubert, Zola, Daudet and Maupassant, notwithstanding the keen sense of form which inspires the work of the first and last. Zola carried the system to an extreme from which there was an inevitable reaction. The two important novelists of the present day, Pierre Loti and Anatole France, are intimate and personal writers who find their inspiration in their own hearts and who certainly are not easily to be imitated.

In Spain the history of the novel in recent times is wholly different. Those writers who have been most successful have paid little attention to the passing fashions of the day, but have followed the old and time-honored traditions of Spanish literature. The romantic movement spent its force mainly in lyric poetry and the drama; the novel of the time was bulky, as were most romantic productions, but almost negligible in quality. The real beginnings of the modern Spanish novel are found in a wholly different direction, in the descriptions of local customs; and this in turn originated in the regional pride which has always been and is so strong a trait of Spanish character. Fernán Caballero and Estébanez Calderón displayed their affection for their native Andalusia by writing about the manners of its rural inhabitants, a thing that Cervantes had done before them. Mesonero Romanos and Larra portrayed the ways of Madrid. These writers (though Fernán Caballero persistently attempted the novel) were hardly more than literary genre painters. Later men and women employed a larger canvas for more dramatic recitals. José María de Pereda, the *montañés*, still is more intent upon his native land than upon his stories. His novels (*Don Gonzalo González de la Gonzalera*, *Sotileza*, *Peñas arriba*) are hardly more than expanded *escenas montañesas*, detailing, now enthusiastically, now with frank pessimism, the local habits of his countrymen in the mountainous region back of the northern coast city, Santander, which was his home. The Galician lady, Emilia Pardo Bazán, won fame with accounts of that northwest corner of the Iberian Peninsula, Galicia, with its soft wooded hills, green vales and all-pervading melancholy. Armando Palacio Valdés is more than a painter—he creates character; but the background of his novels is always clearly defined and based upon careful and loving study of the different parts of Spain. More than half his novels (*Marta y María*, *el idilio de un enfermo*, *el cuarto poder*, *la aldea perdida*, etc.) center about the Asturian district which was his home. But his sympathy is wide, and some of his best works display unequaled insight into the manners of other parts of

Spain (*la hermana San Sulpicio*, Seville; *los majos de Cádiz*, Cadiz; *la alegría del capitán Ribot*, Valencia). Blasco Ibáñez, the foremost writer of the moment, was born in the charming *huerta* of Valencia, and he has always dwelt with delight upon the customs which he observed in boyhood (*Arroz y tartana, Cuentos valencianos, la Barraca*). His realism was sometimes modeled too closely after Zola, and latterly he has strayed a little after political gods; but his best is extremely good. In the galaxy of remarkable novelists whom Spain has produced within the last forty years, Pérez Galdós alone cannot be called regional. A born story-teller, a militant progressive, his novels cover a wide range of history, social problems and eccentricities of character; but he is not the product of any school.

Might it not be that the Spanish novels, having their roots deep in national character and tradition, will outlast the school productions of France? The literary history of the past teaches that oblivion loves books manufactured according to a theory almost as well as it does occasional poetry. At least nine-tenths of Zola is dead already; Flaubert's impeccable workmanship hardly suffices to counterbalance his lack of spontaneity. Even Balzac, that creative giant, carries an inconceivable weight of dross upon his shoulders. Personally, I feel that Pérez Galdós and Palacio Valdés and Blasco Ibáñez at their best can be placed beside the famous French novelists without suffering in the comparison. If their technique never attains the extreme Gallic perfection, their matter is saner and in better taste, since it does not spring from a preconceived theory of dubious value.

In the field of the short story alone, the French show undoubted superiority. There have been numerous collections of Spanish short stories placed on the market for school use within recent years, and one who reads them cannot but be impressed by the unevenness of their material. A few numbers possess high literary merit; but in order to round out the required sum of pages the editors have included stories so weak that it is impossible to imagine their being admitted to a similar French collection. Spain has not yet given birth to any distinctive short story writers equal to Mérimée, Gautier and de Maupassant.

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BACTERIOLOGICAL STUDIES OF MILK SUPPLIES OF BOULDER, COLORADO[1]

FIRST PRELIMINARY REPORT[2]

By Clough Turrill Burnett

I have on many occasions been questioned regarding the purity of Boulder's milk supply, so often, in fact, that it has seemed advisable to make a rather careful investigation of the milk as delivered by the various wagons and milk depots. This work was begun without any idea of making an extensive report and such a report[3] is impossible at the present time.

The examinations cited extend over a period of eighteen months, comprising two sets of examinations during the summer months and one set made in the winter of 1909 and 1910. In all cases the milk was obtained as nearly under normal conditions as possible. If the sample was from a wagon it was rushed to the laboratory immediately on delivery and examination begun at once.

Twenty-one samples were studied up to September 1, 1910. Of these, examination was begun on two, two hours after milking, on one, four hours after milking, on thirteen, five hours after milking, on two, seven hours after milking, on two, eight hours after milking, and on one, fourteen hours after milking. In each case this was the earliest time under existing conditions that the consumer could use the milk. That is, in the thirteen samples examined five hours after milking, these milks used were not available until that time; and no matter what the bacterial count may have been immediately after milking, if it was high when delivered, the milk should be condemned or looked upon with suspicion.

Immediately on being received at the laboratory the milk, after proper cleansing of the mouth of the bottle, was poured into two sterile

[1] From the Laboratory of Bacteriology, University of Colorado.

[2] Read before the University Scientific Society, February 27, 1911.

[3] A careful study of the dairy situation in Boulder is in progress, the work being carried on by a student in the Graduate School.

Ehrlenmeyer flasks of 300 c.c. capacity. In seven examinations one of these flasks was left at 17 degrees C. In the remaining fourteen one was kept on ice and one at room temperature. Plate cultures were made by placing in Petri dishes definite quantities of the milk to be examined, and then there was poured into the Petri dishes melted nutrient agar and this mixed thoroughly with the milk or milk dilutions. The first plates and reaction determinations could be made from either of the flasks. All later work was carried out complete from each flask. In every case the reaction was determined to phenolphthalein.

In six of the samples only one set of plates was made using dilutions of 1/10 c.c. to 1/1000 c.c., according to the age of the milk. All of these plates were incubated at 18 to 20 degrees C., which is considered the average room temperature. Following this first set, plates were made the following evening and then morning and evening until the milk loppered, in each subsequent plating increasing the dilution[1] by ten to one hundred times. These plates were incubated in the same manner. After twenty-four to forty-eight hours, according to the rapidity of the growth, each plate was counted and an average taken.

In the last ten samples examined, plates were made from the flask at room temperature and from that in the ice-box. The reaction was taken from each. Also determinations for butter fat and for the presence of formaldehyde and boric acid were made in each case. By means of this method of examination not only the number of germs in the milk when first received was determined, but also, to some extent, the kind of germs and the time limit these germs place on each milk for its desirability as food. For instance, we find two milks when received (five hours after milking) to have approximately the same number of germs. Later, one is found to have 1,617,200 germs in one cubic centimeter, while the other, two hours later than this, has 10,405,500 germs per cubic centimeter. The reaction of the first milk did not change from that when received, namely 10°. Un-

[1] This work was done under my direction by Mr. Charles F. Poe. The data obtained will be used by Mr. Poe in a more exhaustive report to appear later as a thesis for a Master's degree.

fortunately, in the second reaction notation was destroyed by acid getting on the sheet of notes. However, the reaction jumped in twenty-four hours to 68°, at which time the milk was loppered, so that we may presume that in eleven hours (the time the second plates were made) the reaction was far above that when first taken. The study of these two samples alone will demonstrate that the count is not always the final determining factor, but that the kind of germ must play a very important part in establishing an arbitrary standard.

A brief résumé of the results of each examination will be presented and then comparisons drawn. The work on the first eleven samples was not as extensive as on those done later, but, so far as carried out, was accurate.

Sample No. 1. Producer No. 1. This sample was obtained in the summer. The count when received five hours after milking was 210,064. This milk did not change rapidly in the succeeding hours if kept on ice, but loppered in twenty-four hours at ordinary room temperature.

Sample No. 2. Producer No. 1. This sample was obtained in the summer. The count when received five and one-half hours after milking was 1,604,120. The reaction then was 25° acid. At the end of twenty-nine and one-half hours at 17° C. this rose to 46° acid with a count of 9,700,000.

Sample No. 3. Producer No. 2. This milk was from a private cow furnishing only one family. The sample was taken in the summer. The count when received, two hours after milking, was 35 germs per cubic centimeter, nine hours after milking it was 1,300, and at the end of 128 hours on ice it was only 24° acid. A flask of milk kept at room temperature for twenty-six hours was only 21° acid and did not lopper until fifty-seven hours. Compare this with the initial high acid and count of sample No. 2.

Sample No. 4. Producer No. 2. This is from the same source as Sample No. 3. The sample was taken in the winter. The initial count one hour after milking was 51 per cubic centimeter. In seven and one-half hours it was only 1,600 and the milk did not lopper at room temperature until seventy-four hours. Kept on ice the reaction only changed from 15° to 21° in seventy-four hours. There was 4.8 per cent butter fat.

Sample No. 5. Producer No. 14. This milk was from a licensed dairy, and was obtained in the winter. The bacterial count of this milk when received eight hours after milking was 71,080. This milk loppered thirty-eight hours after milking, or thirty hours after received, when kept at room temperature. The sample kept on ice was still sweet and wholesome at this time. Butter fat 3.9 per cent.

Sample No. 6. Producer No. 1. This was from the same dairy as Nos. 1 and 2, and was obtained in the winter. When received, five and one-half hours after milking, the bacterial count was 447. Please compare this with the preceding sample from the same dairy. Kept at room temperature this did not lopper until ninety hours after milking. The sample kept on ice was still sweet. Butter fat 3.9 per cent.

Sample No. 7. Producer No. 3. This was from a semi-private dairy. This dairy is not licensed but delivers milk to thirty-five families. This milk when received in December, five hours after milking, showed a count of 1,140 germs. Kept at room temperature this loppered in thirty-eight hours. That portion kept on ice was still sweet. Butter fat 4.8 per cent.

Sample No. 8. Source unknown. Presumably from a private cow. The milk when received, five hours after milking, in December, showed a bacterial count of 674. This milk kept at room temperature did not lopper until ninety-five hours, and the portion kept on ice was only a little above the initial acidity at this time.

Sample No. 9. Producer No. 5. This is from a licensed dairy, and was obtained in January. The count when received four hours after milking was 17,457. This did not lopper until 107 hours after milking when kept at room temperature. That kept on ice was still sweet.

Sample No. 10. Producer No. 6. This is from a licensed dairy. The milk when first received in the winter, six hours after milking, had a germ content of only 23,828. This milk loppered in sixty hours at room temperature. That kept on ice was perfectly wholesome at this time.

Sample No. 11. Producer No. 7. This is from a licensed dairy. This sample was taken in the summer (August 18) but still showed a reasonably low count. When received, five and one-half hours after milking, the count was 49,086. This milk loppered in ninety-seven hours at room temperature. The portion kept on ice showed a slight change only at this time.

Sample No. 12. Producer No. 8. This is from a licensed dairy. The sample was taken in the summer, and when received, eight hours after milking, the count was 175,300. In spite of the comparatively high initial count this milk did not sour early, but only loppered in 148 hours at room temperature. This would suggest the addition of some preservative, although tests for formaldehyde and boric acid were negative. I shall point out later another cause for this high count without a subsequent increase in acidity. Butter fat 3.6 per cent.

Sample No. 13. Producer No. 9. This was from a licensed dairy. The sample was taken in the summer, and, when examined five hours after milking, the count was 100,330. This milk loppered in twenty-nine hours at room temperature, but had not loppered 125 hours after milking when kept on ice. This will suggest the need of keeping the milk cold before and after being received by the consumer. Butter fat 3.1 per cent.

Sample No. 14. Producer No. 6. This is milk from the same dairy as No. 10. I may say in passing that this dairy perhaps lays the greatest claims to care in the handling of milk of any of Boulder's dairies. Later I will point out how flagrant an offender this dairy is. This sample was taken in the summer and examination begun when received, five hours after milking, and yet the count showed 2,790,000 germs. This milk loppered at room temperature in twenty-eight hours. Kept on ice this milk did not lopper for 146 hours. Butter fat 3.6 per cent.

Sample No. 15. Producer No. 1. This milk is from a licensed dairy. The sample was taken in the summer and five hours after milking showed a count of 158,200. This loppered in twenty-eight hours at room temperature, and in 172 hours on ice. Butter fat 3 per cent.

Sample No. 16. Producer No. 11. This milk is from a licensed dairy. When received in the original bottle this milk looked as if it had stood over night. The driver refused to state the time of milking. The count when it was received was 947,300. Butter fat 3.1 per cent. This milk loppered in twenty-eight hours at room temperature and 120 hours on ice.

Sample No. 17. Producer No. 12. This is from a licensed dairy. When received in the summer, five hours after milking, the count was 337,060. This loppered in twenty-eight hours at room temperature and 196 hours on ice. Butter fat 2.9 per cent.

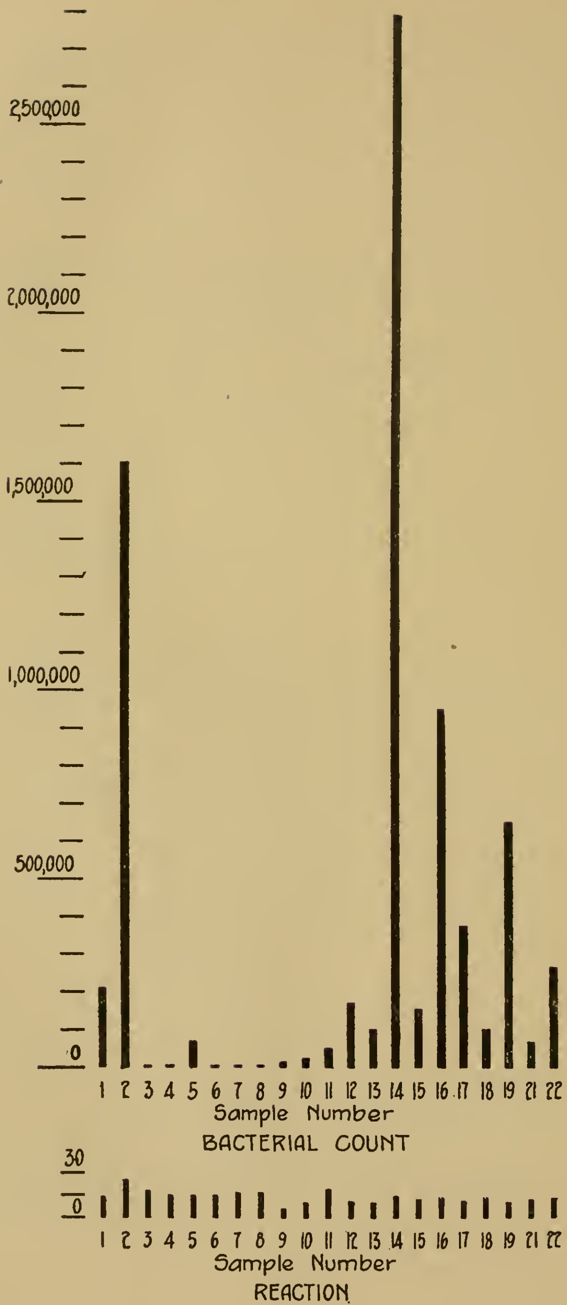
Sample No. 18. Producer No. 14. This is from a licensed producer. When received in the summer, five hours after milking, the count was 100,000. Kept at room temperature this loppered in twenty-eight hours, but the sample kept on ice did not show any appreciable change for 148 hours, or six days, and did not lopper until 244 hours, or ten days. Butter fat 3.1 per cent.

Sample No. 19. Producer No. 13. This is from a licensed dairy. The sample was taken in the summer. The initial count five hours after milking was 651,000. This loppered in twenty-nine hours at room temperature. The sample on ice was lost, so the time of loppering could not be determined. Butter fat 2.8 per cent.

Sample No. 21. Producer No. 14. This is from a licensed dairy. This was taken in the summer and when examined, seven hours after milking, showed a bacterial count of 70,000. Kept at room temperature this loppered in twenty-nine hours—on ice in 172 hours. The butter fat was 3.1 per cent.

Sample No. 22. This is from the same dairy as No. 21. This milk was delivered at 8:00 P.M. and was kept on ice and plated early in the morning, fourteen hours after milking, in order to determine the number of germs at the time the milk could probably first be used. The count was 266,600. After the first fourteen hours the milk was divided and one portion kept on ice and one at room temperature. The portion kept at room temperature loppered thirty-seven hours after milking, or twenty-four hours after exposure to room temperature. The portion kept on ice loppered in 133 hours. Butter fat was 3.6 per cent.

CHART No I



2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22
Sample Number
BACTERIAL COUNT
30
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22
Sample Number
REACTION

A graphic representation of these bacterial counts together with the reactions is found in Chart I. Nine samples of the twenty-one are found to exceed 150,000 germs per cubic centimeter. Twelve of the twenty-one are not above 100,000 germs per cubic centimeter. One is at once struck with the great difference between some of these samples and others. We may ask why the Sample No. 11 should be so low in bacterial count and Nos. 2, 14, 16, 17 and 19 should be so high. All of these are from licensed producers and all are taken in the summer.

From our knowledge of the means of contamination of milk it is safe to assume that some of these milks have not been properly handled. This chart disclosed another interesting fact. If a comparison is made between the height of the bacterial content column and the reaction column in each sample one sees that the reaction taken in the early hours after milking will seldom give any clue to the desirability of the milk as a food. For instance, No. 14 shows a lower acidity than No. 6, and yet No. 14 shows a germ content of 2,790,000, and No. 6 only 447. This is due to the fact that many of these germs cause the formation of alkali, and especially in the early hours. Later the germs of the lactic acid class predominate and finally cause acid formation and curdling of the milk. We now know there are many worse things that may occur to milk than souring, for many of these germs which produce alkalies form highly poisonous compounds.

CHART II

Samples of Milk Showing an Initial Count of 100,000 or Less

Producer No.	Sample No.	Summer*	Winter*	Reaction	Hours after Milking	Butter Fat: Percentage
7	XI	49,086	......	...	5½	...
2	III	35	......	...	2	5.1
2	IV	......	51	...	1	4.8
4	VIII	......	674	...	5	...
14	V	......	71,080	...	8	3.9
14	XVIII	100,000	......	13	5	3.1
14	XXI	70,000	......	12	7	3.1
1	VI	......	447	...	5½	...
3	VII	......	1,140	...	5	4.8
5	IX	......	17,457	...	4	...
9	XIII	100,330	......	10	5	3.1
6	X	......	23,828	...	6	...

* Bacteria per cubic centimeter.

A study of Chart II will show that twelve of the twenty-two samples showed a bacterial count of 100,000 or less when first received. Of these twelve samples five were received during the summer months and seven during the winter months. Of these five summer samples we find an average of 63,890, and of the seven winter samples an average of 16,382. If we omit the counts of samples III, IV and VIII, all of which are from private unlicensed producers, and average only the licensed producers, we find the average of the summer samples to be 79,854, and of the winter 28,203.

CHART III

SAMPLES SHOWING AN INITIAL COUNT OF OVER 100,000

Producer No.	Sample No.	Summer	Winter	Acid	Hours after Milking	Butter Fat: Percentage
1	I	210,064	...	..	5	...
1	II	1,604,120	...	..	5½	...
14	XXII	266,600	...	13	14 (ice)	3.6
13	XIX	651,000	...	10	4½	2.8
6	XIV	2,790,000	...	14	5	3.6
10	XV	158,200	...	12	5	3
11	XVI	947,300	...	13	5	3.1
8	XII	175,300	...	11	8	3.6
12	XVII	377,060	...	11	4½	2.9
		Average 797,738				

Turning now to Chart III we find there are none of these twenty-two samples which showed an initial count of over 100,000. All of these were made during the summer months, and all were from licensed producers. The general average is 797,738.

In Chart IV, I have not only placed the initial counts of the last ten samples but also the number of germs found in these milks in the afternoon or evening of the same day. This will give us an idea of what kind of milk we may expect to have for the evening meal, or worse still, for the baby's evening nursing, under present conditions. Not only that, but this chart shows what kind of milk the well-to-do, who can afford ice, may have, and also what the poor, who cannot afford ice, will have. I take it that it is reasonable to expect a milk to be wholesome at least during the day it is received. While there may be some difference of opinion as to whether 200,000 to 400,000 germs per cubic centimeter at that time is at all detrimental, I believe all who are informed on the subject will agree with me that 4,390,000, as found in No. XIV, and 4,782,600, as found in No. XVI, is too high a count when that milk has been packed in ice all the time. Then when we note that those samples showed 57,666,000 germs per cubic centimeter and 59,546,000 germs per cubic centimeter respectively in the evening of the same first day when not kept on ice, we can appreciate why there is such a high mortality among the children of the poor.

CHART IV

Producer No.	Sample No.	Initial Count		Second Plating Flask on Ice		Second Plating Flask Kept at Room Temperature	
		*		*		*	
8	XII	8	176,300	16	279,500	16	22,950,000
9	XIII	5	100,330	14	359,733	14	1,617,200
6	XIV	5	2,790,000	14	4,390,000	14	57,666,000
10	XV	5	158,200	14	895,000	14	2,985,000
11	XVI	5	947,300	14	4,782,600	14	59,546,000
12	XVII	5	377,060	16	1,798,000	16	16,620,000
14	XVIII	5	100,000	17	1,319,000	17	10,405,500
13	XIX	5	651,000	14	1,165,750	14	24,460,000
14	XXI	7	70,000	15	456,000	15	1,110,300
14	XXII	14	266,600	24	1,572,800	24	44,050,000

* The numbers in these columns refer to *hours after milking*.

There are some apparent discrepancies in this chart—for instance, Sample No. XVIII, which showed an initial count of only 100,000, jumped up to 1,319,000 in seventeen hours when kept on ice, and to 10,405,500 at room temperature, while No. XV, with an initial count of 158,200, in fourteen hours increased to only 895,000 on ice, and to only 2,985,000 at room temperature.

This may be explained in this way: In the early hours of the decomposition of milk there are found predominating certain kinds of germs which produce certain by-products which either inhibit or accelerate the growth of the germs of the lactic acid group. If these germs first on the scene happen to produce a large amount of substance tending to accelerate the lactic acid bacilli, we are likely to note in the second ten hours a very rapid increase of germs—especially of the lactic acid type. This interdependence of germs of entirely different characteristics is known as microbic association or, in this instance, as the associative action of bacteria in milk.

Let us consider these various samples of milk from the standpoint of a food for infant feeding. It is generally accepted that such a milk should not show a greater number of germs per cubic centimeter than 10,000. A perusal of Chart I will show that only five of the twenty-one samples show a count under 10,000. Of these No. 3 and No. 4 are from a private cow. The milk was drawn into a thoroughly clean jar and every means of prevention of contamination was observed. No. 6 was from a general dairy, and throughout showed a remarkably clean milk. No. 7 is from a private dairy furnishing thirty-five families. This milk is poured into pails at the producer's house and delivered in those pails to the consumer. No. 8 showed a low initial count with high acidity and loppered quickly, a circumstance which leads me to think it was dirty milk which was pasteurized after the germs had developed, which would give a low count and high acid reaction. This milk could hardly be recommended raw for infant feeding. This leaves then only four milks of the twenty-one examined, or only three of eleven different dairies, which could be used unpasteurized for infant or invalid feeding. Such a condition of affairs, of course, would not be bad for a city where of necessity there must be a time interval of a good many hours between the milking and delivery to the consumer. In a small town like Boulder, however, such a time interval is not necessary. Now let us consider these milks from the standpoint of the general consumer—not necessarily for infant or invalid feeding.

Some cities have adopted an arbitrary standard. I wrote to the Health Department of about thirty cities of varying sizes to determine what, if any, was the standard accepted as fair and reasonable for such a city. I found that in ten of these cities such a standard had been adopted and Chart V shows the standards and the population of each place. These cities require that any milk sold within their boundaries shall not exceed a certain number of germs. For Boston the number is 500,000, for Rochester 100,000. In each case this limit is the maximum limit. They do not say that the milk is fit for infants and invalids, but have another standard for such milk and call that milk certified milk. Now naturally we might assume that, under conditions as found in and about Boulder, with its oft proclaimed pure air, the counts should all come well within 100,000—the limit set for Rochester, a city of 218,000 population. Yet a perusal of Chart I will show that only twelve of the twenty-one come within this, and furthermore, of these twelve only five were made during the summer months, the other seven being made during December and January. There is quite a strong possibility that some of the seven made in the winter might not have made a good showing during the summer months.

CHART V

City	Population	Bacterial Standard	Certified Standard
Boston	670,585	500,000 per c.c.	Less than 10,000
Buffalo	423,715	500,000	
Rochester	218,000	100,000. If above, will be investigated and censured	10,000
Salt Lake City	93,000	500,000. May adopt standard of 100,000 from October to April and 250,000 from April to October	
Fort Wayne	63,996	500,000. Not enforced	
Kalamazoo	40,000	200,000	
Lansing	32,000	100,000 standard suggested	10,000
Madison	25,000	500,000 for milk, and 800,000 for cream	
Boise, Idaho	25,000	100,000	
Reno	11,000	500,000. Will decrease	

Colorado Springs has established no arbitrary standard, yet a good milk is considered to be one containing under 100,000 bacteria per cubic centimeter, with certified milk 10,000 per cubic centimeter in winter and 20,000 in summer.

Most of the samples taken during the winter show a reasonably wholesome milk from the bacterial standpoint. This suggests that the trouble may be in neglect in proper cooling of the milk during the warm months, for it is well known that unless the milk is rapidly and sufficiently cooled, very soon after milking, the filth bacteria which have entered at this time will reproduce to an enormous extent.

Another source of contamination here in Boulder is the failure to comply with the ordinance requiring the sterilization of every bottle in which milk is sold or delivered. The dairy from which samples Nos. 10 and 14 were obtained is known to disregard this rule quite constantly. The following is a fair example: On one occasion I returned a bottle to this milk depot asking for a pint, or a quart, of milk or cream, as the case may be. The boy took the bottle which I had just brought in from a dusty street, and filled it from a can. I objected—much to his surprise. When I offered sufficient objection, he poured the milk back into the can, and held the bottle under a cold-water faucet and rinsed it a little, then refilled it from the same can. I again objected, and finally got a bottle which he said had been sterilized and had it filled from another can. I followed this up merely as a test, for the bottle he claimed was sterilized was taken from beneath the counter, and I have no reason to believe the second can was any better than the first. These are details which are very important and very easy to comply with if there is the spirit of compliance.

Another instance along the same line: One of the faculty ladies saw a milkman filling bottles in the street from a can. She had just seen him taking empty bottles from an adjoining house. How many of us wish to receive milk in bottles which may have just come from a tuberculous case before they are sterilized? I myself object.

In several conversations with the City Milk Inspector of the period during which these determinations were made, this gentleman deplored the fact that he was not equipped to make bacteriological examinations of the various products entering Boulder, but he assured me that "whenever he had reason to suspicion anyone" he got a sample and had it examined for butter fat. Now Boulder places the very low minimum limit of 3½ per cent butter fat, yet Charts II and III will show that, of fourteen determinations made, seven—or one-half—were less than 3½ per cent. This would seem to indicate that the city is not doing much to protect its milk supply when so simple a thing as the Babcock test for butter fat is not carried out often enough to eliminate these low-grade milks.

It is not considered necessary in this paper to point out the means of eliminating filth, which would at the same time eliminate practically all of this excessive number of bacteria found in some of these samples. Most producers of milk and creameries have been instructed in these methods. What we do need, however, is sufficient machinery of the city government to enforce the thirty sections of "An Ordinance in Relation to the Production, Sale, and Disposal of Milk and Milk Products within the City of Boulder." As in most every other department of civic improvement, we need not more laws, but enforcement of those already enacted.

Many of these dairies are delivering a wholesome product. A few are very delinquent. It seems to me that in order to protect those who would give us the best, we should compel the others to meet the same standard or get out of business.

Just now in the cold weather there is probably no great danger, but with the advent of the hot weather will appear the infant diseases caused by filthy milk. Would it not be better to prevent at least a part of this by compelling the dealers to furnish to the citizens of Boulder a clean, wholesome milk? And this can only be accomplished by proper inspection.

I have not so far suggested what should be the standard for Boulder; at present I am inclined to believe that a standard of not more than 100,000 germs per cubic centimeter from May 1 to November 1 and not more than 75,000 germs per cubic centimeter from November 1 to May 1 would be reasonable.[1]

As soon as one suggests better conditions for the production and handling of milk, a cry goes up of the increased expense. We pay 8 cents a quart for a comparatively low-grade milk, but for a few exceptions. A study of many well-equipped dairies, which are managed so as to produce the greatest returns, will show the fallacy of this idea. A striking illustration may be found reported in *Hoard's Dairyman*, November 18, 1910. A dairy in Wisconsin markets milk in Chicago, 100 miles away. The bacterial count is less than 2,000 per cubic

[1] Mr. Poe of the Graduate School is carrying out more extensive work along this line, and will independently suggest a standard as a part of a thesis which he will present in June.

centimeter, in many instances less than 1,000. The milk is sold in bottles at the farm at 6 cents a quart, and returns a fair profit on the investment. This dairy has thirty cows, and produces 250 quarts a day. "It has been fitted up with the equipment and supplies of a modern sanitary dairy—cement floors, stalls, and stanchions; water supply, washing and sterilizing machines, bottles, bottling machine, cooling apparatus, pails, cans, etc., for less than $1,650."

I am not informed as to the estimated cost of delivery of a quart of milk in Boulder, but it would hardly exceed 2 cents. Yet this producer can deliver high-grade milk at the same price that a producer here, having approximately the same number of cattle, furnishes us with anything from a medium to a low-grade article.

In this report I am not able to present the records of an examination of the milk of every dairy furnishing milk to the citizens of Boulder. I have, in some cases, purposely made two or more examinations of milk from the same source as a means of control. In all, twenty-one samples have been examined from fourteen different sources, which I believe is enough to warrant at least a preliminary opinion.

In conclusion, I believe that many of the dairymen of Boulder are earnestly endeavoring to furnish their consumers with a wholesome milk. There are also a few who seemingly disregard all right of their customers to a pure, wholesome product. I believe these should be forced to conform to a standard which the more progressive have demonstrated is possible and reasonable in Boulder. This can only be brought about by adequate milk inspection, which surely means more than an occasional inspection of premises and wagons. To do this a man must receive more than the salary of the present milk inspector. A comparatively inexpensive laboratory equipment is also necessary, all of which costs money, but to my mind it is just as important to safeguard the milk supply as to protect the water supply.

BACTERIOLOGICAL STUDIES OF MILK SUPPLIES OF BOULDER, COLORADO

SECOND PRELIMINARY REPORT[1]

By Clough Turrill Burnett
and
Charles F. Poe

Since the presentation of a paper read by one of us in February, which appears in this number of these *Studies*, we have been asked many times to state by name those dealers in Boulder who are furnishing wholesome milk. So far we have declined, because we have not felt warranted in making either favorable or unfavorable reports on the products of any of the dairies until such time as we were prepared to report on all dairies operating in Boulder. We have now completed a sufficient number of bacteriological examinations of samples from the various dairies to permit us to give this information to the public.[2]

Reference will be made from time to time to certain portions of the First Preliminary Report, which appears elsewhere in this journal, but the charts presented here will refer only to the samples not already reported.

In this series will be found the examinations of thirty-one samples of milk from fourteen dairies. In the First Preliminary Report will be found examinations of twenty-one samples of milk from fourteen dairies. This makes a total of fifty-two samples examined from twenty-eight dairies. We obtained the complete list of licensed dairies from the City Milk Inspector and believe we have examined at least one sample from each dairy.

The examination cited extends from September 21, 1910, to March 15, 1911. The method of examination was the same as that used for

[1] From the Laboratory of Bacteriology, University of Colorado.

[2] In this paper we shall designate the dairies only by the Producer Number, but a key will be furnished to the City Milk Inspector and to each member of the Boulder County Medical Society (the latter representing the practicing physicians of Boulder), indicating the dairy designated by each Producer Number.

Samples No. 12 and No. 22 of the First Preliminary Report, which was given in detail in that report.

We will present first a résumé of each examination. Only the salient features will be mentioned, omitting the reactions and time of loppering unless one or both of these records seem of especial importance. Each sample was tested for boric acid and formaldehyde, but no milk was found to contain either.

Sample No. 23. Producer No. 1. This sample is from a licensed dairy and was taken September 21. This is milk of the preceding night and was received eighteen hours after milking. In spite of this the bacterial count was only 28,625 germs per cubic centimeter. In twenty-four hours on ice this was only 29,300, while at room temperature in the same time the count increased to 113,530. The butter fat was 3.6 per cent. This milk may serve as a sample of what it is possible to produce in Boulder during the late summer.

Sample No. 24. From the same dairy as No. 23, Producer No. 1. This milk is of the same day as No. 23, but this is morning's milk and was received six hours after milking. The count was 44,000 germs per cubic centimeter. In twelve hours at room temperature this increased to 575,160, while on ice the count was somewhat lower than at six hours—namely 35,480. The butter fat was 3.4 per cent. This sample, which was received twelve hours earlier than No. 23, shows a much higher count. While in both instances this shows a reasonably low count we would point out that there must be some source of contamination of No. 24 which was not present in No. 23, and that probably more care could have eliminated this increase.

Sample No. 25. Producer No. 6. This sample is from a licensed dairy which furnished Nos. 25, 28, 34, 47 and 50 (and Nos. 10, 14, First Preliminary Report) and was received September 27, three hours after milking. The count at this time was 934,000. The reaction was 10 degrees acid. This sample kept on ice showed a count of 2,052,000 in twelve hours and at room temperature in the same time the bacterial content was 23,280,000. At this time the acidity had only increased to 13 degrees. This suggests to us the probability of the presence of many alkali-producing germs, many of which we know may elaborate extremely toxic substances. The butter fat was 2.8 per cent.

Sample No. 26. Producer No. 10. This is from a licensed dairy. This was received October 1, five hours after milking. The count at this time showed 233,300 germs per cubic centimeter. In twelve hours on ice this had increased to 662,100, while at room temperature in the same time the count was 8,700,000. Butter fat was 3.4 per cent.

This twelve-hour count at room temperature is of importance, for a large number of the residents of Boulder cease taking ice after October 1, so this will represent the kind of milk they will have in the evening of the day the milk is delivered, if the milk is filthy when delivered. It is fair to state, however, that the increase between the five- and twelve-hour plating was partly influenced by the fact that the mean room temperature on this day was 23 degrees C.—slightly higher (1-4 degrees) than the mean room temperature of the days on which preceding and succeeding samples were examined.

Sample No. 27. Producer No. 14. This is from a licensed dairy. The sample was received October 8, five hours after milking, when the bacterial count was 8,750. After seven hours (that is, twelve hours after milking) on ice there was a slight decrease in the bacterial count, while at room temperature the count was only 35,060. The butter fat was 3.6 per cent.

Sample No. 28. Producer No. 6. This is from a licensed dairy, being from the same dairy as No. 25. This was received October 15, five hours after milking. The bacterial count was 227,300. Kept on ice, at the end of twelve hours after milking, or only seven hours after the first examination, the germs increased to 793,000 per cubic centimeter, and at room temperature to 20,970,000 germs. The butter fat was 3.1 per cent. The mean room temperature on that day was 20 degrees C. This was at a time of year (October 15) when most people were doing without ice, so we may assume that this is the kind of milk the customers of this dairy used for the evening meal. This sample was obtained from the central milk depot and rushed to the laboratory, so it was probably kept under the best conditions which that dairy affords—at least it was not subjected to the dust and the possible heating of a long milk route.

Sample No. 29. Producer No. 8. This is from a licensed dairy (same as No. 12, First Preliminary Report) and was received October 17. When examined, six hours after milking, the count showed 55,020 germs. At the end of another five hours on ice this did not increase, but at room temperature (mean 16 degrees C.) it reached 124,700. The butter fat was 3.3 per cent.

Sample No. 30. Producer No. 15. This is from a licensed dairy and was examined October 22. Five hours after milking the count showed 36,750 germs per cubic centimeter. Twelve hours after milking, when kept on ice, the count showed 50,180 germs, but at room temperature this had increased to 1,176,000 (mean temperature 20 degrees C.). The butter fat was 3 per cent.

Sample No. 31. Producer No. 13. This is from a licensed dairy. The sample was received October 22, five hours after milking, at which time there were 261,800 germs per cubic centimeter. Twelve hours after milking there were 316,000 germs per cubic centimeter, in the portion kept on ice, and in the portion kept at room temperature 7,615,000. The butter fat was 2.7 per cent.

Sample No. 32. Producer No. 14. This is from the same licensed dairy as No. 27. It was examined November 19, five hours after milking, and gave a bacterial count of 4,850. Twelve hours after milking when kept on ice the count was 5,865 and in the same time at room temperature (mean 20 degrees C.) 32,120. The butter fat was 3.8 per cent.

Sample No. 33. Producer No. 8. This is from the same licensed dairy as No. 29. When received, November 20, six hours after milking, the count was 17,525. There was no appreciable change in six hours (twelve hours after milking) in the portion kept on ice, and in the portion at room temperature the count only reached 23,370. The butter fat was 3.4 per cent.

Sample No. 34. Producer No. 6. This sample is of especial interest, for it is from the same dairy as Nos. 10, 14, 25, 28, 34, 47 and 50. This was taken January 19 and plated four hours after milking, and we find an initial count of 14,200. (Compare this with the previous high count of samples from this dairy.) Twelve hours after milking the sample kept on ice showed 14,900 and that at room temperature 175,300. The butter fat was 3 per cent.

Sample No. 35. Producer No. 15. This is from the same licensed dairy as No. 30. When received, January 21, four hours after milking, it showed 520,250 germs per cubic centimeter. (Compare Sample No. 30.) Kept on ice this increased, at the end of twelve hours after milking, to 771,300, and to 12,050,000 in the portion kept at room temperature. The butter fat was 3.5 per cent.

Sample No. 36. Producer No. 11. This is from a licensed producer[1] and was received January 22, five hours after milking. The initial count was 4,930. This increased at the end of twelve hours to 15,025 when kept on ice, and to 42,900 when kept at room temperature. The butter fat was 4.4 per cent.

Sample No. 37. Producer No. 10. This is from same dairy as No. 26 (also No. 15, First Preliminary Report). When received, January 23, five hours after milking, the bacterial count was 6,835. This increased to 14,600 twelve hours after milking in the sample kept on ice and to 164,300 in the sample at room temperature. The butter fat was 3.7 per cent.

Sample No. 38. Producer No. 14. This sample is from the same dairy as Nos. 27 and 32. It was received January 27, five hours after milking, and showed a bacterial count of 1,080. This increased to 1,730 on ice and to 4,860 at room temperature at the end of twelve hours. The butter fat was 4.7 per cent.

Sample No. 39. Producer No. 8. This is from the same dairy as Nos. 29 and 33. The sample was received January 28, six hours after milking, at which time there was a germ content of 7,960. This did not increase on ice in twelve hours and at room temperature it was only 21,220 at this time. The butter fat was 4.2 per cent.

Sample No. 40. Producer No. 16. This is from one of the new dairies. It was received February 4, and five hours after milking contained 26,670 germs per cubic centimeter. At the end of twelve hours after milking the count increased to 63,000 in the sample kept on ice and to 159,600 in that at room tempterature. The butter fat was 3.6 per cent.

[1] See No. 16 in the First Preliminary Report.

Sample No. 41. Producer No. 17. This also is from a new dairy. It was received February 4, and five hours after milking there were 2,650 germs per cubic centimeter. There was no increase in the sample kept on ice at the end of twelve hours, and in that kept at room temperature the count was 10,430. The butter fat was 4.1 per cent.

Sample No. 42. Producer No. 1. This is from the same dairy as Nos. 23 and 24 (also Nos. 1, 2, 5, 18, 21 and 22, First Preliminary Report). This was taken February 7, and when received, four hours after milking, there were 12,920 germs per cubic centimeter. On ice in twelve hours after milking this increased to 45,700 and at room temperature to 161,000. The butter fat was 3.8 per cent.

Sample No. 43. Producer No. 8. This is from the same dairy as Nos. 29, 33 and 39 (also No. 12, First Preliminary Report). The sample was received February 11, and when examined, eight hours after milking, the bacterial content was 9,300. Twenty-seven hours after milking this had increased to 19,200 in the sample kept on ice and to 7,395,000 in the sample kept at room temperature (mean temperature 20 degrees C.). The butter fat was 2.8 per cent.

Sample No. 44. Producer No. 18. This is from a licensed dairy and was examined February 11. Five hours after milking the bacterial count was 7,300. This did not increase at the end of twelve hours after milking in the sample kept on ice, but increased to 70,240 in the same time at room temperature. The butter fat was 4.6 per cent.

Sample No. 45. Producer No. 20. This sample was taken February 13, and five hours after milking showed a count of 15,100. At the end of twelve hours on ice this increased to 20,400 and to 375,000 at room temperature. The butter fat was 3.4 per cent.

Sample No. 46. Producer No. 19. This is from a new dairy which has many features to commend[1] it (aside from the bacteriological findings). This was taken February 24, and five hours after milking showed a germ content of 6,100. This did not increase at the end of twelve hours on ice. The count of the sample kept for seven hours at room temperature (twelve hours after milking) showed 2,690,000. This may be explained by the fact that the mean room temperature during the tests was 25 degrees C. This is about the optimum temperature for most of the germs found in milk, and so much importance cannot be attached to the last figures. The butter fat was 3.3 per cent.

Sample No. 47. Producer No. 6. This is from the same dairy as Nos. 25, 28, 34 and 47 (also Nos. 10 and 14, First Preliminary Report). This was taken February 25, and twelve hours after milking there were 10,366 germs per cubic centimeter. (Compare this with Nos. 25 and 28 of this series and No. 14, First Preliminary Report.) At the end of twenty-seven hours on ice this had only

[1] Each bottle is filled at the farm and a cap is sealed on the neck of the bottle.

increased to 11,400 germs per cubic centimeter, but in the sample at room temperature the number at this time was 91,950,000 (mean temperature 21 degrees C.). The butter fat was 3 per cent.

Sample No. 48. Producer No. 20. This is from one of the new dairies. This was taken March 3, and when received, five hours after milking, there were 39,075 germs per cubic centimeter. In twelve hours after milking, on ice, the count was 50,250 and in the same time at room temperature 56,800,000. The butter fat was 3.7 per cent.

Sample No. 49. Producer No. 21. This is from a private dairy. When received, March 3, fourteen hours after milking, the count was only 870 and in twenty-three hours on ice the count was 2,100. In the same time at room temperature it was 1,330,000. The butter fat was 4.1 per cent.

Sample No. 50. Producer No. 6. This is from the same dairy as No. 25. This was taken March 4, and four hours after milking contained 16,833 germs per cubic centimeter. Twelve hours after milking, on ice, there were 18,900 and in the same time at room temperature there were 1,257,500. The butter fat was 3 per cent.

Sample No. 51. Producer No. 22. This is from a licensed dairy. When received, March 7, five hours after milking, there were 16,850 germs per cubic centimeter. In twelve hours after milking, on ice, there were 28,300 and in the same time at room temperature 234,000. The butter fat was 3.1 per cent.

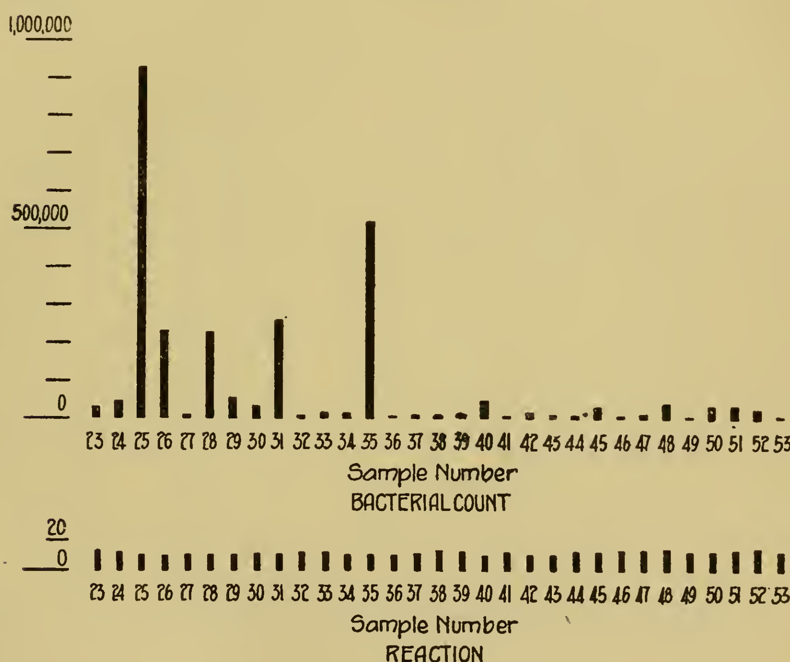
Sample No. 52. Producer No. 23. This is from a licensed dairy. When received, March 10, three hours after milking, there were 12,250 germs per cubic centimeter. In twelve hours after milking, on ice, there were 28,566 and in the same time at room temperature 1,220,000. The butter fat was 4 per cent.

Sample No. 53. Producer No. 19. This is from the same dairy as No. 46. When received, March 10, six hours after milking, there were 3,733 germs per cubic centimeter. In twelve hours after milking, on ice, there were 9,133 and in the same time at room temperature 645,000. The butter fat was 3.3 per cent.

A graphic representation of these bacterial counts will be found in Chart I. It will be interesting to compare this chart with a similar chart presented in the First Preliminary Report (p. 156). One can see at a glance the marked improvement in most all cases over those shown in the first series, but that this is only an apparent improvement is recognized when we note that all of this series save Nos. 23 and 24 were examined after October 1—that is, only two out of the thirty-one of our present series were made during the so-called summer months, against fourteen out of twenty-one of the first series, which were made during the summer months.

Of these thirty-one only five are above 100,000 germs per cubic centimeter and only six above 50,000 germs per cubic centimeter. As suggested in the first paper, if most of the dealers can, with only the most meager municipal supervision, produce a clean milk, surely the others should be compelled to meet the standard which has independently been set by certain of the dairymen.

CHART No 1



As in the other series, we also find that the initial acidity—unless very high—gives no indication as to the degree of contamination.

In Chart II we present a tabulation of the results of the examination of all samples which show an initial count of less than 100,000. Of the thirty-one of this series, twenty-six come in this class. Most of these make an exceedingly good showing, in spite of the fact that several of these samples were taken in comparatively warm weather, when perhaps the same care in cooling would not be observed as is the case in the summer. Of these twenty-six samples eleven are below the requirements in butter fat (3.5 per cent).

CHART II

SAMPLES SHOWING AN INITIAL COUNT OF 100,000 OR LESS

Sample No.	Producer No.	Date	Hours after Milking	Summer*	Winter	Acid	Butter Fat Percentage
23.........	14	8/21/10	18	28,625	......	13	3.6
24.........	14	8/21/10	6	44,000	......	12	3.4
27.........	24	10/ 8/10	5	......	8,750	10	3.6
29.........	8	10/22/10	6	......	55,020	10	3.3
30.........	15	10/22/10	5	......	36,750	11	3.0
32.........	24	11/19/10	5	......	4,850	12	3.8
33.........	8	10/20/10	6	......	17,525	12	3.4
34.........	6	1/19/11	4	......	14,200	11	3.0
36.........	11	1/21/11	5	......	4,930	10	4.4
37.........	10	1/23/11	5	......	6,835	11	3.7
38.........	24	1/27/11	5	......	1,080	13	4.7
39.........	8	1/28/11	6	......	7,960	12	4.2
40.........	16	2/ 4/11	5	......	26,670	9	3.6
41.........	17	2/ 4/11	5	.....	2,650	12	4.1
42.........	14	2/ 7/11	4	......	12,920	10	3.8
43.........	8	2/11/11	9	......	9,300	10	2.8
44.........	18	2/11/11	5	......	7,300	12	4.6
45.........	20	2/13/11	5	......	15,100	12	3.4
46.........	19	2/24/11	5	......	6,100	13	3.3
47.........	6	2/25/11	12	......	10,366	13	3.0
48.........	20	3/ 3/11	5	......	39,075	14	3.7
49.........	21	3/ 3/11	14	......	870	12	4.1
50.........	6	3/ 4/11	4	......	16,833	12	3.0
51.........	22	3/ 7/11	5	......	16,850	13	3.1
52.........	23	3/10/11	3	......	12,250	14	4.0
53.........	19	3/10/11	6	......	3,733	12	3.3

* All samples in this set taken before October 1 are classed as summer samples; all those after October 1 as winter samples.

The data obtained in the examination of the five samples having an initial count of over 100,000 are shown in Chart III. It is of interest that only Sample No. 35 meets the legal requirements in butter fat. Samples Nos. 25 and 28 are from the same dairy (from this dairy was also obtained Sample No. 14, First Preliminary Report, which showed a bacterial content of 2,790,000). Compare this with Chart II.

CHART III

SAMPLES SHOWING AN INITIAL COUNT OF OVER 100,000

Sample No.	Producer No.	Date	Hours after Milking	Summer*	Winter	Acid	Butter Fat Percentage
25.........	6	8/27/10	3	934,000	......	10	2.8
26.........	10	10/ 1/10	5	......	233,300	9	3.4
28.........	6	10/15/10	5	......	227,300	10	3.1
31.........	13	10/22/10	5	......	261,800	11	2.7
35.........	15	1/21/11	4	......	520,250	10	3.5

* All samples in this set taken before October 1 are classed as summer samples; all those after October 1 as winter samples.

In Chart IV we have tabulated in numerical order not only the initial count and reaction, but the count and reaction in the evening of the same day when that milk is kept on ice and when kept at room temperature. One of us has pointed out[1] that a milk should not only be wholesome when received, but should be capable of remaining so at least during the day of delivery and that a bacterial count made at that time will disclose the true conditions. This chart will show the keeping qualities of these milks under an unchangeable condition, that is, when kept on ice, and under changeable conditions, viz., when kept at room temperature. It is interesting to note that of the samples kept on ice the only ones showing a high count in the evening are those showing a high initial count, all being above 200,000 germs per cubic centimeter. Of the samples kept at room temperature we find only two that show a very high count in the evening which did not have a high initial count. These are Nos. 47 and 48. No. 47 is from a dairy which claims to pasteurize all of its milk. We are not informed just what method or temperature is used. It is a well-known fact, however, that after pasteurization if milk is not kept at a low temperature (below 50 degrees F.) bacteria develop rapidly and the milk will, after twelve to twenty-four hours, be more dangerous than if it had not been heated at all, since, unlike raw milk, it does not usually sour and reveal its contaminated condition. We find in this case there has been no change in reaction in spite of the enormous increase in germ content. We suggest that this increase in No. 47 is due

[1] Page 158, First Preliminary Report.

CHART IV

Sample Number	Producer Number	Date	Hours after Milking	First Plating	Acid	Hours after Milking	Second Plating (Kept on Ice)	Acid	Hours after Milking	Second Plating (Kept at Room Temperature)	Acid	Mean Room Temperature	No. of Hours before Curd at Room Temperature	No. of Hours before Curd on Ice	Butter Fat Percentage
23.....	1	8/21/10	18	28,625	13	24	29,300	13	14	113,530	14	22°	48	367	3.6
24.....	1	8/21/10	6	44,000	12	12	35,480	12	12	575,160	14	22°	36	371	3.4
25.....	6	8/27/10	3	*934,000**	10	12	*2,052,000*	10	12	*23,280,000*	13	20.5°	36	361	2.8
26.....	10	10/ 1/10	5	*233,300**	9	12	*662,100*	9	12	*8,700,000*	19	23°	27	291	3.4
27.....	24	10/ 8/10	5	8,750	10	12	8,250	10	12	35,060	12	19°	36	243	3.6
28.....	6	10/15/10	5	*227,300**	10	12	*793,000*	10	12	*20,970,000*	12	20°	38	391	3.1
29.....	8	10/17/10	6	55,020	10	12	45,920	10	12	124,700	13	16°	51	363	3.3
30.....	15	10/22/10	5	36,750	11	12	50,180	11	12	1,176,000	13	20°	36	266	3.0
31.....	13	10/22/10	5	*261,800**	11	12	*316,000*	11	12	*7,615,000*	14	20°	36	266	2.7
32.....	24	11/19/10	5	4,850	12	12	5,865	12		32,120	14	20°	50	410	3.8
33.....	8	11/20/10	6	17,525	12	12	14,370	12		23,370	13	19°	49	363	3.4
34.....	6	1/19/11	4	14,200	11	12	14,900	11	12	175,300	12	19°	51	315	3.0
35.....	15	1/21/11	4	*520,250**	10	12	*771,300*	10	12	*12,050,000*	12	18°	52	267	3.5
36.....	11	1/22/11	5	4,930	10	12	15,025	10	12	42,900	11	16°	51	267	4.4
37.....	10	1/23/11	5	6,835	11	12	14,600	11	12	164,300	13	19°	36	267	3.7
38.....	24	1/27/11	5	1,080	13	12	1,730	13	12	4,860	13	19°	51	267	4.7
39.....	8	1/28/11	6	7,960	12	12	7,770	12	12	21,220	13	19°	75	195	4.2
40.....	16	2/ 4/11	5	26,670	19	19	63,000	9	12	159,600	10	20°	51	219	3.6
41.....	17	2/ 4/11	5	2,650	12	12	2,700	12	12	10,430	13	20°	51	291	4.1
42.....	14	2/ 7/11	4.	12,920	10	12	45,700	10	12	161,600	12	20°	36	267	3.8
43.....	8	2/11/11	8	9,300	10	27	19,200	10	27	7,395,000	14	20°	51	267	2.8
44.....	18	2/11/11	5	7,300	12	12	7,270	12	12	70,240	13	20°	51	267	4.6

CHART IV—*Continued*

Sample Number	Producer Number	Date	Hours after Milking	First Plating	Acid	Hours after Milking	Second Plating (Kept on Ice)	Acid	Hours after Milking	Second Plating (Kept at Room Temperature)	Acid	Mean Room Temperature	No. of Hours before Curd at Room Temperature	No. of Hours before Curd on Ice	Butter Fat Percentage
45.....	20	2/13/11	5	15,100	12	12	20,400	12	12	375,000	14	21°	27	219	3.4
46.....	19	2/24/11	5	6,100	13	12	5,500	13	12	2,690,000	14	25°	27	243	3.3
47.....	6	2/25/11	12	10,366	13	12	11,400	13	12	91,950,000	15	21°	51	219	3.0
48.....	20	3/ 3/11	5	39,075	14	12	55,300	14	12	56,800,000	17	21°	27	267	3.7
49.....	21	3/ 3/11	14	870	12	23	2,100	12	23	1,330,000	12	21°	62	326	4.1
50.....	6	3/ 4/11	4	16,833	12	12	18,900	12	12	1,257,500	14	20°	30	267	3.0
51.....	22	3/ 7/11	5	16,850	13	12	28,300	13	12	234,000	15	21°	51	267	3.1
52.....	23	3/10/11	3	12,250	14	12	28,566	14	12	1,220,000	15	20°	36	216	4.0
53.....	19	3/10/11	6	3,733	12	12	9,133	12	12	645,000	13	20°	36	216	3.3

* Figures in italic and followed by an asterisk (*) are of samples showing an initial count of over 200,000 bacteria per cubic centimeter.

CHART V

Producer No.	Bacteria	Butter Fat*	Bacteria	Butter Fat*	Bacteria	Butter Fat*	Bacteria	Butter Fat*	Bacteria	Butter Fat*
1†...	[1‡] 210,064	...	[2‡] 1,604,120	...	[6‡] 447**	...	......	...	......	...
2....	[3] 35	5.1	[4] 51	4.8	......	...	......	...	......	...
3....	[7] 1,140	4.8	....	...	......	...	......	...	......	...
4....	[8] 674	...	....	...	......	...	......	...	......	...
5....	[9] 17,457	...	....	...	......	...	......	...	......	...
6††..	[10] 23,828	...	[14] 2,790,000	3.6	[25] 934,000	2.8	[34] 14,200	3	[28] 227,300	3.1
7....	[11] 49,086	...	....	...	......	...	......	...	......	...
8....	[12] 175,300	3.6	[29] 55,020	3.3	[33] 17,525	3.4	[39] 7,960	4.2	[43] 9,300	2.8
9....	[13] 100,330	3.1	....	...	......	...	......	...	......	...
10....	[15] 158,200	3	[26] 233,300	3.4	[37] 6,835	3.7	......	...	......	...
11....	[16] 947,300	3.1	[36] 4,930	4.4	......	...	......	...	......	...
12....	[17] 377,060	2.9	....	...	......	...	......	...	......	...
13....	[19] 651,000	2.8	[31] 261,800	2.7	......	...	......	...	......	...
14....	[5] 71,080	3.9	[21] 70,000	3.1	[22] 266,600	3.6	[18] 100,000	3.1	[28] 28,625	3.6
15....	[30] 36,750	3	[35] 520,250	3.5	......	...	......	...	......	...
16....	[40] 26,670	3.6	....	...	......	...	......	...	......	...
17....	[41] 2,650	4.1	....	...	......	...	......	...	......	...
18....	[44] 7,300	4.6	....	...	......	...	......	...	......	...
19....	[46] 6,100	3.3	[53] 3,733	3.3	......	...	......	...	......	...
20....	[45] 15,100	3.4	[48] 39,075	3.7	......	...	......	...	......	...
21....	[49] 870	4.1	....	...	......	...	......	...	......	...
22....	[51] 16,850	3.1	......	...	......	...	......	...	......	...
23....	[52] 12,250	4	....	...	......	...	......	...	......	...
24....	[27] 8,750	3.6	[32] 4,850	3.8	[38] 1,080	4.7	......	...	......	...

* The municipal requirement is 3.5 per cent butter fat.

† This dairy has passed under a new management since these samples were obtained.

†† This is the dairy referred to on p. 173 regarding commercial pasteurization of milk.

CHART V—*Continued*

Producer No.	Bacteria	Butter Fat*	Bacteria	Butter Fat*	Summer		Winter		Butter Fat Percentage
					Above 100,000	Below 100,000	Above 50,000	Below 50,000	
1.........	.....	...	.....	...	2	0	0	1	....
2.........	.....	...	.....	...	0	1	0	1	4.9
3.........	.....	...	.....	...	..	...	0	1	4.8
4.........	.....	...	.....	...	..	...	0	1	....
5.........	.....	...	.....	...	..	...	0	1	....
6.........	[47] **10,366**	3.0	[50] **16,833**	3.0	2	0	1	4	3.08
7.........	.....	...	.....	...	0	1	...	...	....
8.........	.....	...	.....	...	1	0	1	3	3.46
9.........	.....	...	.....	...	1	0	...	...	3.1
10.........	.....	...	.....	...	1	0	1	1	3.36
11.........	.....	...	.....	...	1	0	0	1	3.7
12.........	.....	...	.....	...	1	0	0	0	2.9
13.........	.....	...	.....	...	1	0	1	0	2.75
14.........	[24] 44,000	3.4	[42] **12,920**	3.8	1	4	0	2	3.5
15.........	.....	...	.....	...	...	...	1	1	3.25
16.........	.....	...	.....	...	...	...	0	1	3.6
17.........	.....	...	.....	...	...	...	0	1	4.1
18.........	.....	...	.....	...	...	...	0	1	4.6
19.........	.....	...	.....	...	...	...	0	1	3.3
20.........	.....	...	.....	...	...	...	0	2	3.55
21.........	.....	...	.....	...	...	...	0	1	4.1
22.........	.....	...	.....	...	...	...	0	1	3.1
23.........	.....	...	.....	...	...	...	0	1	4.
24.........	.....	...	.....	...	...	...	0	3	4.03

** All counts made from October 1 to April 1 (winter months) will be found in bold-face. The remainder are of summer samples.

‡ The numbers in the upper left hand corner of the space for the bacterial count refer to the number of the sample.

to pasteurization followed by insufficient cooling. The dealer will no doubt reply that had we kept this cool as the other portion of the sample, this increase would not have taken place; however, it is our opinion that if one is to treat milk in such a manner as to cause it to deteriorate more rapidly than normal, he should apprise the public of that fact and indicate to the consumer how such deterioration may be prevented. In a later paper one of us will consider the advisability of commercial pasteurization of milk in a city as small and as close to the producing dairies as is Boulder. Without much consideration of the subject it seems to us that it is unnecessary and may be extremely harmful.

Thirteen of the thirty-one samples fail to meet the butter fat requirement. This, however, is better than the first series, where only one-half of the samples were up to the standard.

In Chart V we have arranged the Producer Numbers in numerical order and following each number is found the initial count of each sample and the butter fat percentage when determined. In the last column is the average of all the butter fat determinations on milks from that dairy. In case only one determination was made, that has been set down as the average, but this may be a questionable procedure. We suggest that the reader give this fact due allowance in interpreting the results.

We attempted a classification of these dairies into four groups, good, fair, doubtful and poor. Here again we were met with the fact that to so classify we must often compare the results of many examinations of one dairy's milk with a single examination of another. This obviously would be unfair, so we have deferred such a classification until such time as we have made a comparatively equal number of examinations of each dairy's product. Furthermore, in making such a classification it is best to take into consideration such other factors as the condition of the cattle, premises and attendants, care of utensils, manner of cooling, etc. Without a knowledge of these a thoroughly reliable rating is impossible. For this reason it will be advisable to complete this investigation with a rating based upon some score-card system.[1]

[1] A thorough study of this phase of the work will be undertaken by one of us and reported independently.

In conclusion, we believe this second series has substantiated in the main the conclusions arrived at earlier by one of us. We would modify an opinion introduced in the First Preliminary Report (p. 163). A standard of not more than 100,000 germs per cubic centimeter from April 1 to October 1, and not more than 75,000 germs per cubic centimeter from October 1 to April 1 was suggested. We now believe that a winter standard of not more than 50,000 would not be unreasonable.

Further studies on this subject are now being made to determine some adequate standard and means of control of the milk supply in a small town such as Boulder.

TUBERCULOSIS AS AN ECONOMIC AND SOCIOLOGIC FACTOR

By Francis Ramaley

Introduction.—In the following pages an attempt is made to indicate in outline the important economic rôle played by tuberculosis. Related topics have been avoided so that the main issue be not obscured. Activities directed toward the control of the disease have been mentioned only in so far as they are concerned with expenditure of public moneys. The writer hopes to prepare at some future time a discussion of recent progress in the prevention and sanitary control of this great scourge of the human race.

There is scarcely any factor of modern civilization having such profound sociological import as tuberculosis. The disease is the greatest single cause of sickness and death, hence it influences in large measure the average span of human life. It breaks up homes, destroying family life, thus forcing children to seek the aid of charity. As a promoter of poverty it deprives many a bright child of an education. Every organized charity, orphan asylum, hospital, public school, church, labor union, and fraternal society is interested in the subject of tuberculosis. There is hardly a family in the civilized world, save among the well-to-do, but has lost some member by the disease. Even among the better-fed and better-clothed of society the disease is all too common.

To the business of life insurance tuberculosis is of great moment. Both fraternal societies and "old line" companies are beginning to appreciate the fact that payment of death benefits could often be deferred if tuberculosis were made less common. A few companies are spending money for health literature. One has established a "health bureau" for its policy-holders.[1]

Tuberculosis is a disturbing factor in the business world. It incapacitates many men for the regular work in which they have

[1] Letter from Eugene L. Fisk, M.D., medical director of the Provident Savings Life Assurance Society, October 25, 1910.

been trained and forces them into occupations which call for less physical strength. It is a notorious fact that tuberculosis is common among hotel waiters and that many of the persons engaged in domestic service are doing such work because of physical weakness in part due to the disease. A few years ago the occupation of ticket clipper on elevated railroads was recommended to consumptives as combining light work and out-door air. Soon there was an overplus of applicants for all available positions. In Colorado, California and all other "health resort" states there is a great crowding of professional ranks by men who are forced to reside in the West for reasons of health.[1]

There is no other human ailment which so promotes the business of the patent-medicine manufacturer and, to a less degree, that of the medical quack. Those persons wax and grow fat on the money of the ignorant consumptive who does not know that hygienic treatment under competent medical supervision will alone cure him. The continued existence of quackery, with all its degrading influence upon the public and its injury to the medical profession, depends to a considerable extent upon the prevalence of tuberculosis.

Many sufferers from tuberculosis originally became susceptible to the disease through the use of alcoholic drinks which, when taken to excess, weaken the system, and permit invasion of the body by the tubercle bacillus. On the other hand, men with the disease are often led to intemperance by a desire to forget their troubles. Thus there is a reciprocal relation between alcohol and tuberculosis. Disease leads to dissipation and dissipation brings on disease.

The Prevalence of Tuberculosis.—About one-ninth of the members of the human race die of tuberculosis. In England and Wales it causes over 60,000 deaths annually, and in the United States probably more than 150,000. It is always the commonest of the

[1] Since writing the above, I have read carefully a paper on "The Question of Employment" (for the tubercular) in the *Transactions of the National Association for the Study and Prevention of Tuberculosis*, sixth annaul meeting, Washington, D.C., May 2–3, 1910. The author of the paper, Dr. A. M. Forster, in advocating farm work for sanatorium patients, notes incidentally the disturbance of conditions by shifting of employment. He calls attention to the fact that the number of employments in cities suited to consumptives is small, mentioning laundry agent, collector, etc. The average tuberculous patient who returns to work after a "cure" at a sanatorium must take employment at a lower wage than he is accustomed to, hence must have less desirable home surroundings and possibly insufficient food.

more fatal infectious diseases. There are at all times many persons disabled by it. Some of them live for two or more years and then die; others recover after a long illness. No doubt in the United States there are constantly ill with this disease at least 400,000 individuals.

Tuberculosis is not confined to cold or temperate countries. In tropical districts where accurate records are taken it is found to be quite prevalent. In the city of Honolulu, for example, for the year ending June 30, 1909, tuberculosis caused 16.6 per cent of all deaths. The annual death rate for this disease per 100,000 living persons was 390 as against 178 in England and Wales and 174 in the United States for 1904. In like manner, Ceylon, the Philippine Islands, Porto Rico, and other tropical countries are known to have astonishingly high death rates from consumption and other forms of tuberculosis.

No more striking statement of the prevalence of the disease has been given than that in the weekly bulletin of the health department of the city of Chicago for November 27, 1909, which is well worth quoting:

> Consumption, a preventable disease, kills upward of 4,000 Chicago people each year. There are 10,000 living cases approximately in Chicago today. Consumption costs Chicago about $23,600,000 each year. It is the most pauperizing of all diseases. Consumption kills more people than diphtheria, scarlet fever, smallpox, typhoid fever, cancer, appendicitis, meningitis and influenza combined. Consumption will kill upward of 50,000 Chicagoans in the next ten years. *You* may be one of them.

Table I shows mortality[1] from tuberculosis in various places. The localities are selected to show the great variation in different parts of the world. The high death rates in California and Colorado are to be accounted for by the presence of many invalids in those

[1] It may be well to point out that "annual death rate" means the average number of deaths each year in a population of 1,000 living persons. If a town have 1,000 inhabitants, and of these an average of 18 die each year, the "annual death rate" is 18. If, of these 18 who die, 3 are victims of tuberculosis, the proportional deaths due to this disease will be 3:18, $\frac{3}{18}$ or $\frac{1}{6}$. In other words, tuberculosis kills $\frac{1}{6}$ of the population, or 16.6 per cent. If a city have 2,000 inhabitants with 18 deaths per annum, the annual death rate is 9. Thus it is seen that annual death rate is not a percentage—it is not figured on the hundred—but is the ratio per 1,000 of living persons. In working with death rates for single diseases, it is customary to express the rate per annum as a ratio to 100,000 living persons. By this means it becomes possible to discard fractions. In the example cited above where the annual death rate from tuberculosis was 3 per 1,000 it would be, of course, 300 per 100,000.

states who have gone there for the beneficial effects of climate. South Dakota, New Hampshire, and to a less extent Michigan, are largely rural communities, hence their comparatively slight mortality from consumption, which is especially a disease of the poor and the over-crowded.

TABLE I

Annual Death Rate from Tuberculosis (All Forms) per 100,000 Living Persons

Area	Death Rate
South Dakota* (1908)	102
Michigan* (1908)	102
New Hampshire* (1908)	129
Rural districts of registration† states, U.S. (1908)	136
United States registration† area (1908)	174
England and Wales (1904)	178
Registration† cities of United States (1908)	197
New York City (1907)	242
California* (1908)	271
Colorado* (1908)	301
Honolulu,* T.H. (1908)	390

* Figures for the various states are taken from *Bulletin 104*, Bureau of the Census, Washington, D.C., 1909. For Honolulu, the data were obtained from the publications of the Department of Health of Hawaii,

† The registration area of the United States includes certain cities and states, the vital statistics of which are considered sufficiently accurate to be accepted by the United States Bureau of the Census. It is customary to disregard altogether the statistics from other parts of the United States.

TABLE II

Death Rate from Pulmonary Tuberculosis (Consumption, Phthisis) in Various Countries per 100,000 Living Persons

Country	Death Rate
Tasmania	63
Victoria, Australia	112
Italy	114
Great Britain and Ireland	134
Japan	146
United States (registration area)	170
Germany	185
Norway	196
Austria	334

Figures for foreign countries are often made for pulmonary tuberculosis alone and cannot be compared exactly with those given in Table I. From a very valuable report on *Tuberculosis in the United States*, published by the United States Bureau of the Census, some interesting data have been put together in Table II.

Reduction in Death Rate from Tuberculosis.—With a higher standard of living in the past twenty or thirty years there has been a great decline in the death rate from tuberculosis. On account of unreliable statistics it is impossible to know what the rate from any particular disease was at a period before 1870. Even in England and Wales, where the most accurate figures are available, we cannot use returns of earlier years because nearly all lingering diseases were recorded as "phthisis" (pulmonary tuberculosis). The reduction in mortality from this disease is indicated in Table III, which is adapted from the report on *Tuberculosis in the United States* already mentioned.

TABLE III

Annual Death Rate from Tuberculosis (All Forms) per 100,000 Population for Registration Area of the United States

Year	Death Rate	Decrease in Death Rate	Percentage of Decrease
1880	326	...	...
1890	267	59	15
1900	201	66	24
1908	174	27*	13*

* For eight years only; the other figures in the same columns are for ten-year periods. All figures from official sources.

The countries and cities of Europe, with few exceptions, show a considerable decrease in the death rate from tuberculosis of the lungs in recent years. While in these same countries and cities there has also been a lowering of the general death rate, i.e., the total rate from all causes, it appears that the percentage decline has been greater for tuberculosis than for the other causes as a whole. Table IV from Newsholme[1] shows the decline in mortality from pulmonary consumption in a period of about twenty years.

[1] Newsholme, Arthur, *The Prevention of Tuberculosis*, London and New York, 1908.

TABLE IV

ANNUAL DEATH RATE FROM PHTHISIS (PULMONARY TUBERCULOSIS) PER 100,000 LIVING PERSONS

Area	1881–85	1901–3	Percentage of Decrease or Increase
England and Wales	183	123	−32
Scotland	211	147	−30
Ireland	208	215	+3
London	220	165	−25
Paris	441	365	−17
Berlin	332	204	−38

The lowering of the death rate from consumption in practically all countries and cities is to be ascribed to more sanitary living and general increase in wealth and resultant better food. While in many localities pneumonia (another impure-air disease) seems actually on the increase, it is seen that only Ireland, of the countries named, shows any increase of pulmonary consumption.

Concerning tuberculosis other than pulmonary, the decline in death rate has been slight, if any. The pulmonary form is alone readily susceptible to cure by hygienic methods.

Tuberculosis in Relation to Age and Sex.—While the average age at death from all causes changed in the United States (registration area) from 31 years in 1890 to 38 in 1907, the average of those dying from pulmonary tuberculosis was not altered to any appreciable extent. It remained practically constant at about 35 years. From these figures it is apparent that the disease is now killing, as it has done in the past, chiefly those in early manhood and womanhood.

Unfortunately, reliable statistics are wanting in regard to the other forms of the disease. Since general tuberculosis and tuberculosis of the intestines attack chiefly the young, it is likely that if these were all included the average age at death would be reduced one or two years.

For youth and early manhood and womanhood (15 to 29 years of age) nearly a third (33.2 per cent) of all deaths are due to tuberculosis in some of its forms. . . . . For infants and children the percentage is low (according to the returns), being 4 per cent. But many of the deaths from "meningitis," "convulsions," "diarrhoea," "enteritis," and others are probably due to tubercular infection. The story of the dealings of tuberculosis with infancy and childhood is not yet told by statistics, nor will it be until physicians are much more careful in their certificates of cause of death, and indeed, until science has rendered it less difficult to obtain precise information in many cases.[1]

Because of the fact that tuberculosis is most prevalent in the years of early adult life the disease has special sociological and economic significance. It takes away the breadwinners from families at the time when the children are likely to be young and unable to care for themselves. Hence it is one of the greatest causes of poverty and destitution.

As is well known, the general death rate of males at all ages is greater than that of females. Tuberculosis contributes very largely to this disparity. In Table V some figures are given which make this apparent.

TABLE V

Annual Death Rate from Pulmonary Tuberculosis (Consumption) per 100,000 Living Persons

Area	Males	Females	Excess of Male Rate over Female
England and Wales (1891–1900)	158	121	37
England and Wales (1904)	146	10	43
United States (registration area, 1906)..........	175	142	33

The difference in male and female death rate is partly accounted for by occupation. Those trades in which the tuberculosis death rate is highest are open only to men. As examples may be named the trades of pressman, bookbinder, marble cutter, machinist, brass-foundryman, etc. On the other hand, very few women have healthful outdoor work to correspond to that of farmers, teamsters, lumbermen, and others with low death rates. Perhaps the real reason for the differences in the death rates is to be sought for in the body differences of the two sexes. As is well known, the female sex is characterized by greater constructive metabolic activity than the male.

[1] *Tuberculosis in the United States*, p. 33, 1908.

Women tend to be more "fleshy" than men, i.e., to accumulate fat, and fat people are not so likely to become tubercular as thin people.

Tuberculosis and Occupation.—Before discussing the relation of tuberculosis and occupation, it is well to point out some facts which should influence our interpretation of registration figures. Thus in England and Wales in 1901, tuberculosis was responsible for 17 per cent of all deaths of "occupied" males and 58 per cent of unoccupied males, between the ages of 25 and 65 years. This does not mean, as might be inferred, that it is three times as dangerous to be "unoccupied" as "occupied." As a matter of fact most of those in any community who are "unoccupied" are those who are either ill or not strong. Also it is to be noted that those who are naturally not strong are able to engage in certain rather light work and such occupations will therefore show high mortality from tuberculosis. This explains the high rate among hotel waiters. Also there are certain trades where men of naturally weak constitutions could not

TABLE VI

Proportional Mortality (Percentage of All Deaths) Due to Pulmonary Tuberculosis among Males in Certain Occupations for Age Period 25 to 34 in the Registration Area of the United States During the Year 1908*

Occupation	Proportional Mortality
Compositors, printers, pressmen	49†
Bookkeepers and clerks	42
Tailors	41
Mill and factory operatives	40
Machinists	36
All occupations (average)	31
Merchants and dealers	31
Laborers	30
Blacksmiths‡	27
Farmers and farm laborers‡	26
Policemen‡	22

* Compiled from *Bull. 104*, Bureau of the Census.

† This means that of all the compositors, printers and pressmen who died in the registration area of the United States in the year 1908, 49 per cent, or nearly one-half, died of pulmonary tuberculosis.

‡ These persons evidently belong to a selected class. Only those naturally strong would attempt the kind of work demanded. Besides this it is perfectly evident that work in these occupations should serve to build up bodily strength.

find employment. No one who was not naturally of good bodily health would think of learning the trade of blacksmith. Having in mind these precautions which are to be used in interpretation of figures, it will be found of value to consult Table VI.

Certain occupations with high death rates from tuberculosis are of such nature that they are to be reckoned as "dangerous trades." Marble cutting, with its fine mineral dust, predisposes to the disease. So also do printing and bookbinding with their confined work often in ill-ventilated rooms. Table VII is prepared from figures in *Nothnagel's Encyclopaedia of Practical Medicine* to illustrate the mortality from tuberculosis in certain trades in the city of Berlin. The figures are based on records of mutual benefit associations.

TABLE VII

TUBERCULOSIS AS A CAUSE OF DEATH IN DANGEROUS TRADES IN THE CITY OF BERLIN

Occupation	Deaths Recorded, All Causes	Deaths from Tuberculosis	Per cent Caused by Tuberculosis
Bookbinder	300	189	63
Upholsterer	2,135	1,314	61
Cabinet maker	1,414	778	55

A careful study of the mortality in different occupations for England and Wales has been made by Newsholme. It is of special interest to note that in certain occupations there has been no decrease in death rate in recent years, whereas in the general population there has been an important decrease. In Table VIII there is presented

TABLE VIII

PROPORTIONAL MORTALITY (PERCENTAGE OF ALL DEATHS) FROM PULMONARY TUBERCULOSIS IN ENGLAND AND WALES ACCORDING TO OCCUPATIONS (*Newsholme*)

Occupation	1890–91–92	1900–1–2
Tin miner	58	83*
Hotel servant (London)	70	66
Laborer (industrial districts)	36	56
Copper miner	38	50
File maker	46	37
All occupied males	21	17

* This means that 83 per cent of all tin miners who died in the years named were victims of pulmonary tuberculosis.

a set of figures which show the appalling loss of life from tuberculosis in the occupations named. The business and professional classes have a comparatively low death rate from the disease, so that they bring down the average for "all occupied males" far below that of the majority of skilled trades or of unskilled labor.

Statistics of occupation are seldom accurate, so that not too much weight should be given to them. The high death rate in each of the trades noted above is, however, easily explained. Tin miners, copper miners and file makers come in contact with metallic dust, and the first two are underground much of the time; laborers are poorly paid and hence are likely to be badly housed and have insufficient food; hotel servants are usually men not strong enough to work in other occupations.

Tuberculosis and Poverty.—About one-tenth of the cases of poverty and destitution in the large cities are found to be due to tuberculosis, which kills or incapacitates the breadwinner of the family. On the other hand, it is likely that one-half of the cases of tuberculosis are due to poverty, for it is a disease which attacks most of all the underfed, the insufficiently clad, and the poorly housed.

When tuberculosis attacks the father of a poor family, the mother may be forced to seek employment taking her away from home. Thus the children are neglected and are likely to have insufficient and improper food. At the same time, with lack of proper home supervision the family life is destroyed and the children run the streets or must go out as wage-earners. The education of the children becomes impossible, and hence ignorance and often vice and crime are the harvest of the tuberculosis seeds sown in the body of the parent. If the mother, instead of the father, becomes a victim of the disease, the results, as must be appreciated, are hardly less disastrous. Again the children are neglected and with the same results.

In the city of Hamburg, in Germany, the annual death rate from tuberculosis per 100,000 living persons in the poorest quarter is 670, while for residents of the better parts of the city it is only 110. In New York City the boroughs of Manhattan and Bronx, in which there is great crowding, show a much higher death rate from tuberculosis than do the other boroughs where conditions of living average better.

The poor have not only insufficient food but they are often quite ignorant of proper methods of cooking and know nothing of the "balanced ration" which is made up of necessary amounts of protein, carbohydrate, and fat. It may be said that housewives of families in moderate circumstances are likewise ignorant of such matters, and this is all too true. But where there are sufficient funds, people usually have a diet made up of meat, eggs, milk, bread, butter, vegetables and fruit, so that average men and women are likely to get fairly nutritious food. The poor, however, do not know how to make the best use of the little money they have, and are hence often worse fed than need be.

The Tenement House Problem.—In all large cities many people live in tenement buildings, three- to five-story structures arranged to house a great many families in a very small space. Such buildings are cheaply constructed in the beginning and are seldom kept in good repair. The sanitary arrangements are likely to be bad and the hallways dark. Many rooms have no window at all, the only way in which air is admitted being through the door or transom from an unventilated hall. Such dark buildings are almost necessarily dirty because the dirt is not easily seen. Oftentimes no pretense is made of keeping halls clean, and in a few cases there is a pretense and that is all. So long as such insanitary tenement houses are permitted, so long will tuberculosis be a scourge of the large cities. There are certain areas in lower New York where cases of tuberculosis are reported in the same houses year after year. This condition has been strikingly pointed out by Dr. Hermann M. Briggs of the New York Department of Health. He shows maps of congested areas with a black dot for each case of the disease ("spot maps"). Two maps of the same area showing cases of tuberculosis in different years have much the same appearance. The disease persists in infected houses year after year, new cases developing to take the place of those removed by death.

It is gratifying to note that health authorities the world over are now requiring tenement buildings to be more sanitary. Regulations as to window space allotted to each room are being enforced, and larger, lighter and cleaner hallways are required. It is reported, however, that there are still many thousand bedrooms in New York City alone without a window. Hence, there is much to be done before conditions are even tolerable.

Tuberculosis and Orphanage.—Just as a great many cases of poverty may be ascribed to tuberculosis, so also may orphanage. It is no uncommon thing to find in orphan asylums children who have lost both parents through this disease. A study was made recently by an investigator[1] who examined a number of orphan asylums to determine the proportion of children there of tuberculous parents. He classes children as "tuberculous orphans" if one or both parents had the disease or died from it. In three asylums there were 216 children; of these 95, or about 44 per cent, belonged to the "tuberculosis orphan" group. In some other asylums the number was somewhat smaller, but it is certainly the case that a very large number of the inmates of orphans' homes are there because of the disease in their parents. If the death rate from tuberculosis could be reduced it would mean reduction of the number of orphans. Here again is seen how the effects of this widespread disease influence institutions which at first sight would be thought to have no interest in the suppression of the "great white plague."

Money Loss by Deaths from Tuberculosis.[2]—The rearing of children is expensive. Food, clothing, medical attention and education all require the expenditure of money by the parents. If a child dies before it is able to earn what all this costs there is a distinct money loss to the parents and to the community. Children who die at two years from miliary tuberculosis naturally do not entail so great a loss as those who die at ten from abdominal tuberculosis or

[1] Knowlton, Millard, "Tuberculosis a Cause of Orphanage," *Journal of the Outdoor Life*, Vol. VII pp. 201–4, 1910.

[2] This subject is fully considered by Professor Irving Fisher in a thirty-two page article on "The Cost of Tuberculosis in the United States, and Its Reduction" in Vol. III of the *Transactions of the Sixth International Congress on Tuberculosis.* More accessible is his *Report on National Vitality, Its Wastes and Conservation,* being an extract from *Report of National Conservation Commission* (Senate Document No. 676, Vol. III, Sixtieth Congress, 2d ed.). This work, printed in pamphlet form, is distributed by the Committee of One Hundred on National Health, New Haven, Conn.

those who succumb to consumption at twenty. These last, if they belong to the well-to-do class, have each cost from $1,000 to $5,000 or more. Even among those in comparatively poor circumstances the cost of raising and educating a child can be little less than $1,000.

Another way to determine the monetary loss due to premature death is to calculate what might have been earned by the decedent if he had lived a life of reasonable length. By turning to tables of "life expectation" it is found that if a person lives to 33 years he may, on the average, be expected to live to the age of 66. The victims of tuberculosis die, on the average, at about 33 years. Hence they are cut off 33 years before their time. If a man earn $100 a year more than the cost of his own keep, he would have earned a total of $3,300 in the time lost by his early death. Since, however, most employed persons support not only themselves but a family as well, it is evident that the average loss per year through untimely death is much more than $100. Of course, there are some who die of tuberculosis who have no occupation and are not producers. But taking all these things into consideration, it would seem that $2,000 is a very conservative estimate of the money value of the average tuberculosis victim. Most students of the subject use a figure nearly twice as large. With 150,000 deaths each year from the disease in the United States, the annual loss is therefore $300,000,000. A relatively small sum spent for prevention would undoubtedly cut down the death rate by at least one-half and save to the country $150,000,000.

Money Loss from Illness Due to Tuberculosis.—In the previous paragraph only loss due to death of the patient was considered. But every death means a case of sickness averaging two years' duration. If there are 150,000 deaths from tuberculosis per year in the United States, there must be 300,000 sick with the disease who will die. Besides these, many persons are ill but recover. If these latter cases average one year and there are 100,000 of them, the total number of persons sick in any one year with the disease is 400,000. The cost of illness could not be less than $200 on an average. This sum is very small indeed to pay for medical attention, nursing, and loss of earnings by the patient and his family. This item foots up to $80,000,000 annually for the United States, and when added to the loss due to deaths brings the total to $380,000,000.

Possible Financial Saving through Preventive Measures.—All thoughtful students of the subject will agree that one-half of the present illness and loss of life due to tuberculosis is readily preventable. Fisher places the ratio of preventability of pulmonary tuberculosis at 75 per cent. Using the smaller figure, it is evident that by education of children and the public, together with the other means well known to the medical profession, it would be possible to save one-half of $380,000,000, or $190,000,000, per annum. Here we have taken no account of the misery, the pain, and the loss of parents nor the loss of education to orphaned children. All of the vast sum of money named could be saved by the expenditure of a few millions of dollars for education and for enforcement of health laws. Eventually, with a persistent campaign, the disease might become as rare as bubonic plague and typhus fever now are in civilized communities. The sum of $190,000,000 is fifteen times the cost of operation of all the state universities in the country, and it is more than twice the annual output of gold for the United States.

Expenditure of Public Moneys for Suppression of Tuberculosis.—For a number of years the more progressive state boards and city commissioners of health in the United States have furnished circulars describing the best means for prevention of tuberculosis. The use of public funds for such purposes has never been questioned. Some of the states have already established sanatoria and others have plans for such establishment. If there be justification for maintenance by the state of the harmless insane, of imbeciles, the blind and deaf, there is also for taking care of incipient cases of tuberculosis. A cured consumptive, well and strong, able to support himself and a family, is certainly of more value to the state than a trained blind man or an imbecile. If the state spends money in educating the young, it can well spend a little more in keeping these educated young people from dying at an early age. Those who are thus saved become taxpayers and return to the state more than it expended in their care.

About 50,000 tuberculous workmen pass every year [in Germany] through these sanatoria, of whom, on an average, 75 per cent return "cured"; i.e., able to support their families for a long time to come. This represents an enormous social progress, the ultimate extent of which can hardly as yet be estimated.[1]

There are now twenty-seven states where sanatoria are authorized by law. In some of the states the county officials have authority to erect and operate sanatoria without submitting the question to the voters; in other states sanatoria can be erected only when a bond issue has been voted for the purpose by the people. The following[2] have state-supported institutions: Arkansas, Connecticut, Georgia, Indiana, Iowa, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Dakota, Vermont, Virginia and Wisconsin. In Maine such an institution is maintained by the State Sanatorium Association, a quasi-public corporation, and in Nebraska there is an arrangement by which indigent patients may be cared for at public expense in certain hospitals designated by the State Board of Health.

In communities where the establishment of sanatoria has not been secured because of objections on the ground of expense, it is probable that money could be obtained for public dispensaries. Indeed, many cities have such institutions and are operating them with great success. The small outlay of funds brings large returns in economic gains to the community.[3]

Appropriations have been made by some of the legislatures for an educational campaign by means of advertising, public lectures, dissemination of pamphlets, and by the maintenance of a tuberculosis exhibit to be carried from place to place, especially in the larger cities.

[1] Professor Gotthold Pannwitz, in a lecture reported in the *Transactions of the Sixth International Congress on Tuberculosis*, at Washington, D.C. (special volume), p. 59, Philadelphia, 1908.

[2] Information on these points was secured by correspondence with every state board of health in the country.

[3] An interesting discussion of this subject is given in *Public Health* (London, Vol. XXIV, pp. 172–73, 1911), in connection with an article by Dr. William Robertson on "A Scheme for the Municipal Control of Pulmonary Tuberculosis."

Medical research laboratories established by municipalities are doing much to further a knowledge of tuberculosis, and the money spent in their maintenance is well spent—witness the valuable work of the Research Laboratory of the Department of Health of the City of New York.[1]

In Germany, Great Britain and elsewhere it has been found possible to furnish meals to school children who were ordinarily underfed. Generally there has been an agreement between the School Board and some philanthropic organization. In other instances the entire expense has been paid out of school funds. Tubercular children have been aided to recovery and the non-tubercular have been strengthened to resist possible infection. Valuable evidence and suggestions are given by various witnesses summoned by a committee which reported to the British Parliament a few years ago upon the subject of physical deterioration.[2]

Segregation of Consumptives.—From time to time various proposals have been made concerning the enforced segregation of consumptives from the rest of the community. Such a plan seems to the writer both unnecessary and unwise.

The enforced removal of persons suffering from tuberculosis may often result in breaking up a home. In poor families if the father, for example, is obliged to go away to some distant sanatorium and thus is unable to furnish any support, or if the mother is removed and her care lost to the children, most disastrous results may follow so far as the children are concerned. If, however, only a temporary residence were required in a sanatorium, the family might be kept together through the adoption of some makeshift for a few weeks or months. Certainly, wherever possible, the home should be maintained. Charity organizations as well as the authorities should work toward this end. Even the best orphan asylum is not as good a place to bring up a child as the average home.

[1] This institution has recently published a volume on "The Relative Importance of Bovine and Human Types of Tubercle Bacilli in Different Forms of Human Tuberculosis," by William H. Park and Charles Krumwiede, Jr.—*Collected Studies from the Research Laboratory, Department of Health, City of New York*, Vol. V, pp. 1–164, 1910.

[2] *Report of the Inter-departmental Committee on Physical Deterioration* (especially pp. 70–72), London, 1904.

Enforced segregation of consumptives is unwise in that it makes the consumptive, in the eyes of his fellows, as one unclean. It is certainly not necessary for the protection of the public to keep consumptives away from the rest of the population. All that is necessary is to see that the consumptive is properly educated and that the public is made familiar with the dangers of the disease and the means of avoiding these dangers. In families where ignorance and indifference prevail, it may be necessary to remove the consumptive to some place where he can do no harm. This is a condition that would seldom arise were education in matters concerning sanitary science and hygiene to become universal. In some quarters there is now an unreasoning fear of tuberculosis which it should be the business of intelligent people to combat.

Marriage of Persons with Tuberculosis.—A social problem of much complexity is the question of marriage of consumptives. If young people were attracted only by the healthy and strong of the opposite sex, there would be no problem to be considered in this paragraph. Unfortunately, social position and wealth have so long been important factors in the making of marriages, that the attributes which should naturally attract seem to have lost much of their force.

The marriage of the tuberculous should certainly not be prohibited by law. The intimate relation of husband and wife may be maintained without the tuberculous member of the pair infecting the other; in such families healthy children may be reared. On the other hand, the natural weakness which originally permits a parent to take the disease is likely to be transmitted to the offspring and the children thus be particularly susceptible. In many families children have been known to acquire the disease from the parents. If one of the parents is tubercular the children may be weaklings. When the question is examined impartially, any thinking man or woman is likely to decide that it is unwise to marry one who has the disease in the active form. In regard to those in whom there has been full and complete recovery with no relapse in many years, there need be no fear. With merely arrested cases it is well to remember that they may develop at a later time into the active form.

Probably when the science of eugenics shall have secured a firmer footing there will be more which can be said with definiteness concerning marriage by tuberculous persons. At any rate, it would be well if young people could be taught by their parents and if it could be made the custom to seek for, in their mates, health and strength of body, mind and character. Such custom would help to decrease the prevalence of tuberculosis and insure a stronger race of men in generations to come.

Note

The most valuable collection of information on the economic and sociological importance of tuberculosis is found in Volume III of the *Transactions of the Sixth International Congress on Tuberculosis* (Washington, D.C., September 28 to October 5, 1908). The following selected list of papers will serve to illustrate the topics discussed:

"The Cost of Tuberculosis in the United States and Its Reduction"—Professor Irving Fisher.

"The Burdens Entailed by Tuberculosis on Individuals and Families"—Mr. Sherman C. Kingsley.

"The 'Piece Work' System as a Factor in the Tuberculosis of Wage Workers"—Miss Jane Addams and Dr. Alice Hamilton.

"Tuberculosis as an Industrial Disease"—Mr. Frederick L. Hoffman.

"Factory Legislation and Tuberculosis"—Mr. John Martin.

"Relation of Tuberculosis to Crime and the Incarcerated Criminal"—Dr. Julius B. Ransom.

"Study of the Relation of Prostitution to Tuberculosis"—Dr. J. Willoughby Irwin.

"Tuberculosis and the Public Schools"—Dr. Luther H. Gulick.

THE PHONETIC SYSTEM OF THE UTE LANGUAGE

By John P. Harrington

The Ute Indians held in former times nearly all of the western or mountainous half of the present state of Colorado. Their range covered also the greater part of what is now eastern Utah. To the south of the ancient Ute homeland lay the country of the Navaho; to the west and north lived the Paiute and Shoshoni, linguistically and otherwise related to the Ute; to the east roved the warring and shifting tribes of the Great Plains. Of the Indian peoples which have at various times lived within the present boundaries of the State, the Ute alone are to be regarded as Colorado's ancient and typical inhabitants. Secure in their mountain fastnesses, from the vicinity of Fort Collins in the north to that of Trinidad in the south, the Utes witnessed wave after wave of the Plains tribes surge along the eastern base of their mountainous range—Comanche, Kiowa and Kiowa Apache, and Arapaho and Cheyenne, all in historic times—swept on by the force of great tribal movements active far beyond the ken of the Utes and in no wise affecting them.

The Utes have perhaps been less studied than any other Indian people living in the United States. And this is true notwithstanding their numerical and historical importance and the remarkable primitiveness of both their life and thought even at the present day. The Ute language, habits of life, material culture, mythology and religion are equally unknown. The people of Colorado, especially the young people whose homes are in western Colorado, can render an invaluable contribution to science if they but make accurate record of what can be learned of the life and lore of this interesting people ere it is too late.

The Ute language must, of course, serve to a large extent as a basis or medium for accurate study, and it is with the hope of making a start on this great work that these imperfect notes on a difficult subject, the phonetic system of the Ute language, are presented. The investigation on which they are based was made at the Southern Ute Indian Agency, at Ignacio, Colorado, in March and April, 1910, under the auspices of the University of Colorado. The dialect is that of the Moguache (Ute: mɯɯqatʃy*u*) and Capote (Ute: k*a*pɯɯt*a*) bands of "Southern Ute," which differs only in unimportant details from the other dialects of the language. I wish to mention here with especial gratitude the names of the Regents, of President Baker, and Professors Henderson and Thompson, of the University of Colorado, Dr. Edgar L. Hewett, of the Archaeological Institute of America, Mr. E. G. Fine, of Boulder, Colorado, Mr. Charles F. Werner, superintendent of the Southern Ute Indian Agency, and Mr. James A. Turner, teacher of the Indian day school at Ignacio, Colorado, who have helped to make this study possible and successful. Other results of the investigation will be published at a later date.

The Utes belong linguistically to Brinton's "Uto-Aztecan" family of American languages, which is supposed to include many tongues of the Great Basin area, of the southwestern United States, and northern and central Mexico—notably the Ute and Paiute, Shoshoni and Comanche, Hopi, Pima and Papago, Tarahumare, Huichol and the "Nahuatl," the latter spoken by the Aztecs and other tribes of Mexico and Central America. Not one of these languages, not even that of the Aztecs, has been as yet thoroughly studied or accurately recorded. According to their material culture the Utes are supposed to resemble the Plains tribes in many respects. They appear to be closely related in every way to their western and northern neighbors, the Paiute and Shoshoni. The study of the Utes is certain to throw new light upon the problems connected with the prehistoric sedentary "cliff-dwellers" of Colorado, New Mexico and Arizona. The Hopi, a typical sedentary cliff-dwelling Pueblo people, speak a language closely related to Ute.

It appears that the Utes have no general name for themselves other than nɯɯtʃy, person, plural nɯɯtʃy*u*, people, of which Spanish "Yuta" and English "Ute" is possibly a corruption. The Utes are divided into many bands, each known by a special name, having peculiar customs and dialect, and presided over by a chief. To illustrate, an individual of the Moguache band is called mɯqatʃ*y*, plural mɯqatʃy*ɯ*. The chief (ta'wayvʙɪmʙɪ) of the Moguache is at present jɯqɯwytʃ*y*, Coyote, whose English name is "Buck-skin Charley."

The phonetic system of the Ute is more difficult than that of the majority of Indian languages. The number of "individual sounds," that is, of etymologically distinct phonetic elements, is unusually small, there being perhaps only fourteen, but these sounds, chameleon-like, constantly change their quality according to their setting, in other words, according as they are influenced by contiguous or surrounding sounds.

Those who have studied European languages know that they vary considerably as regards the differences of pronunciation permitted in the case of a single phonetic element. Thus in English one may vary the vowel of "ask" all the way from "esk" to "awsk," without seriously offending the ear. Students of European languages have also observed that the sounds of any one language vary according to their position in a "word" or sentence. Thus in English, the quality of the "a" in "m*a*n," "p*a*rt" and "w*a*ter" is clearly in each case the result of influence of surrounding sounds. The "th" of English "ba*th*" is different from the "th" of English "ba*th*e"; the "d" of German "Ba*d*" is quite another sound than the "d" of German "ba*d*en." In fact, one of the most important problems in phonetics, one emphasized by all the modern European phoneticians, is the determination of the extent and manner in which sound acts upon sound, and it has been shown that *Umlaut* and vowel and consonant harmony exist to some extent in all languages, that one sound may modify, much or little, the quality of every other sound in a long "word," and that this phenomenon and that of analogy go far toward explaining change of phonetic condition in language.

In Ute this process of modification of sound by sound has run wild. The organs of speech utter, in more or less rapid succession, sound after sound, not noticeably lengthening or stressing any one sound, but making each, in lazy fashion, as much as practicable like preceding and following sounds, that is, making short cuts and agreements, evening or levelling sounds, to a degree which would not be tolerated in any European language of which I know. Thus Ute "a" may vary from a sound as in English "m*e*t" to one similar to that in English "b*u*t," or again to one approaching that in English "*o*n" or "wh*a*t." Ute "k" appears now as a deep velar guttural, now as the "c" or "k" in English "*c*art" or "*k*ey," now as a "ky" sound approaching English "ch"—and in every instance it has its particular quality because of surrounding sounds.

No coming together of consonants exists in the Ute language. Even when in rapid pronunciation a consonant appears to follow another immediately, slower or more careful pronunciation reveals the fact that a vowel intervenes between the two consonants in question. Thus one may think he hears, for instance, k*ɯ*tρɯtʃyak*a*, "it is a hat," but k*ɯ*tɯρɯtʃyak*a* is really pronounced. Ute speech is composed of syllables of apparently practically equal length, each of which consists either of a vowel only, or of a consonant plus a vowel.

A peculiar and difficultly acquired feature of the Ute language is the existence of a voiceless counterpart of every voiced sound. Voiced and voiceless counterparts require exactly the same position of the oral and nasal organs. The only difference is that in pronouncing voiced sounds the vocal cords vibrate, whereas in pronouncing voiceless sounds the vocal cords do not vibrate. Voiceless sounds are not whispered. Whispering requires a special adjustment of the larynx. They merely lack voice, as can be easily demonstrated by laying the fingers on the larynx while voiced and voiceless sounds are being produced. In the case of voiced sounds the vibration can be plainly felt, which in the case of voiceless sounds is lacking. The vowels of final syllables are either wholly or partially voiceless, having their final portion at least without voice, that is, ending in voiceless breath of the timbre of the vowel. Also many not final syllables appear occasionally without voice, for reasons not understood.

All the Ute vowels are normally pronounced with the tongue lying more or less flat on the floor of the mouth. They therefore belong in greater or lesser degree to Sweet's "mixed" series, in which neither the front nor the back portion of the tongue is greatly raised. This general position of the tongue imparts to the vowels an "impure" resonance which reminds one of the timbre of English "u" in "b*u*t." Theoretically, vowels of this series are made with minimum muscular effort.

The Ute vowels seem to be only four in number, namely a, y, ы and ɯ. (See below.) With regard to this small number of etymologically distinct vowel sounds one should compare Ute with the Salishan languages spoken in the Northwestern United States and possibly related to Ute, which distinguish the vowels a, ɐ, e and o only, or again with our European Russian, which uses only a, e, i, o, u and ы, whereas the Tewa language of New Mexico possesses with just as great certainty at least twelve vowel sounds, and our English distinguishes, as is well known, at least sixteen different vowels.

Two imperfectly fused diphthongs are also heard in Ute: ay and aɯ.

The two semivowels, j and w, have, like the vowels, a peculiar "mixed" resonance.

The only laryngeal consonant is the glottal stop, produced by closing the glottis by means of the vocal cords. This stop forms the termination of many vowels in *Inlaut*, being especially audible before continuant consonants such as n, s, v. Occasionally it is faintly heard between two otherwise contiguous vowels, or again it is used to break a vowel the portion of which following the stop is voiceless. An illustration of such vowel breaking would be the monosyllabic "word" mы'ы̱, "hand." The glottal stop is in this article indicated by the apostrophe.

The series of stops k, kw, t, tʃ and p probably approach most nearly to Siever's series of unaspirated "Sprengtenues." The organs exploding in their production are tense, they are not accompanied by voice during the period of occlusion and are not followed by an audible outrush of breath. Usually, but not invariably, they are either preceded by a voiceless vowel or by no sound at all, or are followed by a voiceless vowel; occasionally they occur between two voiced vowels, as in mataqɯtʃ*y*, the moon. The stops in their acoustic effect upon the English-speaking person are intermediate between "k" and "g," "kw" and "gw," "t" and "d," etc., respectively, chiefly because they lack the aspiration characteristic of the English "k," "kw," "t," etc. Corresponding to each stop, with exception of tʃ, is (1) a voiced, and (2) a voiceless fricative continuant of similar articulatory position. Thus to k correspond q (open g as in some pronunciations of German "sagen") and x (German "ch" as in "ma*ch*en"). To kw correspond qw and x*w*. The stop t has as corresponding continuants ρ (a peculiar untrilled r) and ꝗ (the same sound voiceless). The stop p has as corresponding continuants v (bilabial v as in some pronunciations of German "*W*asser") and f (bilabial f as in some pronunciations of Japanese "*F*ujiyama"). No continuants appear to correspond to the stop tʃ. The voiced continuants occur only between two voiced vowels, and the voiceless continuants are heard only when a voiced vowel precedes and a voiceless vowel follows. The continuants appear to be connected in some more or less irregular way with the stops. The more the matter is studied the more perplexing it seems. Thus although kan̥*y*, house, and nɯqan̥*y*, tipi, are clearly related, and avatʃ*y* is clearly the Spanish and English word Apache, p and f both appear after a voiced and before an unvoiced vowel, as in tывɯpы, earth, but ыыfы, bone. The reason why now stop, now continuant appears may be a historical one. Thus Latin "*p*ersona," Spanish "*p*ersona," but Latin "ca*p*ra," Spanish "ca*b*ra," pronounced "ca*v*ra."

The continuant s is voiceless and less "sh"-like than the element following the t in the consonantal diphthong tʃ, which is accordingly written tʃ (ʃ like English "sh") instead of ts. The continuant s appears in every position in which it is possible for any consonant to occur in Ute and nowhere exhibits great modification of quality.

The nasal consonants n and m have each a voiceless counterpart: n̥ and m̥. The sounds n̥ and m̥ appear only before voiceless vowels. The beginning portion of n̥ or m̥ is voiced when the preceding vowel is voiced. A sound like English "ng" seems not to occur in the dialect examined.

The language does not seem to distinguish between orinasal and purely oral sounds. Only in the instance of the vowels ы and ы̲ is nasality occasionally markedly audible, and this is probably due to the tongue-position of the vowel. Nasality has been indicated in this article by placing an exponent n (^{n}) after the vowel-symbol.

No procedure would at this time be more dangerous than an attempt to lace the Ute sounds into the straight-jacket of a normalized orthography. We present the Ute "words" of this article spelled in a purely empirical manner, just as they were heard, without altering or systematizing their orthography in the slightest degree. Only a few diacritical marks, originally added to indicate delicate nuances of quality caused by surrounding sounds, have been omitted, and this largely for typographical reasons.

The sounds of the Ute language are exemplified by the following lists of words grouped according to sounds which they contain in common. The alphabetic order is scientific, not traditional.

I. Vowels

a

The sound here symbolized by "a" resembles that of English "a" in "f*a*ther." It varies to the continental sounds of e or o, or to the sound of "u" in English "b*u*t."

pa'avy*ш*, worms
ыaf*y*, salt
atʃы̲, bow (the weapon)
ta'wayvыть̲ы̲, chief
sap*y*, belly
masыf*y*, fingers
nыvaf*y*, snow
pawыtʃ*y*, beaver
kwyjaqatы, bear
t*ш*kшaf*y*, meat

ta*a*, shirt
tatʃ*y*, summer
ka'*a*, sing thou!
avat*y*mъ*a*sыwыnъ*a*, thumb
nɯqanъ*y*, tipi
kanъ*y*, house
tawatʃ*y*, sun
ta'watʃ*y*, man
k*ɯ*kwap*y*, wood
wykanyp*ɯ*, old houses, ruins
paqыы, fish
pa*a*, water
nana'sytʃ*y*, butterfly
paρыy*a*, elk
patʃɯk*ɯ* otter
тыpɯtʃyjanykыpɯnyk*a*, I saw a stone
takыytʃ*y*, crow
tɯwa'ρytы, night
pa'ɯaqы, rain
pap*y*, blood
syjajyn*y*, it is cold

a

This sound is the same as "a" except it is not accompanied by voice.
ы*a*, arrow
nыnay nap*a*, my foot
ka'*a*, sing thou!
avat*y*mъ*a*sыwыnъ*a*, thumb
*wa*tʃɯwynъ*y*, four
wa*wa*tʃɯwynъ*y*, eight
sɯwaρɯqɯmъ*a*sыwynъ*y*, nine
nы^{n}' *a*, I
p*a*kwanъ*a*, frog
nыway kwyp*a*, he hit me
kayp*a*, mountain

y

The letter "y" has been used to indicate what seems to be normally an "impure" open y or i sound similar to that in English "symbol" or "p*i*n." It varies toward "ee" of English "k*ee*p" or toward a sound similar to that represented in German by ö. After p, v, f, ɱ and m it sounds like English "wi" in "*wi*th," or like "y" in Russian "m*y*lo," soap.

wayjyыɱ*y*, two
wytʃ*y*, knife
paavy*ɯ*, worms
wytatʃ*y*, little knife
jɯqɯwytʃ*y*, coyote
tytʃ*y*, head
ымy t*y*tʃyvы*a*, your hair
pyjɯp*y*, heart
tɯpytʃы̲, rock, stone
*wa*tʃɯwyɱ*y*, four
sɯwysы, one
na'na'sytʃ*y*, butterfly
pы'yf*y*, somebody's eye
mana'ajɯqwy*y*, you 3+ people are sitting
takыytʃ*y*, crow
pɯtʃyf*y*, star
tɯwa'*ρ*ytы̲, right
wytʃytʃ*y*, bird
pyqwa'*y*, go thou to sleep!
kwypы̲, smoke
пынay py*y*, my breast
yvykaɱ*y*, a house built of lumber
mɯsɯt*ɯ*kwytʃ*y*, bobcat
kы*ρ*ыky*y*, get thou up!

y

This symbol designates voiceless y. This sound gives a preceding tʃ a very ts-like quality.

wytʃ*y*, knife
ыaf*y*, salt
wytatʃ*y*, little knife
nыnay kwy*y*, my neck
nыvaf*y*, snow
nыnay t*y*tʃyvы*a*, my hair
tɯkɯaf*y*, meat
pыыf*y*, skin, fur, hair
tatʃ*y*, summer
kaɥ*y*, house
tawatʃ*y*, sun
kɯkwap*y*, wood
pы'*y*, eye
sыnawaf*y*, God
nɯp*y*, liver

ы

The sound represented by this character, the Russian 'jery,' resembles the German ö or ü to a slight degree. It is less "hard" than the Russian sound symbolized by ы. It can perhaps best be described as a sound like that in English "b*u*t," but with the angle of the jaws much more acute. One hears the sound occasionally in the groaning of an English speaking person. The mouth is slightly open, the lips are inactive, the tongue rests flatly on the floor of the mouth. It occasionally has a nasal tinge, especially when in contact with n or m.

ыaf*y*, salt
nыna*y*, my
pыы̲, trail, road
pыыf*y*, skin, fur, hair
manыqыɥ*y*, five
nыnay tыp*a*, my mouth
nыnay mыvыtы'ы̲, my nose
pы'*y*, eye
sыnawaf*y*, God

sakamыpɯtʃы̱, jack rabbits
tыvɯpы̱, earth
ɯwыf*ɯ*, grass, hay
nы'ы tʃ*a*katʃyqыtы̱, I have a brother
nыvaf*y*, snow
nыnay mы'ы̱, my hand
mыⁿtatatʃ*y*, humming bird
ыⁿmъ*y*, thy
nыⁿnay mыⁿ*a*'avy*y*, my father is lying

ы̱

The voiceless counterpart of ы is ы̱.
kwypы̱, smoke
atʃы̱, bow (the weapon)
tɯpytʃы̱, rock, stone
sɯwysы̱, one
na'atы̱, fire
tыpɯtʃы̱, stone, rock
towa'*ρ*ytы̱, night
pa'ɯ(w)aqы̱, rain
paqыnaqa*ρ*ыqы̱, cloud

ɯ

This character represents an open u or close o sound similar to English "u" in "p*u*t." It often has a very "mixed" resonance. Occasionally it is heard as close "u" as in German "Schule."
ɯ*a*, arrow
ɯъ*y*, bow and arrows
jɯqɯwytʃ*y*, coyote
kɯtʃ*ɯ*, buffalo
t*ɯ*kɯaf*y*, meat
tɯmъ*ɯ*, winter
nɯqaъ*y*, tipi
mɯsɯt*ɯ*kwytʃ*y*, bobcat
patʃɯk*ɯ*, otter

nыnay mɯqɯ*ɯ*, my heart
ɯwыf*ɯ*, grass, hay
pɯtʃyf*ɯ*, star
pa'ɯ(w)aqы̱, rain
sɯwysы̱, one
tыpɯtʃ*y*, rock, stone

ɯ

This is the voiceless sound corresponding to ɯ. It is very frequent as one of the plural-forming postfixes.

pa'avy*ɯ*, worms
nыnay sap*ɯ*, my belly
kɯtʃ*ɯ*, buffalo
t*ɯ*kɯaf*y*, meat
tɯmъ*ɯ*, winter
mɯsɯt*ɯ*kwytʃ*y*, bobcat
wykanyp*ɯ*, old houses
ɯwыf*ɯ*, grass, hay
tʃɯtʃ*ɯ*, pipe (used in smoking)
nɯtʃy*ɯ*, Ute Indians

2. Diphthongs

ay

The sounds a and y coming together seem to blend to a more or less perfect diphthong.

maykavaypɯnyk*a*, I see the horse
wayjɯynъ*y*, two
ta'wayvыmъы̱, chief
nыnay nap*a*, my foot
navayjɯynъ*y*, six
navayka'vanъ*y*, seven
kayf*a*, mountain

a*y* (?)

This combination has not been noted.

aɯ

The sounds a and ɯ blend to form an imperfect diphthong.

kavaɯpɯnyk*a*, I see the horses

nɯnay aɯx*ɯ*, my tongue

a*ɯ*

This combination is common as the last syllable of plural forms the singular of which ends in -a.

pa*p*ya*ɯ*, elks

3. Semi-Vowels

j

The letter j is here used to represent a sound similar to that of German j, English consonantal y, but of the same quality as Ute y. In many instances Ute j is undoubtedly a parasitic vowel-glide between two vowels one of which is y, such as meets us in Sanskrit "dhiyā," instrumental case of "dhīṣ̌," 'thought.' Thus kwyjaqat*a* or kwyaqat*a*, bear (the animal).

jɯqɯwytʃ*y*, coyote

jak*wa*p*ɯ*, dead

wayjɯyn*y*, two

kwyjaqat*a*, bear (the animal)

pyjɯp*y*, heart

navayjɯn*y*, six

mamɯsɯqɯsɯja'wyk*a*, they 3+ are standing

tɯpɯtʃyjanykɯpɯnyk*a*, I saw a stone

syjajyn*y*, it is cold

j (?)

No voiceless counterpart of j has been noted.

w

The sound here represented by w is perhaps in reality nothing but a short ɯ. Ute w : ɯ : : j : y. Like j, the Ute w is frequently a mere parasitic vowel-glide between two vowels one of which is ɯ, comparable to w in English 'áuwer' for 'aur,' "hour." Thus jɯqɯ-wytʃ*y* or jɯqɯytʃ*y*, coyote.

wytʃ*y*, knife
ta'wayvыmъы̱, chief (cf. ta'watʃ*y*, man)
pawыtʃ*y*, beaver
tawatʃ*y*, sun
sɯwysы̱, one
tawynɯwayja'wyk*a*, they 3+ are standing
ɯwыf*ɯ*, grass, hay
sыnawaf*y*, God
wytʃytʃ*y*, bird
sawa*p*yt*y*, flower

w

Voiceless w was noticed only in two words:
*wa*tʃɯwynъ*y*, four
wa*wa*tʃɯwynъ*y*, eight

4. Larynx Consonants

'

The Ute language presents no h sound or other laryngeal consonant than the glottal stop. This is made, as stated above, by closing the glottis by means of the vocal cords, and appears perhaps in three positions. It is a slight sound and was usually nearly or quite omitted by the speakers. It is written by the apostrophe.

1. It occurs before continuant consonants or semi-vowels:
ta'wayvыmъы̱, chief
manыqы'nъ*y*, five
navayka'vanъ*y*, seven
na'na'sytʃ*y*, butterfly
tamy'qɯsы̱ka*p*y*y*, we 2 are sitting
tɯwa'*p*ytы̱, night
nɯnɯ'nɯqы̱qы̱, thunder

2. It occurs between two otherwise contiguous vowel sounds:
nыnay tytʃyvы'*a*, my head-hair
pы'*y*, eye
pы'yf*y*, somebody's eye

pa'ɯaqы̲, rain
nы'aqы̲, wind

3. It is used to break a vowel the portion of which following the stop is voiceless.

nыnay mы'ы̲, my hand, or it is my hand
ta'*a*, shirt
ka'*a*, sing thou!
nы'ы̲, I
nыnay mыvыtы'ы̲, my nose, or it is my nose

5. Back of Tongue Consonants

k

The value of k is that of an unaspirated "Sprengtenuis" such as may be heard in South German.

kɯtʃ*ɯ*, buffalo
t*ɯ*kɯafy, meat
ka'*a*, sing thou!
navayka'vaъ*y*, seven
kaъ*y*, house
yvykaъ*y*, house built of lumber
wykanyp*ɯ*, old houses
tamy'qɯsыkaq*y*, we 2 are sitting
takыytʃ*y*, crow (the animal)
katʃы̲, no

q

The voiced spirant corresponding to k is q. It has the value of German "ch" in "a*ch*," voiced.

jɯqɯwytʃ*y*, coyote
kwyjaqatы̲, bear (the animal)
sɯwaᴘɯqɯъ*a*sыwyъ*y*, nine
tɯqɯъ*a*sыwyъ*y*, ten
nɯqaъ*y*, tipi
paqы'ы̲, fish
masы'qɯwyъ*y*, he is standing

mataqɯtʃ*y*, moon
tɯqы'af*y*, rattlesnake
pa'atɯqымывыты'ытʃ*y*, mosquito
paqынaqaqы̲qы̲, cloud
paqawytʃ*y*, dragonfly, Navaho
paqaρыqы̲, lake
paq^{m}atʃ*y*, Ouray Ute Indian
тыqыwyть*y*, friend

x

The voiceless continuant corresponding to k is x, pronounced like German "ch" in "a*ch*." It was observed in one word only.

nыany aɯx*ɯ*, my tongue

6. Labialized Back of Tongue Consonants

kw

The sound of k coalesced with following w seems to be felt by the speakers of Ute as a single phonetic element. It is a frequent sound.

kwyры, smoke
kwyjaqatы̲, bear (the animal)
mɯsɯt*ɯ*kwytʃ*y*, bobcat
k*ɯ*kwap*y*, wood
takwaытʃ*y*, crow (the animal)
kwavyjyramɯsы̲, we 3+ are lying
p*a*kwaть*a*, frog
nыway kwyp*a*, he hit me
tɯkwaρɯть*ɯ*, negro

k*w*

The sound of k followed by voiceless w also occurs, always before a voiceless vowel.

k*wy*paрьы̲, he hit
jak*wa*p*ɯ*, dead
k*wa*kwatʃ*y*, Mexican

qw

The voiced continuant corresponding to kw is qw.
nымynɯway jɯqwy*y*, we 3+ are sitting
payjɯqwajysынынъ*ɯ*jɯqwy*y*, 3 of us are sitting
pyqwa'*y*, go thou to sleep!

x*w* (?)

The voiceless counterpart of qw was not noted.

7. Front of Tongue Consonants

t

Ute "t" is an unaspirated "Sprengtenuis" made by exploding the tongue from the alveolar part of the roof of the mouth.

wytats*y*, little knife
ta'wayvынъы̲, chief
tytʃ*y*, head
ta'*a*, shirt
tɯnъ*ɯ*, winter
tatʃ*y*, summer
tawatʃ*y*, sun
ta'watʃ*y*, man
tamy'qыsы̲kaq*y*, we 2 are sitting
mataqɯtʃ*y*, moon
takыytʃ*y*, crow (the animal)
tɯwa'*ρ*ytы̲, night
tыvɯpы̲, earth
kwyjaqat*a*, bear (the animal)
nынay tytʃyvы'*a*, my head-hair
t*ɯ*kɯaf*y*, meat
avat*y*nъ*a*sыwынъ*a*, thumb
mɯsɯt*ɯ* kwytʃ*y*, bobcat
na'atы, fire

ρ

The voiced continuant corresponding to t is *ρ*. The "l" of words of foreign origin appears in Ute as *ρ* or q.

sɯwaρɯqɯmъ*a*sыwyrъ*y*, nine
tamy'qɯsы̲kaρy*y*, we 2 are sitting
saρytʃ*y*, dog
paρыy*y*, elk
tɯwa'ρytы̲, night
paqыnaqaρыqы, cloud
paqaρыqы̲, lake
рыwыρatʃ*y*, Pueblo Indian
tɯkwaρɯmъ*ɯ*, negro
sawaρyt*y*, flower
kыρыky*y*, get thou up!
k*ɯ*tɯρɯtʃyak*a*, it is a hat

q

The voiceless counterpart of *ρ* is q. It occurs perhaps only after a voiced and before a voiceless vowel.

pa'ɯ(w)aqы̲, rain
paqыnaqaρыqы̲, cloud
nы'aqы, wind
nɯnɯ'nɯρыqы̲, thunder
paqaρыqы̲, lake
sɯwyыsы̲ panakaqы̲, one dollar
panakaqы̲, money
tyavɯq*ɯ*, devil (< Spanish diablo)

tʃ

This is a sound intermediate between English "ch" as in "*ch*ew" and German "z" as in "zehn." It is a stop followed by a glide of the timbre of English "sh" or "s." Before final unvoiced y (*y*) it sounds especially much like German "z." No continuants corresponding to tʃ have been discovered.

nыnay t*y*tʃyvы'*a*, my head-hair
*wa*tʃɯwyrъ*y*, four
patʃɯk*ɯ*, otter
pɯtʃyf*y*, star
wytʃytʃ*y*, bird

watʃytʃ*y*, antelope
tʃɯtʃ*y*, pipe (for smoking)
nы'ыtʃ*a*katʃyqыtы̱, I have a brother
atʃы̱, bow (the weapon)
kɯtʃ*ɯ*, buffalo
tatʃ*y*, summer
katʃы̱, no
wytʃ*y*, knife
tytʃ*y*, head

s

The continuant voiceless fricative "s" appears in all positions. It often sounds much like English "sh" (ʃ).

nынay sap*ɯ*, my belly
nынay masыfy, my fingers
avat*y*m*a*sыwыn*a*, thumb
sɯwaᴘɯqɯm*a*sыwyn*y*, nine
mɯsɯt*ɯ*kwytʃ*y*, bobcat
sɯwysы̱, one
na'na'sytʃ*y*, butterfly
tamy'qɯsы̱kaq*y*, we 2 are sitting
sakamыpɯtʃы̱, jack rabbits
syjajyn*y*, it is cold
sawaᴘyt*y*, flower

n

N is a nasal consonant of the same tongue position as t.

nынay nap*a*, my foot
nы^{n}vaf*y*, snow
nɯqan*y*, tipi
nы'ы̱, I
na'na'sytʃ*y*, butterfly
na'atы̱, fire
nɯnɯ'nɯᴘыqы, thunder
nɯp*y*, liver
nɯtʃ*y*, Ute Indian

ɲ

The anterior portion of voiceless "n" is often wholly or partly voiced.
шɲ*ш*, bow and arrows
masыwыɲ*a*, finger
nшqaɲ*y*, tipi
kaɲ*y*, house
k*w*ypaɲы, he hit
p*a*kwaɲ*a*, frog
syjajyɲ*y*, it is cold
tыqыwыɲы, friend

8. Lip Consonants

Ute p is an unaspirated "Sprengtenuis" made by exploding the two lips.

payjyɲ*y*, three
pa'avy*ш*, worms
nыnay pyy, my breast
pыы, trail, road
pawytʃ*y*, beaver
pyjшp*y*, heart
pыыf*y*, skin, fur, hair
paqыы, fish
pa*a*, water
patʃшk*ш*, otter
pы'*y*, eye
putʃyf*y*, star
pa'ш(w)aqы, rain
pap*y*, blood
paqш(w)atʃ*y*, Ouray Ute Indian (origin of the name "Paiute"?)
nыnay sap*ш*, my belly
k*ш*kwap*y*, wood
wykanyp*ш*, old houses, ruins
nыnay tыp*a*, my mouth
p*a*kwaɲ*a*, frog

nɯp*y*, liver
tыvɯpы, earth

v

The voiced counterpart of p is the bilabial fricative continuant v, which appears only between two voiced vowels.

pa'avy*ɯ*, worms
ta'wayvыrьы̲, chief
nы^{n}vaf*y*, snow
navajyы*y*, six
navayka' varь*y*, seven
yvykarь*y*, house built of lumber
nынay mыvыtы'ы̲, my nose
may kavay pɯnyk*a*, I see the horse
tɯqы'avy*ɯ*, rattlesnakes
tyavɯq*ɯ*, the devil (<Spanish diablo)
avatʃ*y*, Apache, Indian (<Spanish Apache)
tыvɯp*y*, earth

f

Bilabial f is the voiceless counterpart of v. It occurs only before voiceless vowels.

ыaf*y*, salt
nынa*y* masыf*y*, my fingers
nыvaf*y*, snow
t*ɯ*kɯaf*y*, meat
pы'yf*y*, somebody's eye
tɯqы'af*y*, rattlesnake
ɯwыf*y*, grass, hay
pɯtʃyf*y*, star
sынawaf*y*, God
kayf*a*, mountain

m

M is a nasal consonant of the same lip position as p.

nынay mы'ы, my hand
ы^{n}my t*y*tʃyvы'*a*, your hair

manыqы'ӈy, five
mɯsɯtɯkwytʃy, bobcat
ta'my'qɯsы̱kaqy, we 2 are sitting
mataqɯtʃy, moon
nынay mɯqɯɯ, my heart
mɯqatʃy, Moguache Indian
mɯwatavywatʃy, White Rock Ute Indian

ӎ

The anterior portion of voiceless m is often wholly or partly voiced.
tɯmɯ, winter
avatyӎasыwыӈa, thumb
sɯwaρɯqɯӎa sыwyӈy, nine
tɯqɯӎasыwyӈy, ten
paӎasыwyӈy, thirty
tɯkwaρɯӎɯ, negro

According to the foregoing forms the "individual sounds" of Ute appear to be:

Vowels

	a *a*	
y *y*	ы ы̱	ɯ *ɯ*

Semi-Vowels

j *j* (?)		w *w*

Consonants

'		
k	q	x
kw	qw	x*w* (?)
t	ρ	q
tʃ		
s		
n	ӈ	
p	v	f
m	ӎ	

The following words illustrate some striking instances of modification of sound by sound.

a) Vowel harmony. Thus manaqaтъ*y* for manыqы̲тъ*y*, five.

b) *Umlaut.* Thus mamыsыqɯsыja'wykʸ*ä* for mamыsыqɯsыja'wyk*a*, they 3+ are standing.

c) Palatalization of a consonant by a vowel. Thus mamыsыqɯsыja'wykʸ*ä* (with palatal kʸ) for mamыsыqɯsыja'wyk*a*, they 3+ are standing.

d) Labialization of a vowel by a consonant. Thus pyjɯp*wy* for pyjɯp*y*, heart.

e) Epenthesis. This is perhaps the most interesting of the phenomena. By epenthesis we understand the appearance of the same vowel both before and after a consonant, the consonant itself, of course, partaking of the timbre of the vowel. Thus tamynыway wыnыы̲, we 2 (inclusive) are standing, but nыmыynыway wыnыы̲, we 2 (exclusive) are standing (ыy for y because of preceding ы); mamыsыqɯsыja'wykʸy*ä* for mamыsыqɯsыja'wyk*a*, they 3+ are standing (y*ä* for *a* because of preceding y); kaᴘayjытъы̲ for kaᴘyjытъы, I am sitting (ay for y because of preceding a). This is the same phenomenon that we have in Old English speech. This Anglo-Saxon feolu for felu, much; mioluc for miluc, milk.

f) Vowels mutually change place. Thus the Indians say indifferently either typɯtʃ*y* or tɯp(w)ytʃ*y*, rock, stone. This is probably to be explained in the following manner: the more original form is probably tɯp(w)ytʃ*y*. The p labializes the anterior portion of the y, producing a parasitic w, and this is strengthened by the ɯ of the preceding syllable until it produces a form tɯp(w)ɯtʃ*y*. But the ear requires a y sound in the first syllables of the word. And so the form typ(w)ɯtʃ*y* may originate.

Typographical impracticabilities prevent further discussion of these interesting changes here.

Perhaps there never has been, and never again will be, as good an opportunity for learning about the Utes as there is right now. The schools established by the Government and otherwise have made it possible to obtain intelligent interpreters for all the dialects, and the settlement of the region by whites has rendered sojourn among the Indians pleasant and convenient, *while the things of the past are still remembered, retained and cherished.* There is crying need for young students and others who will investigate these aborigines of western Colorado.

Such work requires little or no special training. It requires honesty, common-sense, a well-rounded education and diligence. Correspondence is earnestly invited concerning any matters pertaining to the Utes, and the University will assist any investigation of this interesting people according to its best ability.

Volume VIII Number 4

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FRANCIS RAMALEY
EDITOR

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CONTENTS

THE FAUNA OF BOULDER COUNTY, COLORADO[1]

By T. D. A. Cockerell

Boulder County has an area of only 751 square miles, but within its borders are four or five different life-zones, the altitudes ranging from a little over 5,000 to 14,271 ft. The mean annual rainfall is said to be about 17 inches, and the mean annual temperature 45° to 50° Fahr., but these figures lose much of their significance in view of the very different conditions obtaining in different parts.

A catalogue of the flowering plants and vascular cryptogams of the county, by Dr. Francis Daniels, will shortly be published by the University of Missouri. This list is fairly complete, but the enumeration of the fauna is much more difficult. The vertebrates have been recorded about as well as the higher plants, but the invertebrate fauna is still very incompletely known and undoubtedly includes multitudes of species not yet collected and identified, a fair proportion altogether new to science. The synopsis which follows must therefore be regarded only as a beginning, and it is hoped that in course of time it will be replaced by another, representing a much more advanced stage of knowledge. This desirable advance will be possible only through the co-operation of many workers, the field being much too large to be covered by any individual.

Several groups not mentioned in the present contribution have been reviewed in previous numbers of these studies, as follows: Birds, Vol. VI, No. 3; Fishes, Vol. V, No. 3; Mollusca, Vol. IV, Nos. 2 and 3; Crustacea, Vol. V, No. 4; Bees, Vol. IV, No. 4, and VII, No. 3; Scale Insects, Vol. II, No. 3; Ants, Vol. VII, No. 4.

[1] *Publication of the Colorado Biological Survey*, No. 1. The Biological Survey of Colorado was organized recently by the Regents of the State University, with Professors Ramaley, Cockerell and Henderson in charge. It is intended to continue and amplify the work (long in progress without definite organization) on the fauna and flora of Colorado, living and extinct. While the work has been organized at the State University, we hope to secure the co-operation of naturalists in various parts of the state and of specialists in other states.

Boulder County contains the type-localities of the following vertebrates:

MAMMALS: *Eptesicus pallidus* Young, *Eutamias operarius* Merriam, *Evotomys gapperi galei* Merriam, *Neotoma fallax* Merriam, *Phenacomys preblei* Merriam.

BIRDS: *Dryobates villosus monticola* Anthony, *Megascops asio maxwelliæ* Ridgway (in part).

FISHES: *Notropis universitatis* Evermann & Cockerell, *Richardsonius evermanni* (*Leuciscus evermanni* Juday).

The type-localities of very many invertebrates are in Boulder County, and will be indicated in the treatment of the different groups. There are indications, especially noticeable in the flora, that during Pleistocene or early post-Pleistocene time the climate of the county was less arid, and the biota of the eastern states spread westward through Nebraska, invading the foothill region of Colorado. This invasion appears to be quite distinct from the northern element spreading down the Rocky Mountain chain. Its members now suffer from the more arid conditions, and survive only in more or less isolated spots, as may be observed in various places in northeastern Colorado. In several cases, at least, the specific types have been altered, so that we have endemic forms, sometimes of extreme rarity. Such are the birch *Betula andrewsii* A. Nelson, the fern *Asplenium andrewsii* A. Nelson, and certain species of *Cratægus* in our county. The discovery and study of these forms is of extreme interest to the student of evolution.

Species which have been found on the University campus are marked with an asterisk.

PHYLUM **PROTOZOA**

For a modern classification see Calkins, *Protozoölogy* (1909). For our species, see these *Studies*, Vol. IV, p. 261, and Vol. VI, p. 305.

SUBPHYLUM **Mastigophora**

Protozoa in which the kinoplasm is concentrated in the form of one or more vibratile or undulating motile processes, called flagella, or in a kinetonucleus which may lie inside or outside of the trophonucleus. Simplest forms closely related to bacteria (Calkins).

Class ZOOMASTIGOPHORA

Flagellated forms in which animal characteristics are predominant (Calkins).

Order *MONADIDA*

Organisms of simple structure with one or more flagella at one end.

The *Deinamoebidæ*[1] (Rhizomastigina of Bütschli) have both flagella and pseudopodia. The others are without definite pseudopodia.

Family ANTHOPHYSIDÆ (heteromonadina Bütschli)

With two flagella, but one often not readily visible.

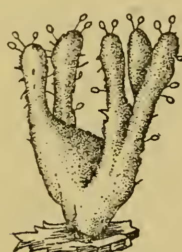

Fig. 1.

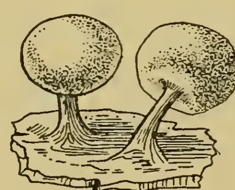

Fig. 2.

Fig. 1.—*Ceratiomyxa mucida.* Sporophore, greatly enlarged. (After Lister.)
Fig. 2.—*Physarum nutans.* Two sporangia, much enlarged. (After Lister.)
Drawings by Miss Edith Farrington.

Subfamily ANTHOPHYSINÆ (dendromonades Stein)

Colony-forming.

(1) **Anthophysa** Bory de St. Vincent. Animals united in compact clusters, often attached to a somewhat rigid, simple or branched stalk. Bodies pear-shaped, each with two flagella of unequal length (Edmondson). *A. vegetans* (Müller). Detached clusters roll through the water in the manner of *Volvox.*

Order *HETEROMASTIGIDA*

The essential morphological characteristic is the possession of two or more flagella, one or two of which are directed downward and backward, while the other is directed forward and used in locomotion (Calkins).

Family NOTOSOLENIDÆ

(2) **Notosolenus** Stokes. Oval or subangular, flattened, concave on one side, rigid, with the long flagellum straight and stiff, vibratile at end. *N. opocamptus* Stokes.* Length of body 12 μ.

[1] Concerning the identity of *Mastigamoeba* with *Deinamoœba*, see Penard, *Ann. Soc. Zoöl. Suisse,* Vol. 17, fasc. 2 (1909).

Family ANISONEMIDÆ

(3) **Anisonema** Dujardin. Subcuneate in form, with two flagella, one directed backward, trailing beyond the end of the body; a distinct mouth. *A. acinus* Duj. Length 25 μ.

Order *EUGLENIDA*

Flagella one or two, at the base of which is a mouth; often possessing chlorophyll (Edmondson).

Family EUGLENIDÆ

Usually green, with red "eye-spots."

(4) **Euglena** Ehrenberg. Elongate, usually bright green; one flagellum. *E. viridis* Ehr.*; *E. deses* Ehr.* The first of these is pointed, the second blunt, at the aboral end.

(5) **Eutreptia** Perty. Like an elongate *Euglena*, but with two flagella, and remarkable peristaltic movements. *E. viridis* Perty.

(6) **Phacus** Nitzsch. Flat, more or less leaf-like, pointed at the aboral end; color green. Known from *Euglena* by the much broader form. *P. pleuronectes* (Müller)*; *P. longicaudus* Ehr.* The latter has the pointed end relatively long, usually straight.

Family ASTASIIDÆ

Body colorless and without eye-spots; shape much like *Euglena.*

(7) **Astasia** Ehrenberg. Elongate, plastic, changeable in form; flagellum single. *A. trichophora* Ehr.*

Family PERANEMIDÆ

Body persistent in shape and plastic; flagella one or two (Edmondson).

(8) **Petalomonas** Stein. Broad-cuneate, the aboral end rounded; one long flagellum; shape persistent. There is a groove leading back from the base of the flagellum. *P. mediocanellata* Stein.

Class PHYTOMASTIGOPHORA

Flagellated forms in which the plant characteristics, if not predominant, are clearly marked. Here are classified the majority of complex colony-forming types, but the single cells are invariably of simple structure, possessing eye-spots, pyrenoids, and yellow, green or brown chromatophores (Calkins).

Subclass PHYTOFLAGELLATA

Order *CHRYSOFLAGELLIDA*

With yellow chromatophores.

Family CRYPTOMONADIDÆ

(9) **Chilomonas** Stein. Elongate-oval, anterior end with a lip-like projection; two flagella, both directed in advance. *C. paramœcium* (Ehr.).* Length 25–40 μ.

Subclass DINOFLAGELLATA

With yellow or brown pigment, two or more flagella, and usually a shell of cellulose secreted in the form of plates.

Order *DINIFERIDA*

With furrows, one transverse, the other longitudinal (Calkins).

Family **PERIDINIIDÆ**

Cross-furrow near middle of body, without wide ledges.

(10) **Peridinium** Ehrenberg. Covering of polygonal plates. *P. tabulatum* (Ehr.).

(11) **Glenodinium** Stein. Covering delicate, without evident structure. *G. cinctum* Ehr.

(12) **Gymnodinium** Stein. Without membrane surrounding body; a complete furrow around body. Our species* has not been identified.

Subphylum **Mycetozoa** De Bary (Myxomycetes)

I follow Calkins in placing these with the Protozoa, but the botanists regard them as plants. Lister (*Guide to the British Mycetozoa*, 1903) defines the group thus: The Mycetozoa are a group of organisms which may be placed on the border-land between the animal and vegetable kingdoms. They are characterized by the constant sequence of three main stages in their life-history, viz.:

(1) The firm-walled spore gives birth to a *swarm-cell.*

(2) The swarm-cells coalesce to form a wandering *plasmodium.*

(3) The plasmodium ultimately concentrates to form either *sporangia*, enclosing numerous spores (*Endosporeæ*), or *sporophores*, bearing spores on their outer surface (*Exosporeæ*).

A fuller definition is given by Sturgis in *The Myxomycetes of Colorado*, published by Colorado College, 1907. Lister treats the group as a class, Calkins makes it a subclass of Rhizopoda: it is here regarded as a subphylum.

The Boulder County records are derived from the paper by Sturgis, quoted above, and are based on specimens collected by Messrs. Bethel and Sturgis.

Class **EXOSPOREÆ** Rostafinski

Order *CERATIOMYXACEÆ*

Family **CERATIOMYXIDÆ**

(13) **Ceratiomyxa** Schroeter. *C. mucida* (Pers.). Sporophores white or pinkish yellow, forming either simple or branching tufts. On rotten logs (Lister).

Class ENDOSPOREÆ

The genera down to *Enerthenema* have the spores violet, violet-brown or pale ferruginous; those beyond have them variously colored, but not violet or violet-brown, except in some species of *Cribraria* not yet found in Boulder County. The genera from *Badhamia* to *Spumaria* have the sporangia provided with calcium carbonate.

Order *PHYSARACEÆ*

Lime in the form of minute round granules.

Family BADHAMIIDÆ

Capillitium (interior network of sporangium) charged with lime throughout.

(14) **Badhamia** Berkeley.

B. panicea (Fr.). On fallen cottonwood and box-elder logs. Sporangia 1 mm. diameter, white.

B. populina Lister. Allied to *B. capsulifera*, but with white plasmodium and banded spores. Sporangia white, grey or pinkish, usually in dense clusters (Sturgis). On cottonwood and box-elder bark.

B. versicolor Lister. On bark of box-elder. Sporangia very small, .3 to .5 mm. diameter, pure grey or with a tinge of flesh-color. Boulder is the only known locality in America (Sturgis, 1907).

B. orbiculata Rex. Sporangia discoid or annulate, on short blackish stalks. On bark of cottonwood. An apparently distinct variety also occurred.

Family PHYSARIDÆ

Capillitium of hyaline threads with vesicular expansions filled with lime (lime-knots).

(15) **Physarum** Persoon. Fructification simple, sporangium wall membranous, calcareous. *P. viride* (Bull.), varieties *luteum* (Bull.) and *incanum; P. nutans* Pers. and var. *robustum* Lister. These two species belong to the subgenus *Tilmadoche* Fries.

Macbride, who treats *Tilmadoche* as a genus, writes as follows: Aside from the general delicacy of structure the principal distinctive feature of *Tilmadoche* is the capillitium. The threads of the capillitium rise vertically from the flat, generally persistent base of the peridium, and hence are in their general course nearly parallel one to the other. This is in sharp contrast with the netted intricate framework of *Physarum.*

P. nefroideum Rost.; *P. cinereum* (Batsch.); *P. contextum* Pers.; *P. diderma* Rost., var.; *P. sinuosum* Bull.; *P. didermoides* (Ach.), var.; *P. lateritium* (Berk. and Br.); *P. auriscalpium* Cke.

(16) **Cienkowskia** Rostafinski. Sporangium wall cartilaginoid at base; capillitium with free hooked branches; lime-knots taking the form of vertical plates.

C. reticulata (Alb. and Schw.). A remarkable species easily recognized by the creeping and anastomosing plasmodiocarps of a brownish color, marked with dull scarlet bosses (Sturgis).

(17) **Fuligo** Haller. Fructification compound, called an æthalium. Large convex masses, up to 20 cm. broad, varying from pale yellow to red and brown. *F. septica* (Linn).

(18) **Craterium** Trentepohl. Sporangia in the shape of a covered goblet, the stalks cartilaginoid. On dead leaves and twigs.
C. leucocephalum (Pers.), sporangia, red-brown, white and mealy, with sprinkled yellow granules on upper half and lid; *C. minutum* (Leers), sporangia smooth, with a pale lid.

Family DIDERMIDÆ

Capillitium without lime.

(19) **Diderma** Persoon. Sporangium wall opaque, of two layers, containing granular deposits of lime. *Diderma* proper, including in our fauna *D. spumarioides* Fries and *D. globosum* Pers., has the outer sporangial wall distinctly calcareous, fragile. The subgenus *Leangium*, of which we have *D. trevelyani* (Grev.) and *D. stellare* (Schrad.), has the outer sporangial wall cartilaginoid, the inner less distinct, or not separable from the outer. *D. trevelyani* is chestnut-brown.

(20) **Diachæa** Fries. Sporangium wall hyaline, the lime confined to the stalk and columella. *D. leucopoda* (Bull.).

Order *DIDYMIACEÆ*

Lime in crystals deposited outside the sporangium wall (Lister).

Family DIDYMIIDÆ

(21) **Didymium** Schrader. Fructification simple; sporangium wall membranous; crystals stellate. *D. farinaceum* Schrad.; *D. squamulosum* (Alb. and Schw.); *D. anellus* Morg.; *D. nigripes* (Link.), var. *eximium* (Pk.).

(22) **Spumaria** Persoon. Fructification compound, the sporangia forming an æthalium. Very variable; on grass, shrubby plants, etc.
S. alba (Bull.) and var. *solida* Sturgis.
Macbride considers that *Spumaria* should be called *Mucilago* Adans., and *S. alba* becomes *Mucilago spongiosa* (Leyss.).

Order *STEMONITACEÆ*

Sporangia distinct, without lime, provided with a stalk and columella. (The columella is the axis of the stalk prolonged upward into the sporangium.)

Family STEMONITIDÆ

Sporangium wall evanescent. (In Lamprodermatidæ it is more or less persistent.)

(23) **Stemonitis** Gleditsch. Sporangia cylindrical; capillitium forming a net at surface. The following key separates the Boulder County forms:

Spores grey, violet-grey or rufous violet.
- Spores reticulated; sporangia dark or reddish brown, 4 to 15 mm. high . . . *fusca* Roth.
- Spores minutely warted, almost smooth.
  - Meshes of surface net rounded, 20–100 μ or more wide . . . *splendens* Rost.
  - Meshes of surface net angular, less than 20 μ wide . . . *herbatica* Peck.

Spores ferruginous or pale reddish-brown.

Spores 8 to 9 μ diameter . . . . *fusca* var. *rufescens* Lister.

Spores 4 to 5 μ diameter . . . . *ferruginea* Ehrenb.

S. smithii Macbride, which is included by Sturgis, following Lister, in *S. ferruginea*, is common in Boulder County, as I am informed by Mr. Bethel. The plasmodium is white or greenish-white.

(24) **Comatricha** Preuss. Sporangia globose or cylindrical; no distinct surface net. *C. nigra* (Pers.), and var. *æqualis* (Peck); *C. laxa* Rost.; *C. typhina* (Wigg.); *C. irregularis* Rex; all Boulder.

C. nigra var. *suksdorfii* (Ellis and Ev.). Yankee Doodle Lake, Tolland, etc.

According to Macbride *C. typhina* should be called *C. stemonitis* (Scopoli).

The following key is partly based on that of Macbride:

Capillitium very lax, the branching open.

Spores nearly smooth; sporangium minute, ovate . . . . . *C. laxa.*

Spores spinulose . . . . *C. irregularis.*

Capillitium dense.

Sporangia very small, 1 to 2 mm. diameter, cylindric, stipitate *C. stemonitis.*

Sporangia very small, spherical or ellipsoidal . . . . . . *C. nigra.*

Sporangia larger.

Sporangia black . . . . *C. suksdorfii.*

Sporangia pale ferruginous . . . . *C. æqualis.*

(25) **Enerthenema** Bowman. Sporangia globose; capillitium springing from apex of columella only. *E. papillata* (Pers.).

Order *CRIBRARIACEÆ*

Sporangium wall membranous, beset with microscopic round plasmodic granules; capillitium wanting; spores pallid or brown.

Family CRIBRARIIDÆ

(26) **Cribraria** Persoon. Sporangium wall forming a persistent irregular net; sporangia stalked. *C. argillacea* Pers. (sporangia clay-colored) and *C. minutissima* Schw. (sporangia brown or rufous, very small).

Order *RETICULARIACEÆ*

Sporangia combined into an æthalium; their walls incomplete, perforated or forming a spurious capillitium (Lister).

Family RETICULARIIDÆ

(27) **Dictydiæthalium** Rost. Sporangia columnar, their walls represented by 4 to 6 straight threads extending from base to apex; externally only the flattish slate- or clay-colored æthalium is seen, the apices of the sporangia producing a minute areolation. *D. plumbeum* (Schum.). Spores pale yellow, spinulose.

(28) **Enteridium** Ehrenberg. Not unlike the last, but sporangium walls with large round perforations. *E. rozeanum* Wingate (*splendens* Morgan). Cortex brown, smooth and shining; spores with about two-thirds of the surface reticulate.

(29) **Reticularia** Bulliard. Persistent portion of sporangium walls rusty brown, forming broad folds and strands, as though frayed out. *R. lycoperdon* Bull. Not definitely reported by Sturgis from our district, but he writes: "This species appears to be common throughout the state, and often attains a very large size, four to five inches in diameter. It occurs frequently on decorticated portions of living trees and, with its silvery-white cortex, forms a very conspicuous object." The æthalium is more or less convex. Spores pale rusty brown, closely reticulate on one side. Mr. E. Bethel writes me that he has found it not infrequent in Boulder County, on decorticated conifers and occasionally on poplars.

Reticularia Bulliard (1791) has long priority over *Reticularia* McCoy (1844) in Brachiopoda.

Order *LYCOGALACEÆ*

Sporangia forming an æthalium; pseudocapillitium consisting of branched colorless tubes (Lister).

Family LYCOGALIDÆ

(30) **Lycogala** Micheli. Æthalia subglobose or subpyriform, with a cortex consisting of two or more closely combined layers, provided with cell-like vesicles; spores in mass pale pinkish-grey. *L. flavofuscum* (Ehr.), æthalia subpyriform, brown, smooth.

L. epidendrum (L.) is not specifically reported by Sturgis from our district, but is said to be "the commonest of all myxomycetes everywhere." It has the cortex minutely roughened or warted. Mr. E. Bethel tells me that he has found it very common about Boulder.

Order *TRICHIACEÆ*

Capillitium consisting of free tubular threads (elaters), or a network branching at wide angles, with thickening in the form of spirals or rings.

Family TRICHIIDÆ

(31) **Trichia** Haller. Capillitium of free elaters. *T. contorta* Rost., var. *inconspicua* Rost.; *T. varia* (Pers.). The elaters have a fine spiral sculpture. The sporangia in our species are sessile.

(32) **Hemitrichia** Rostafinski. Capillitium combined into a net, the threads with spiral bands. *H. clavata* (Pers.). In a variety collected by Mr. Bethel at Boulder the threads of the capillitium, instead of being spirally banded, are minutely and densely spinulose (Sturgis). The sporangia are ochraceous-yellow.

Order *ARCYRIACEÆ*

Capillitium a network of tubular threads branching at wide angles and thickened with cogs, half-rings, spines or warts.

Family ARCYRIIDÆ

Capillitium elastic.

(33) **Arcyria** Hill. Sporangia stalked, walls evanescent. *A. incarnata* Pers. (sporangia flesh-color, crowded, stalks short); *A. pomiformis* (Leers) (sporangia

globose, yellow); *A. cinerea* (Bull.) (sporangia ashen grey, sometimes yellowish-tinted); *A. nutans* (Bull.) (sporangia cylindrical, ochraceous).

Family **PERICHÆNIDÆ**

Capillitium not elastic.

(34) **Perichæna** Fries. Sporangia sessile; wall persistent, thick. *P. depressa* Libert. Sporangia depressed, polygonal, crowded, brown, dehiscing with a well-defined lid; spores yellow.

Order *MARGARITACEÆ*

Capillitium of solid threads coiled and hair-like, or straight and attached to the sporangium wall, simple or branching at acute angles (Lister).

Family **MARGARITIDÆ**

Sporangia dehiscing irregularly. (In Listerellidæ dehiscing in lobes.)

(35) **Prototrichia** Rostafinski. Threads penicillate, spirally banded. *P. flagellifera* (Berk. and Br.). Yankee Doodle Lake (Bethel). Sporangia globose, sessile, brown or pinkish-brown, shining (Lister).

In addition to the material already reported, Mr. E. Bethel has collected many specimens in our district, which he intends to record at some future time.

The Mycetozoa may be regarded as Protozoa adapted to life in air. It has seemed remarkable that so many species should exist in semiarid regions, but it may be that the group arose in such regions, where the need for its peculiar characteristics was greatest. The swarm-cells possess a nucleus and contractile vacuole, and feed on bacteria. They are flagellate, a fact which is against their classification (after Calkins) as Sarcodina. In *Ceratiomyxa* the flagellate swarm-cells swim about in clusters, simulating the Mastigophoran genus *Anthophysa*, except that the latter is stalked. In the plasmodium stage the slime-moulds are saprozoic.

The cell-division of the mycetozoa, as described by Lister, is remarkable and raises the question whether they are always to be regarded as colonies of unicellular organisms, or truly multicellular. The ameboid swarm-cells, on emerging from the spore capsules, become flagellate and proceed to feed. Thereupon, like other Protozoa, they increase by division, the nuclei showing the phenomena of karyokinesis. These cells now collect in clusters and unite to form plasmodia, which are multinucleate masses of protoplasm.

The plasmodium now feeds saprozoically, and as it grows, greatly multiplies its nuclei. According to Lister, this multiplication of nuclei appears to take place by simple division, without karyokinesis; but in a single case (in *Badhamia utricularis*) he observed very characteristic karyokinetic figures, which he illustrates. In the formation of the sporangium, there is at a late stage a karyokinetic division of nuclei into two, resulting in a mass which presently divides into two spores. The colonial interpretation of the mycetozoan structure—and certainly the plasmodium must be regarded as a colony—suggests close affinity with the mastigophora.

Dr. W. C. Sturgis writes me that he is equally unwilling to class the mycetozoa as plants or animals, but would treat them as a border-group. He also gives me the following very interesting information: "No certain example of a hybrid is known. I have seen a compound form develop on top of another simultaneously, with no sign of mixed characters. I have also seen two and even three simple forms so closely disposed that, when transformed to sporangia, the latter were inextricably mixed; yet the characters of each species remained absolutely normal."

Subphylum **Sporozoa**

Parasitic forms, without cilia or flagella, "but capable of moving from place to place by structural modifications of one kind or other" (Calkins). Reproduction mainly by spore formation, which is either asexual (schizogony) or sexual (sporogony).

Class **TELEOSPORIDA** Schaudinn

Sporozoa in which sporulation ends the life of the individual.

Order *GREGARINIDA*

Suborder Eugregarinæ Lèger

Reproduction apparently limited to sporulation, division occurring, if at all, within the host cell and during the young stages (Calkins).

Family **MONOCYSTIDÆ** (Acephalinæ Kölliker)

(36) **Monocystis** Stein. The boat-shaped spores occur in the seminal reservoirs. of the earthworm; observed in Boulder by Dr. Ramaley and Mr. W. E. Watkins.

Family **GREGARINIDÆ** Labbé

Gregarines parasitic in insects are doubtless numerous with us, but none have been examined. A brief search in grasshoppers (*Melanoplus*) was without result.

Order *HEMOSPORIDIA* Danilewsky

Living in blood.

Family PLASMODIIDÆ

The genus *Plasmodium*, the cause of malaria, is apparently not normally present in Boulder County, nor has the sporogonic host (*Anopheles*) been observed. The tick which carries the parasite (*Babesia*) supposed to cause Rocky Mountain Spotted Fever occurs here, but the parasite is probably absent, as the disease has not been reported.

Subphylum Sarcodina

Protozoa showing no connections with the bacteria, usually of simple structure and characterized mainly by motile organs in the form of changeable protoplasmic processes—the pseudopodia (Calkins). Calkins includes the mycetozoa here, but their swarm-cells are flagellate, and for several reasons it seems impossible to regard them as Sarcodina.

Class RHIZOPODA

Sarcodina without axial filaments in the pseudopodia, which may be lobose, filose or reticulate.

Subclass AMEBEA

Our principal source of information is E. Penard's great work, *Faune Rhizopodique du Bassin du Léman*, which although ostensibly dealing with a single district in Europe is in reality a monograph of the species of the world.

Order *GYMNAMEBIDA*

Body uncovered, though there is, in many cases, a tendency of the peripheral plasm to harden into a denser, membrane-like zone which approaches the simpler forms of tests (Calkins).

Family AMIBIDÆ

The "kleine Proteus" of Rösel (1755), the basis of *Chaos* L., was, from its size, probably *Pelomyxa*, as remarked by Dr. E. L. Walker. The genus *Proteus* was however based by Müller on an animal actually observed by him, *P. diffluens*, which was the *Amoeba proteus* of modern authors. *Proteus* being preoccupied, Bory de St. Vincent substituted *Amiba*, which appears to be valid. I have not examined Müller's work, but E. Donovan (*Nat. Hist. British Insects*, Vol. 2, 1793) gives a good figure of the common Amoeba as *Proteus diffluens* (Plate XLVII, p. 27).

(37) **Amiba** Bory. Body naked, with pseudopodia; contractile vacuole and nucleus present. *A. diffluens* (Müll.)*; *A. verrucosa* Ehr.; *A. limax* Duj.; *A. radiosa* Ehr. Penard long ago reported a doubtfully new species from Bald Mtn. (alt. 11,470 ft.). He now kindly informs me that this was what he subsequently described from Spitzbergen as *A. radiosa* var. *gemmifera* (Penard, 1903).

Calkins places provisionally in Gymnamebida the organisms connected with smallpox and rabies, both of which diseases have occurred recently in our area.

(38) **Cytoryctes** Guarnieri. *C. variolæ* Guarnieri. Connected with smallpox.
(39) **Neuroryctes** Williams. *N. hydrophobiæ* Williams. Connected with rabies.

ORDER *TESTACEA* M. Schultze (Thalamophora R. Hertwig)

Covered with definite membranes or tests; pseudopodia protruded through the usually single opening of the shell, and may be lobose or branched, but do not normally anastomose. It is questionable whether the name Testacea, previously used in Mollusca, should be applied here, but I follow Calkins. The Gromiidæ, in which the pseudopodia normally anastomose, are regarded as Foraminifera. They are mostly marine but a few live in fresh water, and may occur in our fauna. The Testacea are divided into families according to the form of the pseudopodia, following the grouping of Penard, although he does not recognize families. Edmondson (*Protozoa of Iowa*) recognizes Arcellidæ and Euglyphidæ. Diplophryidæ (*Diplophrys*, *Microcometes* and *Amphitrema*) with more than one opening for pseudopodia have not yet been observed in our fauna. They are the Amphistomina, of Bütschli.

FAMILY ARCELLIDÆ

Pseudopodia thick; more or less filiform in *Cryptodifflugia*, which is in some degree transitional to the next family.

FIG. 3.

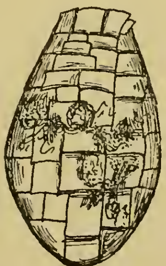

FIG. 4.

FIG. 5.

FIG. 3.—*Difflugia constricta*, Wiesbaden, 1889. (E. Penard.)
FIG. 4.—*Quadrulella symmetrica*, Wiesbaden. (E. Penard.)
FIG. 5.—*Trinema enchelys*, Wiesbaden. (E. Penard.)
FIGS. 3, 4 and 5 are drawings by Miss Edith Farrington from microscopic mounts prepared by Dr. Penard.

(40) **Microchlamys** Cockerell. A small patelliform organism, circular, convex above, with a large opening beneath through which the pseudopodium protrudes. *M. patella* Clap. and Lach. The name *Pseudochlamys* Claparède and Lachmann was earlier used for a beetle, and after consultation with Dr. Penard, has been changed to *Microchlamys* in a note sent to the Zoologischer Anzeiger.

(41) **Cochliopodium** Hertwig and Lesser. Shell a delicate, exceedingly flexible, transparent membrane, convex above. There are several pseudopodia, which are more or less triangular or sublinear, pointed. *C. bilimbosum* (Auerbach).*

(42) **Lecquereusia** Schlumberger. Shell globular, with a large neck twisted to one side, as though beginning a spiral, and ending in a round opening through which the pseudopodia protrude. *L. spiralis* (Ehrenberg).

(43) **Difflugia** Leclerc. Shell more or less urn-shaped, composed of foreign matter (mostly sand grains) agglutinated together by a chitinous secretion. One end is rounded (rarely pointed), the other occupied by the broad, round mouth, from which the pseudopodia protrude. Exceptional species are *D. constricta*, in which the subterminal mouth is lateral, and *D. arcula*, which is very broad, rounded, patelliform, with the oral opening in the middle of the flat side, and trilobed. *D. rubescens* has the plasma of a beautiful brick-red color. *D. pyriformis* is much larger than any of our other species; *D. fallax* and *lucida* are extremely small. *D. rubescens* has the neck more or less constricted, at least in the normal form. *D. bacillifera* is a slender species, always more or less covered with diatoms. Our species are *D. pyriformis* Perty,* *D. rubescens* Penard (type-locality in Boulder County), *D. arcula* Leidy, *D. lucida* Penard, *D. fallax* Penard, *D. bacillifera* Penard, and *D. constricta* (Ehrenberg).

(44) **Nebela** Leidy. Shell flask-shaped, compressed, so that the lateral view is only about half as broad as the other; surface areolated, composed of small round or oval plates; plasma containing round, bluish grey or yellowish masses. *N. collaris* (Ehrenberg); *N. tubulosa* Penard; *N. longicollis* Penard; *N. dentistoma* Penard. The species are much alike. *N. dentistoma* is much broader than the others, with the edges of the mouth more or less crenulate. *N. tubulosa* is sharp-edged at the aboral end, so that in lateral view this end appears pointed. *N. longicollis* is relatively slender, little compressed. The last may not be distinct from *N. barbata* Leidy.

(45) **Quadrulella** Cockerell. Shell like *Nebela*, but composed of relatively large quadrangular plates. In the typical species the globules in the plasma are red. *Q. symmetrica* (Wallich). In his recently published (1911) paper on the Rhizopods of the British Antarctic Expedition, Penard calls attention to the curious fact that while the square plates of *Q. symmetrica* are siliceous, those of *Q. irregularis* (Archer) are calcareous, and will dissolve in hot concentrated sulphuric acid. He therefore inclines to agree with Awerinzew that the two animals are really generically distinct, and represent a case of convergent evolution.

(46) **Heleopera** Leidy. Shell ovoid, much compressed laterally, with a reticulate or alveolar surface. This is very like *Nebela*, but has sand-grains at the aboral end. The pseudopodia are numerous. Our species is of a wine-red color. *H. rosea* Penard.

(47) **Centropyxis** Stein. Shell discoidal, rarely oboval, sometimes subhemispheric, chitinous, more or less covered with foreign particles. Our species has projecting points. *C. aculeata* (Ehrenberg). Penard considers this to show much affinity with *Difflugia constricta*, and notes that both are extremely timid, rarely showing their pseudopodia.

(48) **Arcella** Ehrenberg. Shell hemispherical or discoid, or (*A. costata*) with flattened lateral faces; oral surface flattened, more or less concave, with a round opening for the pseudopodia; color usually yellow or brown. The surface has

a fine, often alveolar, sculpture. There are no projecting points or spines. The form of the shell resembles that of *Microchlamys*. *A. vulgaris* Ehrenberg* (strongly convex); *A. costata* Ehrenberg (with flattened lateral faces); *A. discoides* Ehrenberg (very flat, 100 to over 200 μ diameter); *A. arenaria* Greeff (shell moderately convex, without regular sculpture, pseudopodia of curious flattened fimbriate form). *A. arenaria* is the same as *A. microstoma* Penard. *A. costata* is the animal figured by Leidy as *A. vulgaris* var. *angulosa*.

(49) **Cryptodifflugia** Penard. Broad flask-shaped or oval, with a clear chitinous shell, occasionally with foreign particles attached. Pseudopodia slender, in our species rarely protruded. *C. oviformis* Penard.

Family EUGLYPHIDAE

Pseudopodia filiform.

(50) **Cyphoderia** Schlumberger. Shell flask-shaped, with the round mouth (pseudopodial aperture) turned more or less to one side. All the species contain little yellow or brown grains (pheosomes), very resistant to reagents. Our species is yellowish or brown. *C. margaritacea* (Ehrenberg).

(51) **Euglypha** Dujardin. Shell elongated, shaped much as in *Difflugia*, but entirely composed of imbricated oval or round siliceous scales; those of the aperture are finely crenulated or denticulate. *E. alveolata* Duj.*; *E. ciliata* (Ehr.); *E. compressa* Carter; *E. cristata* Leidy; *E. lævis* Perty. *E. ciliata* and *compressa* have numerous fine spine-like lateral projections; the latter is greatly compressed. *E. cristata* is long and narrow, with very fine long spine-like processes (modified scales) at the aboral end. *E. alveolata* and *lævis* are without spiniform processes; the latter is very small (35–60 μ long), with the scales or plates indistinct.

(52) **Sphenoderia** Schlumberger. Shell like *Euglypha*, with the same imbricated scales, not compressed; margin of oral aperture in our species dentate, but the margins of the scales not crenulate. *S. dentata* Penard.

(53) **Assulina** Ehrenberg. Shell of the *Euglypha* type, greatly compressed; oral aperture finely denticulate. Our species is very small, about 35 μ long. *A. minor*. Penard.

(54) **Trinema** Dujardin. Shell of the *Euglypha* type but mouth on one side, near the end, instead of terminal. *T. enchelys* (Ehr.)*; *T. galeatum* (Penard); *T. complanatum* Penard; *T. lineare* Penard. *T. galeatum* has the mouth conspicuously wider than long; the others have it practically circular. *T. complanatum* is short and broad, the oral end not or hardly narrower than the aboral *T. lineare* is very small, about 16 to 26 μ long, rarely as much as 30 μ. *T. enchelys* is about 40 to 45 μ, rarely larger.

(55) **Corythion** Taranek. Resembles Trinema, with aperture turned to one side, but the scales elongate, indistinct. *C. dubium* Taranek; *C. pulchellum* Penard. *C. dubium* is much broader than the other.

Class ACTINOPODA

Sarcodina provided with fine ray-like pseudopodia which are supported by a central axial filament (Calkins).

Subclass HELIOZOA

Typically freshwater[1] forms of actinate Protozoa in which there is no trace of a chitinous central capsule separating ectoplasm and endoplasm (Calkins). (The other subclass of Actinopoda is Radiolaria, exclusively marine.)
Our principal work of reference for the Heliozoa is Penard's *Les Héliozoaires d' eau douce* (1904).

Order *APHROTHORACA*

Naked, except during encystment.

Family ACTINOPHRYIDÆ

A single nucleus.

(56) **Actinophrys** Ehrenberg. The "sun-animalcule," so called from its spherical form and long ray-like pseudopodia. *A. sol* Ehrenberg.*

Order *CHALAROTHORACA*

Covering made up of separate or loosely connected particles.

Family HETEROPHRYIDÆ

With a thick protoplasmic or mucilaginous covering, in which are very fine spicules, which extend outward in every direction as radiating filaments, much shorter than the pseudopodia. Schaudinn and Calkins place this group in the order Chalmydophora, which typically has a mucilaginous covering without solid elements. I follow Penard in placing it with the Chalarothoraca.

(57) **Heterophrys** Archer. An undetermined species was found by Penard near Caribou. The spicules in this genus are said to be chitinous, whereas those of the Rhaphidophryidæ (*Rhaphidophrys* and *Rhaphidocystis*) are.siliceous.

Family ACANTHOCYSTIDÆ

No true mucilaginous envelope; siliceous elements of two kinds, scale-like and spine- or needle-like. The latter are often invisible in living specimens.

(58) **Acanthocystis** Carter. Near Caribou Penard found a species which he recorded doubtfully as *A. myriospina* Penard. *A. myriospina* has the plasma bluish, the nucleus sublateral. It is 15 to 20 μ in diameter, not counting the spinules, which extend outward on all sides in the manner of *Heterophrys*.

Order *DESMOTHORACA* R. Hertwig & Lesser

Covering of one piece, perforated by numerous openings.

Family CLATHRULINIDÆ

Stalked forms.

(59) **Clathrulina** Cienkowsky. The spherical shell with numerous round openings; color yellowish or brown, darkening with age. *C. elegans* Cienk. This beautiful species, originally described from St. Petersburg, Russia, was found near Ward, Boulder County, in 1909, and studied by Dr. C. T. Burnett and the writer.

[1] Penard enumerates eleven species which are marine.

Subphylum Infusoria

Protozoa in which the motor apparatus is in the form of cilia, either simple or united into membranes, membranelles or cirri. The cilia may be permanent or (Suctoria) limited to the young stages. With two kinds of nuclei, macronucleus and micronucleus. Reproduction is effected by simple transverse division or by budding (Calkins).

Class CILIATA

Ciliate in all stages.

Order *HOLOTRICHIDA*

Cilla alike and usually distributed all over the body (for exceptions see Chilodontinæ, Microthoracidæ, etc.), or longer in vicinity of mouth; trichocysts (poison organs) present.

Suborder Gymnostomina

No undulating membrane about the mouth, which remains closed except when food is taken.

Family ENCHELINIDÆ

Mouth terminal or subterminal.

(60) **Coleps** Ehrenberg. Ovate, persistent in shape; surface usually deeply furrowed longitudinally and transversely, the furrows bearing cilia (Edmondson). *C. hirtus* Ehr.*

(61) **Mesodinium** Stein. Ovate or pyriform, rounded posteriorly, produced into a conical proboscis anteriorly. Our species* has not been determined.

(62) **Lacrymaria** Ehrenberg. Elongate-oval or flask-shaped, anterior extremity usually very narrow and neck-like, compared with that of a swan in *L. olor*. *L. olor* (Müller);* *L. truncata* Stokes.

(63) **Prorodon** Ehrenberg. Oval, without any neck or process, not furrowed as is *Coleps*. *P. teres* Ehr.*; *P. edentatus* C. and L.*

Family TRACHELIIDÆ

Distinctly asymmetrical, with the dorsal side arched.

(64) **Lionotus** Wrzesniowski. Elongate, slug-like animals. *L. fasciola* (Ehr.),* contractile vesicle single, posterior; *L. pleurosigma* Stokes,* contractile vesicles numerous. These animals are quite large, 100 μ or more long.

Family CHLAMYDODONTIDÆ

General form oval or kidney-shaped; mouth almost always posterior; pharynx supported by a rod apparatus, or smooth, firm tube.

Subfamily CHILODONTINÆ

Body generally flattened, and cilia stronger on dorsal side, or confined to that region.

(65) **Chilodon** Ehrenberg. Elongate-oval or oblong; the anterior end with a more or less lip-like structure. *C. cucullulus* (Müller).* Length 125–200 μ. The young are in several respects unlike the adults.

Suborder Trichostomina

In addition to the general coating of cilia there is usually an undulating membrane (or membranes) at edge of mouth or in the pharynx. The mouth is always open (Calkins).

Family COLPODIDAE (chiliferidæ)

Mouth anterior or central; pharynx short or absent.

(66) **Frontonia** Ehrenberg. Elongate-oval or elliptical; mouth lateral, appearing as a slit-like opening; pharynx short, with minute teeth; surface striated longitudinally (Edmondson). *F. leucas* Ehr.* Length 250–300 μ. (*F. elliptica* Beardsley occurs near Greeley.)

(67) **Loxocephalus** Eberhard. Elongate, with more or less parallel sides, and with a long caudal and a pair of lateral setæ, the caudal like a stiff flagellum. *L. granulosus* S. Kent.*

(68) **Colpoda** Müller. More or less kidney-shaped, or with one side more or less concave, the other convex. Mouth a minute cleft-like depression. *C. helia* Stokes*; *C. campyla* Stokes.*

(69) **Glaucoma** Ehrenberg. Dorsal side convex, ventral flattened and ciliated; contractile vesicle single. *G. scintillans* Ehr.*

Family MICROTHORACIDÆ

Small asymmetrical forms, with the mouth invariably in the hinder portion. The cilia are always more or less dispersed, sometimes limited to the oral region (Calkins).

(70) **Cinetochilum** Perty. Broad and short, with blunt ends; dorsal surface with oblique furrows; cilia on ventral surface; a number of hair-like setæ projecting obliquely posteriorly. *C. margaritaceum* (Ehrenberg).*

Family PARAMÆCIIDÆ

Elongate-oval, entirely clothed with cilia; mouth at the end of a large oblique oral groove.

(71) **Paramæcium** Müller. *P. caudatum* Ehr.*; *P. trichium* Stokes.
Jennings and Hargitt (*Journal of Morphology*, December, 1910) have published a most interesting paper on the diverse races of *Paramœcium*. They find that *P. caudatum* has one micronucleus, whereas *P. aurelia* has two. Several distinct races of *P. caudatum* were obtained; the largest was 180 to 230 μ long. *P. trichium* is shorter and broader than *P. caudatum*; its length is 75–100 μ.

Family PLEURONEMIDÆ

Mouth at the posterior end of a ventral furrow or peristome.

(72) **Lembadion** Perty. Oval but flattened; peristome occupying the greater part of the ventral surface; a tuft of rigid cilia posteriorly. *L. bullinum* Perty.*

(73) **Cyclidium** Müller. Cilia very long, about as long as the diameter of the body; a long posterior seta. *C. glaucoma* Ehr.* There is some doubt about the identity of the animals described by Müller and Ehrenberg, but our species is the same as Ehrenberg's.

Family OPALINIDÆ

The form is oval and the body may be short or drawn out to resemble a worm. They are characterized mainly by the absence of mouth and pharynx (Calkins).

(74) **Opalina** Purkinje and Valentin. A species occurs with us, parasitic in the frog (Ramaley).

Order *HETEROTRICHIDA*

With a usually uniform covering of cilia, and an "adoral zone," consisting of short cilia fused together into membranelles. Edmondson gives this definition: body entirely ciliate, cilia of the oral region longer than those of the general surface and often fused together. However, in the suborder Oligotrichina the cilia are limited to certain areas.

Suborder Polytrichina

With a uniform coating of cilia.

Family PLAGIOTOMIDÆ

Mouth near or posterior to the middle of the body, preceded by a narrow peristomal furrow (Edmondson).

(75) **Spirostomum** Ehrenberg. Very long and narrow; one side of oral furrow with larger cilia. *S. teres* C. and L.*

(76) **Nyctotherus** Leidy. We have a species parasitic in the frog (Ramaley).

Family STENTORIDÆ

Large trumpet-shaped animals, the shape evidently suggesting the name *Stentor*.

(77) **Stentor** Oken. *S. cœruleus* Ehrenberg*; blue, 250–300 μ long.

Suborder Oligotrichina

Cilia limited to certain areas.

Family HALTERIIDÆ

Body with an anterior ring of cilia, and in our genus a circle of long fine springing hairs in the equatorial region.

(78) **Halteria** Dujardin. Small, nearly spherical, with a leaping motion. *H. grandinella* (Müller).*

Order *HYPOTRICHIDA*

Usually flattened, with cilia confined to the ventral surface (Edmondson). Conn's definition is: adoral zone wound to the left (to the right in Peritrichida); ventral surfaces with characteristically arranged large cilia, while the dorsal surface carries only five cilia or none.

Family OXYTRICHIDÆ

Cilia of the central surface usually fused into styles or setæ arranged in series.

(79) **Oxytricha** Ehrenberg. Elongate, with three or more frontal styles and several caudal styles. *O. pellionella* (Müller).* Length 80–100 μ.

(80) **Stylonychia** Ehrenberg. Eight frontal, five ventral and five caudal styles. Our species has not been determined.

Family EUPLOTIDÆ

Oval, dorsal surface convex; caudal styles usually well developed, but the others often reduced in number or lacking.

(81) **Euplotes** Ehrenberg. Seven frontal styles, three ventral and several caudal in our species. *E. charon* (Müller)*; broad oval, about 80 μ long.

(82) **Aspidisca** Ehrenberg. Resembling *Euplotes;* no caudal setæ. *A. costata* (Dujardin).* Length 35 μ.

Order *PERITRICHIDA*

Ciliata usually of cylindrical or cup-like form, in which the cilia are reduced, as a rule, to those which form the adoral zone, but secondary rings of cilia may be present (Calkins).

Family VORTICELLIDÆ

Attached or unattached; the adoral zone, seen from above, forms a dextral spiral.

Subfamily VORTICELLINÆ

With no permanent secondary circlet of cilia.

(83) **Epistylis** Ehrenberg. Zoöids bell-shaped, on a branching stem, which does not contract. *E. plicatilis* Ehr.*

(84) **Vorticella** Linné. More or less bell-shaped, with an elongate contractile stalk. *V. campanula* Ehr.*; *V. alba* From.*; *V. telescopa* S. Kent.*

Class SUCTORIA

Cilia, except in a very few cases, absent in adult; there are tentacles of various kinds, some for sucking, some for piercing.

This group has not been divided into orders.

Family PODOPHRYIDÆ

Some of the tentacles knobbed, others pointed and prehensile.

(85) **Podophrya** Ehrenberg. Our species is spherical and stalked, the slender tentacles ending in minute knobs, like a pin. *P. fixa* (Müller).*

Family ACINETIDÆ

Tentacles numerous, usually knobbed and all alike.

(86) **Acineta** Ehrenberg. Body inhabiting a lorica which is produced posteriorly into a rigid stalk. Our species* has not been identified.

Phylum PORIFERA (Sponges)

Freshwater sponges occur in Boulder County, but the species has not been determined.

Phylum COELENTERATA

Class HYDROZOA

Represented in our fauna by the freshwater genus *Hydra* Linné, the species not determined. I have seen a specimen collected by Mr. L. C. Bragg.

Phylum ECHINODERMATA

These marine animals may be found fossil in our Mesozoic rocks.

Phylum VERMIDEA

Our district has undoubtedly a rich fauna of worms and rotifers, but they have been almost wholly neglected. I therefore give only a brief account of the group, enumerating the few recorded forms and indicating some which are certain or likely to be found.

Class PLATYHELMINTHIA (Flat Worms)

Order *TURBELLARIA* Ehrenberg

Freshwater Planarians undoubtedly occur in our fauna. They are slug-like, very flat, and slowly glide over the stones in pools and streams. According to Gamble *Planaria alpina* Dana is characteristic of cold mountain streams.

Order *TREMATODA*

Includes the parasitic liver-fluke and related forms. The larva of the liver-fluke lives in small snails of the genus *Lymnæa.* Professor H. S. Pratt has published a synopsis of North American Trematoda in *American Naturalist* (1902). Many of the species have hosts which occur in Boulder County.

Order *CESTODA*

The tape-worm, of which we doubtless have several species. Many of the recorded hosts occur with us. For Cestoda of cattle, sheep, etc., see Stiles and Hassall, *Bull. No. 4*, Bureau of Animal Industry, U.S. Dept. Agriculture (1893); of dogs, see M. C. Hall. *Proc. U.S. Nat. Museum* (1910); of rabbits, see M. C. Hall, *Proc. U.S. Nat. Museum* (1908); of birds, see B. H. Ransom, *Bull No. 69*, U.S. Natl. Museum (1909); of fishes, see Linton, *Proc. U.S. Nat. Museum* (1897).

Class NEMATHELMINTHIA

Order *NEMATODA* (Thread-Worms)

Our fauna undoubtedly includes many thread-worms, both parasitic and free-living. The latter have often been seen in water, but have not been studied.

Family FILARIIDÆ

(87) **Filaria** Müller. An immature worm, apparently of this genus, was found by Terry Duce and Willard Rusk in the neck of an owl, *Asio wilsonianus*, ob

tained at Burnt Knoll, Boulder County. Mr. M. C. Hall informs us that *Filaria attenuata* Rudolphi and *F. megacantha* Leidy have been described from *Asio accipitrinus*, an owl which also occurs in Boulder County.

Order *NEMATOMORPHA*

Family GORDIIDÆ

These are the hair-like worms, popularly supposed to be transformed horse-hairs. Montgomery has published (*Proc. Acad. Nat. Soc.*, Phila., 1907) an account of these animals, in which he records four species from Montana, two from Wyoming, and one from New Mexico. The most abundant United States species is *Paragordius varius* (Leidy).

Class ROTIFERA

Microscopic aquatic animals, known as "Wheel-animalcules." We undoubtedly have many genera and species, but only a few have been identified.

Order *BDELLOIDA*

Family PHILODINIDÆ

(88) **Callidina** Ehrenberg.* More than one species of this genus was found in the pond on the University campus; they were submitted to Professor H. S. Jennings. Another species was collected by Mr. E. Bethel on South Boulder Peak.

Order *PLOIMA*

Suborder Loricata

The five species enumerated below were all from the pond on the University campus, and were determined by Professor H. S. Jennings.

Family CATHYPNIDÆ

(89) **Monostyla** Ehrenberg. *M. bulba* Gosse.*

Family COLURIDÆ

(90) **Colurus** Ehrenberg. *C. bicuspidatus* Ehrenberg.*

(91) **Metopidia** Ehrenberg. *M. lepadella* Ehrenberg* and *M. salpina* Ehrenberg.*

Family ANURÆIDÆ

(92) **Anuræa** Ehrenberg. *A. cochlearis* Gosse.*

Class CHÆTOPODA Oerst.

Worms with lateral bristles or chætæ for use in locomotion.

Order *OLIGOCHÆTA*

This group includes the earthworms, of which we have various species, not yet identified.

Suborder Microdrili

Family AEOLOSOMATIDÆ (Aphaneura)

(93) **Aeolosoma** Sieb. In 1908 a small freshwater worm, ornamented with minute orange-red spots, was found in Boulder. On sending a sketch to Professor J. P. Moore, he identified it as this genus, stating that the species was probably *A. hemprichi*. A good account of the genus is given by Beddard in the *Cambridge Natural History*, Vol. II, p. 374.

Class HIRUDINEA

The leeches in our fauna have not been studied. For a useful account of some American leeches see J. P. Moore, *Bull. Bureau of Fisheries*, XXV (1906). Another important paper by the same author is in *Proc. U.S. National Museum*, XXI (1898).

Phylum BRACHIOPODA Dum.

May occur fossil, but not reported.

Phylum BRYOZOA Ehrenberg. (POLYZOA J. V. Thompson)

Not observed. Freshwater forms may be found.

Phylum ARTHROPODA

Class DIPLOPODA (Myriopoda Auctt., part.)

The millipedes and their allies, cylindrical or more or less flattened animals, with seven antennal joints, are to be separated from the centipedes or Chilopoda, which have numerous antennal joints, and are nearer to the insects. In insects and centipedes the reproductive organs open through a single duct near the hind end of the body; whereas in the millipedes the paired genital ducts open on the anterior region of the body. The classification used for both groups is adapted from the recent synopses by Professor R. V. Chamberlin, and in part from the writings of Dr. O. F. Cook.

Order *MEROCHETA*

Body of 20 (rarely 19) segments, which are complete chitinous rings, without sutures (O. F. Cook). Lateral carinæ or projections nearly always present; eyes wanting.

Family POLYDESMIDÆ

A species apparently belonging here occurs in greenhouses in Boulder.

In the following orders the body has 30 (rarely 26 or 28) segments or more.

Order *COELOCHETA*

Conotyla coloradensis Chamberlin was described from material collected by the writer in Colorado, but unfortunately Professor Chamberlin fails to cite the locality. It belongs to the Family Craspedosomidæ.[1]

[1] Professor Chamberlin now writes that it was taken at Salina, Boulder County, April, 1907.

Order *ZYGOCHETA*

This includes the common millipedes of our region.

Family PARAIULIDÆ

(94) **Parajulus** Humbert and Saussure. Our material was immature, but Professor Chamberlin says was *P. venustus* Wood, with scarcely a doubt. It was taken at Salina, April, 1907.

Class CHILOPODA (Myriopoda Auctt., part.)

The centipedes.

Order *SCHIZOTARSIA*

Tracheæ opening through seven unpaired spiracles arranged along the median dorsal line; antennæ and legs very long.

Family SCUTIGERIDÆ

(95) **Scutigera** Latreille. *S. forceps* Rafinesque. These curious centipedes occur in houses, and specimens caught in Boulder have several times been brought in by students. The species is not a true member of our fauna, but is of southern origin.

Order *ANAMORPHA*

Tracheæ opening through paired spiracles; adults with 15 pairs of legs. These are the common centipedes of our region. Professor Chamberlin has published a synopsis of the suborder Lithobiomorpha, as known to occur in Colorado, in *Canadian Entomologist*, February, 1911.

Family LITHOBIIDÆ

(96) **Lithobius** Leach. The following key to our species is adapted from Chamberlin:

Angles of the 7th, 9th, 11th, and 13th dorsal plates produced; antennæ with 30 to 40 joints . . . . *L. mordax* Koch.

Angles of the 9th, 11th, and 13th dorsal plates produced; claw of penultimate legs armed with a single spine . . . . . . *L. harrietæ* Chamberlin.

Angles of none of the dorsal plates produced; claw of anal legs armed with one spine at base; antennæ normally with 20 to 21 joints; claw of penultimate legs with two spines . . . . *L. coloradensis* (Cockerell).

Order *EPIMORPHA*

Tracheæ opening through paired spiracles; 21 or more pairs of legs.

Family SCOLOPENDRIDÆ

Large centipedes with 21 or 23 pairs of legs.

(97) **Scolopendra** Linné. *S. heros* Girard. Adults 100–150 mm. long; first dorsal plate with a transverse sulcus; second tarsal joints armed, except those of anal pairs of legs; spines of anal legs 17–25 (Bollman). A specimen was taken by Professor R. D. George at Valmont Butte, September 25, 1907.

Family GEOPHILIDÆ

Small thread-like centipedes; pairs of legs never less than 30.

One or more undetermined species occur in our fauna. *Geophilus umbraticus* McNeill is recorded from West Cliff, Colorado.

Class ARACHNIDA

Order *ACARINA*

The mites and ticks. Although quite easily recognized at sight, it is not so easy to give definite characters whereby to distinguish a mite from other Arachnids. The abdomen and cephalothorax are broadly united to each other, and often there is no distinction between these parts. Usually there is no trace of segmentation, but in some forms it is quite distinct. Eyes are often present but rarely only a median pair as we find in Phalangids and Solpugids. The mouth segments have united to form a beak, rostrum or capitulum. Commonly the larva at birth has but three pairs of legs, and obtains the fourth pair only after a molt and metamorphosis. In the Eriophyidæ, however, there are but two pairs of legs in both adult and young, and in *Pteroptus* the young have eight legs at birth. (N. Banks, *Proc. U.S. Nat. Museum*, XXVIII, p. 2.)

Superfamily Desmodicoidea

Abdomen annulate, prolonged behind; very minute forms.

Family ERIOPHYIDÆ

With but four legs, of five joints each; living on plants, often in galls (Banks).

(98) **Eriophyes** Siebold. We have several gall-forming species; one has been described, *E. rhoinus* Cockerell, on *Rhus glabra cismontana*, producing gall-masses consisting of modified branches with multitudes of small, distorted leaves.

(99) **Cecidoba** Banks. Producing galls on leaves of *Salix*. *C. salicicola* Banks.* Ward is the type-locality: I have since found the species on the University campus at Boulder.

Superfamily Ixodoidea

Large forms, commonly known as ticks.

Family IXODIDÆ

Scutum present; mouth-parts of adult prominent from above; pulvillus to tarsus of both adults and young; stigmal plate behind fourth coxæ (Banks).

(100) **Dermacentor** Koch. Eyes present; dorsal surface of capitulum nearly rectangular. *D. venustus* Banks. The common wood-tick of our vicinity, formerly confused with *D. occidentalis*.

Superfamily Oribatoidea

Body usually coriaceous, with few hairs; with a specialized seta or bristle arising from a pore near each posterior corner of the cephalothorax; no eyes; mouthparts and palpi very small; never parasitic (Banks).

Family ORIBATIDÆ

An apparently new species of the genus *Cymbæremæus* Berlese was collected at Tolland by Mr. Bethel, and determined by Mr. Banks.

Superfamily Hydrachnoidea

The water mites. Our species have not been studied.

Superfamily Sarcoptoidea

Palpi small, three-jointed, adhering for some distance to the lip; ventral suckers at genital opening or near anal opening generally present; no eyes; tarsi often end in suckers; adult frequently parasitic (Banks).

Family TARSONEMIDÆ

With tracheæ; no ventral suckers; body divided into cephalothorax and abdomen; the female with a club-shaped process between the first and second legs. The genus *Siteroptes* Amerling is represented at Denver by *S. carnea* Banks (determined by Banks), found by Mr. Bethel in galls on *Sporobolus asperifolius*. The galls are almost exactly like those on *Cynodon dactylon*, attributed to *Lonchæa lasiophthalma* Macq. Mr. Banks notes that a red predaceous mite (family Bdellidæ) also occurs in the *Sporobolus* galls.

Family TYROGLYPHIDÆ

Pale-colored, soft-bodied mites, devoid of tracheæ, usually with prominent chelate mandibles, small palpi; moderately long legs, ending in one claw and often a sucker (Banks). During the hypopial stage they are attached to insects or sometimes mammals; this is a migrating condition, and during it the mite takes no food.

(101) **Trichotarsus** Canestrini.* Hypopial stage on bees. A probably new species near *T. osmiæ* Duf. (det. Banks) was found on the type specimen of the bee *Osmia leonis* Ckll., collected by Miss Edna Baker on the University campus.

Superfamily Trombiboidea

The last joint of the palpus forms a thumb to the one before, which ends in a claw; body often with many hairs.

Family TROMBIDIIDÆ

Mandibles chelate (for biting).

(102) **Trombidium** Fabricius. The larvæ are six-legged mites and are parasitic on insects; the bright red adults wander over the ground, and our species is known to destroy grasshopper eggs. *T. locustarum* Walsh, Boulder, February, 1907 (W. P. Cockerell); determined by Banks. In his catalogue of the Acarina, Mr. Banks places *T. locustarum* in a separate genus *Microtrombidium* Haller. In his Treatise on the Acarina (1904) he says: "our species are all practically congeneric, but those forms that have two claws at the tip of the palpi fall in the genus *Microtrombidium*."

Family RHYNCHOLOPHIDÆ

Mandibles styliform (for piercing). These mites are more slender and agile than the Trombidiids.

(103) **Rhyncholophus** Dugés. An undetermined species occurs at Eldora.

Order *PSEUDOSCORPIONIDA*

The pseudoscorpions; small animals looking like scorpions, but without a tail.

Family CHELIFERIDÆ

Cephalothorax with a transverse median suture; abdominal scutes divided; mandibles small.

(104) **Chelifer** Geoffroy. Two distinct eyes; femur of palpus not pedicillate. A new species (det. Banks) occurs at Boulder (W. P. Cockerell, February, 1907). *C. cancroides* Linné has been found at Fort Collins.

Chelanops grossus Banks is said to be quite common in Colorado; the genus *Chelanops* has the femur of palpus distinctly pedicellate, suddenly enlarged near base; palpi short and stout. *Ideobisium tibiale* Banks was described from material collected by the writer at Florissant. This belongs to the family Obisidæ, in which the cephalothorax has no transverse suture, and the abdominal scutes are entire. *Ideobisium* has four eyes, and the mandibles have a stylet.

Order *PHALANGIDA*

The harvest-spiders, easily recognized in typical forms by the small, oval body and very long legs; the abdomen is very broadly joined to the cephalothorax, and there is a single pair of eyes.

Family PHALANGIIDÆ

With one simple (not compound) claw at the end of each tarsus, and with a claw at end of palpus (Banks). Ours belong to the spinose tribe Phalangiini, the Oligolophini of Banks.

(105) **Homolophus** Banks. Femora wider than eye-tubercle; fifth joint of palpus not longer than the third and fourth together (Banks). *H. biceps* (Thorell), Boulder Cañon, 7,340 ft., September, 1907 (Cockerell); determined by Banks.

(106) **Phalangium** Linné. Fifth joint of palpus longer than the third and fourth together; first femur longer than width of body. *P. cinereum* Wood,* University campus (Cockerell); det. Banks.

Family COSMETIDÆ

(107) **Sclerobunus** Banks. A forked claw on each hind tarsus. Our species red, tips of legs black. *S. robustus* (Packard). Boulder Cañon, 7,340 ft., September, 1907.

Order *ARANEIDA*

The true spiders. Abdomen unsegmented, narrowly joined to the cephalothorax. Several species were recorded from Boulder by Thorell in 1877; all those obtained in recent years have been kindly determined by Mr. N. Banks, with the exception of the *Phurolithus*.

Family DRASSIDÆ

Elongate spiders with low cephalothorax; legs usually rather long, strong, and tapering, terminated by two pectinate claws, armed with spines, and scopulate; the body is smooth or short-haired and frequently unicolorous or sombre-colored, seldom ornate; the eyes, normally eight, are in two transverse rows (Warburton). Commonly found under stones.

(108) **Zelotes** Gistl. *Z. atra* (Hentz).* University campus.

(109) **Gnaphosa** Latreille. *G. gigantea* Keyserling, Eldora, August, 1910. An undetermined species in Boulder Cañon, 7,340 ft.

(110) **Callilepis** Westring. *C. imbecilla* Keyserling. Salina, April 14, 1907.

(111) **Drassus** Walckenaer. *D. coloradensis* Emerton. Salina, April 14, 1907. The type-locality is Gray's Peak.

Family CLUBIONIDÆ

Subfamily CLUBIONINÆ

Allied to Drassidæ; anterior spinnerets close together, and eyes more extended across the head; abdomen often more cylindrical.

(112) **Phrurolithus** Koch. *P. formica* Banks. Boulder, March, 1910, in nests of the ant *Cremastogaster* (W and T. Cockerell). Specimens were sent to Dr. W. M. Wheeler, who noted that whereas the typical *P. formica* of the Eastern States is entirely black like the *Cremastogaster* with which it lives, the Boulder form has the cephalothorax red, corresponding to the accompanying *Cremastogaster*. Our specimens were also examined by Mr. J. H. Emerton, who agreed that they were *P. formica*, nearer to a variety found at Tyngsboro, Mass., than to the typical form, which occurs at Forest Hills.

(113) **Clubiona** Latreille.* An undetermined species on University campus.

Subfamily MICARIINÆ

A group containing ant-like forms.

(114) **Micaria** Westring. *M. perfecta* Banks.* University campus; *M. coloradensis* Banks, Boulder.

Family DICTYNIDÆ

With a cribellum or sieve-like plate in front of the spinnerets in female; eyes normally eight; legs rather strong; tarsi three-clawed and devoid of scopula (tuft of club-like hairs). Making irregular webs.

(115) **Dictyna** Sundevall. *D. arundinaceoides* Keyserling, Eldora, 1910.
D. sublata Hentz,* University campus.

(116) **Titanoeca** Thorell. *T. americana* Emerton. Salina, April 14, 1907; Boulder Cañon, 7,340 ft., September, 1907. This spider, according to Emerton, is a quarter of an inch long, deep black except the cephalothorax, which is dull orange, but covered with long black hairs like the rest of the body. Some have a few light-grey spots on abdomen. It lives under stones in dry places.

Family THERIDIIDÆ

Sedentary spiders, usually with feeble chelicerae (mandibles) and relatively large abdomen; snare irregular (Warburton). There is a comb on the hind tarsus, and the legs are usually without spines.

(117) **Lithyphantes** Thorell. *L. corollatus* (Linné). Boulder (cf. Thorell).
(118) **Steatoda** Sundevall. *S. distincta* Thorell. Ward.
(119) **Lathrodectes** Walckenaer. *L. mactans* (Fabricius),* University campus and Salina. This spider has the most extraordinary range, from the mountains of Colorado down to the tropics.

Family LINYPHIIDÆ

Allied to the last, but legs usually armed with spines; no comb on hind tarsus. At base of mandibles on outer side is a striate or roughened area (Banks).

(120) **Linyphia** Latreille. *L. phrygiana* Koch; Salina, April 14; cephalothorax light yellow, with a black line in middle, forked at anterior end, abdomen yellowish, with a median dark-brown or red stripe, the sides of which are deeply serrate. *L. marginata* Koch*; University campus; colors light yellow and purplish-brown, the abdomen with a series of large marks in the middle line, and lesser markings at sides.

Family TETRAGNATHIDÆ

Related to the Epeiridæ, but mandibles large, strongly divergent; abdomen more or less elongate.

(121) **Tetragnatha** Latreille. Abdomen three or four times as long as broad. *T. grallator* Hentz, varieties *principalis* (Thorell) and *debilis* (Thorell), Boulder (cf. Thorell); *T. laboriosa* Hentz,* University campus; *T. extensa* (Linné),* University campus and Eldora. In the female of *laboriosa*, the cephalothorax is much less than half length of abdomen; in *extensa* ♀ it is about half as long as abdomen.
(122) **Pachygnatha** Sundevall. *P. autumnalis* Keyserling.* University campus.

Family EPEIRIDÆ

These are the ordinary orb-weavers, spinning circular webs about buildings and elsewhere. They are often of large size, with a very large, globular abdomen.

(123) **Epeira** Walckenaer. *E. gemma* McCook,* University campus; *E. displicata* Hentz,* University campus; *E. trivittata* Keyserling (cf. Thorell); *E. carbonaria* Koch, Eldora; *E. aculeata* Emerton, Eldora.
(124) **Argiope** Audouin. Large spiders, more or less silvery, with the abdomen transversely barred. *A. aurantia* Lucas,* University campus; *A. trifasciata* Forskal (*transversa* Emerton),* University campus (Miss Edna Baker, September, 1906), and Eldora.

Family THOMISIDÆ

The "crab-spiders," with the position of the legs and manner of movement more or less crab-like. Some of the species live on flowers, and resemble in color the flowers they frequent.

(125) **Xysticus** Koch. *X. cunctator* Thorell, Boulder (cf. Thorell); *X. gulosus* Keyserling,* University campus; *X. gramineus* Emerton,* University campus.
(126) **Misumena** Latreille. *M. vatia* (Clerck), Boulder (cf. Thorell) and Eldora. Lives on flowers, and varies from white to deep yellow.

(127) **Tibellus** Simon. Peculiar for the very long abdomen, which makes it look very different from the ordinary crab-spiders. *T. oblongus* Walckenaer,* University campus and Eldora.

(128) **Philodromus** Walckenaer. *P. alaskensis* Keyserling,* University campus.

Family LYCOSIDÆ

Wandering hunters, known as "wolf-spiders," in the breeding season carrying their egg-bags with them, attached beneath the abdomen. Eyes in three rows; tarsi three-clawed; no spur at tip of tibia of male palpus.

(129) **Lycosa** Latreille. *L. carolinensis* Walckenaer,* female reaching a length of over 25 mm., mouse-color above, largely black beneath; *L. brunneiventris* Banks,* female 12 mm., sternum and coxæ dark brown, under side of abdomen pale brown, femora not ringed. Both on University campus.

(130) **Pardosa** Koch. *P. sternalis* (Thorell),* University campus; *P. iracunda* (Thorell), Boulder Cañon, 7,340 ft. The species of *Pardosa* are smaller than *Lycosa*, the head with more vertical sides.

(131) **Trochosa** Koch. Third and fourth tibiæ without a spine at base above, though there is one near middle (in *Lycosa* and *Pardosa* these tibiæ have a stout basal spine). *T. cinerea* (Fabricius),* University campus.

Family ATTIDÆ

The "jumping spiders," with three rows of eyes, the first consisting of four large eyes directed forward; eyes of second row very small; legs relatively short. Often bright-colored or prettily marked.

(132) **Phidippus** Koch. *P. opifex* McCook, Boulder (cf. Peckham, *Revis. Attidæ N. Am.*, 1909, p. 393); *P. audax* Hentz=*morsitans* Walck., Peckham,* University campus and Boulder Cañon, 7,340 ft. *P. ardens* Peck., Boulder; *P. monticolus* Banks, Boulder. Also an undetermined species at Eldora. *P. audax* is the common species with white spots on the abdomen.

(133) **Pellenes** Simon.* Undetermined species were taken on the University campus, and at Salina and Eldora.

(134) **Salticus** Latreille.* *S. scenicus* Clerck, Boulder. An undetermined species is common on the University campus.

The Attidæ are numerous in Boulder County, and would well repay study. Banks, in his catalogue of Colorado spiders (*Annals N.Y. Acad. Sci.*, 1895), records 19 species from the state, eleven being reported from Fort Collins. Since then other species have been found, as *Pellenes klauseri* Peckham at Denver and Fort Collins, and *P. birgei* Peckham at Cañon City. At Steamboat Springs, May 27, 1910, I took the following (det. Banks): *Pellenes cockerelli* Banks, *P. festus* Peckham, *Dendryphantes vitis* Cockerell, *Attus palustris* Emerton. *P. cockerelli* was originally described from an altitude of 11,000 ft. in New Mexico, and *D. vitis* from 3,800 ft., also in New Mexico. It is rather remarkable to find them occurring in the same locality in Colorado, at an altitude of 6,780 ft. (The other Arachnids taken on the same day at Steamboat Springs were *Trombidium sericeum* Say, *Tetragnatha laboriosa* Hentz, *Lithyphantes corollatus* [Linné], *Micaria perfecta* Banks, and *Pardosa* sp.)

HABITS OF "AMBLYSTOMA TIGRINUM" AT TOLLAND, COLORADO[1]

By Dean T. Prosser[2]

Amblystoma tigrinum, the salamander with which this paper has to deal, is found in North America between the limits of northern Minnesota and New Mexico. In Colorado specimens have been taken all the way from the plains up to 10,000 feet. It is about twenty-four centimeters long; one-half of this length being tail. The general color is dark brown while the yellow ventral surface is cut into thin cross bands by brown patches. The head is comparatively long. There are twelve costal grooves. The fore limbs when pressed back reach the hind limbs. The male, besides being somewhat larger than the female, has the cloacal lips very much swollen and nodular in appearance in distinction from the smooth lips of the female.

Changes from Larval to Adult Form

This animal, like all other Amblystomatidae, develops from a larval form which has gills. The larvae may reach a length of from fifteen to twenty centimeters. They are thicker dorso-ventrally than are the adult forms and narrower laterally. In passing from larval to adult stage, the change is a gradual one in which the following are some of the most prominent features.

(1) Absorption of filmy portion of tail.
(2) Absorption of gills.
(3) Appearance of head, body and tail curves. (See Fig. 1.)
(4) Growth of the posterior end of the operculum to the body.
(5) Greater development of the limbs.

Field Studies

Tolland, Colorado, where these investigations were undertaken, is located about eighteen miles from Boulder, Colorado, the home

[1] *Publication of the Colorado Biological Survey*, No. 2.

[2] The author is indebted to Professor Francis Ramaley for criticisms and suggestions.

of the State University. Its altitude is about 8,889 feet; the average mean temperature for July about 60 degrees F. In this small hamlet a mountain Laboratory for the study of field biology is maintained every summer by the University.

When first noticed on June 16, 1909, the salamander larvae were found scattered all along the western and southern bank of Park Lake. (See Fig. 2.) None at all were found along the eastern and northern shores. Along these shores there is little grass and few stones under which they could seek shelter. Here, also, the lake bottom recedes gently away to deeper parts. On the sides where the larvae were found the deeper water is close in and there are numerous inlets into marshy places where plenty of grass covering can be found.

The larvae on the first day of observation and for several days following were distributed regularly along these two shores (western and southern) and there was no evidence of congregating in bunches. As yet there was no pond scum (Spirogyra) present on the lake. The larvae were generally found lying with their heads under the protection of a rock. When disturbed, they always swam away to deeper water. Those whose movements could be followed always returned to shallow water near to the place where they left it. The larvae at this time were very active and on several occasions when taken would leap out of a net. This action was brought about by the use of the tail rather than by any movement of the limbs. When in motion, while the fore limbs might appear to aid the action somewhat, the hind limbs were extended backward in the direction of the tail and were practically useless except as a more perfect means of balancing in the water.

On June 20, 1909, while a few were scattered along the west and south of the lake, in one place they were present in a shoal. This was a little inlet with an island dividing it into two parts. Back from the shore a little way it was broken up into numerous little bodies of water which projected farther into the land. Two days before this time pond scum (Spirogyra) became prominent. In fact, this little inlet was entirely covered with it. Here the larvae were present in such countless numbers that they cut the water into ripples, going

FIG. 1.—Photograph of four larvae of *Amblystoma tigrinum* in different stages of development, with one adult. Note the presence of head, body and tail curves in the adult form.

for deeper water when disturbed. There were so many of them that they were in each other's way and were easily caught. Later as the pond scum became thicker, the animals could not be seen; but that they were present in as great numbers was shown by the com-

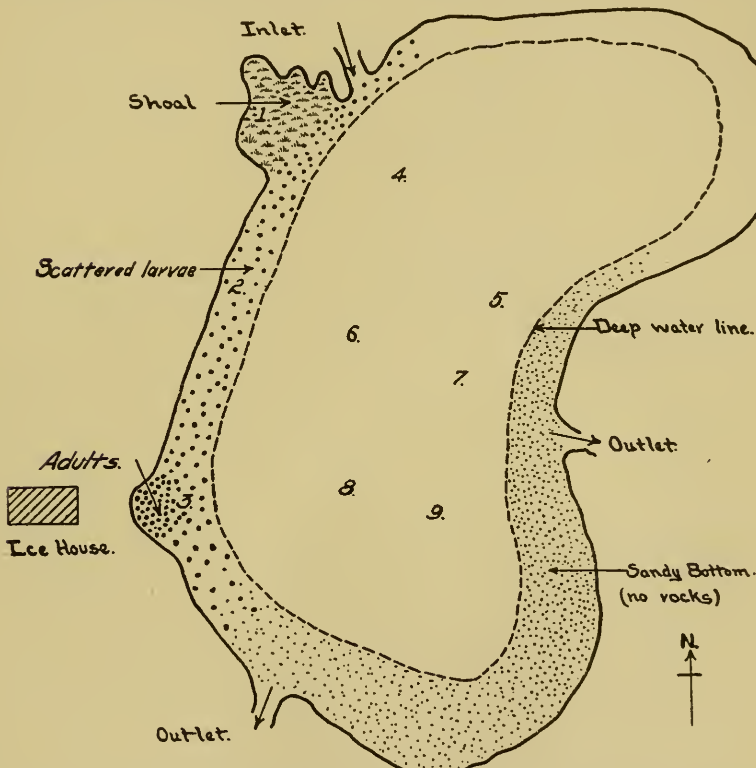

FIG. 2.—Diagram of Park Lake, Tolland, Colorado, showing distribution of the salamanders when first noticed, also showing places where the following temperature averages were taken.

TIME OF DAY	7 A.M.	2 P.M.			8 P.M.
	West	West	Center	East	West
Shoal..........	(1) 58°	(1) 69°	(4) 64°	(5) 66°	(1) 60°
Middle.........	(2) 60°	(2) 66°	(6) 64°	(7) 67°	(2) 63°
Ice House.......	(3) 62°	(3) 74°	(8) 62°	(9) 67°	(3) 59°

motion they created on trying to get to deeper water. All along the shore the few individual ones—which before had been found very close to rocks and grasses—began now as the Spirogyra advanced all along these two borders to be more closely connected with the green masses than with the rocks. The shoal was made up of larval forms in all stages of development. Some were in the full larval condition with long gills and thick (dorso-ventrally) tail; in some the tail was partially absorbed; in others the gills. In some few both of these changes were taking place. Where absorption of the gills was occurring, it seemed to be more in the third one than in the two more forward.

The southwest corner of the lake was a very shallow place with a muddy bottom. With exception of the inlet this was the only place on the lake which had been covered with Spirogyra. This place was examined daily from June 16, and although numerous larvae were taken from it, no adults were seen until June 24. There were only six of these, and as they were shown to be pure adults by the development of the genital organs and distribution of the aortic arches, and as no intermediate stages were found at the time, it is probable that they were last year's adults. These when disturbed were just as likely to swim toward the shore as toward deep water. They would allow themselves to be caught in a net without any particular struggle. On land they were very much more at home than were the larvae. When in motion they used the tail very little. They seemed to prefer to crawl along the bottom with their feet; when swimming they used their feet mainly, i.e., they would give a big shove with them, then they would lay them alongside of the body and would glide through the water until the motion was spent, after which they would repeat the act.

All this time the larvae had been breathing entirely by means of gills and skin, but on June 25, 1909, I noticed that a larva after being under water for about two minutes would come to the surface, take a gasp of air and then go down for another short period, after which it would come for another gasp of air. This signified that the lungs were beginning to function. At this time the limbs seemed to be more in use when in motion; the true larvae allow the limbs to come up close to the body and the movement is more by the tail. On several occasions I put a larva into an enclosure formed by my hands which was closed toward deep water and open toward the shore. Although it would swim around slightly it would not pass out toward shore, but waited until my hands were open toward the deep water, when it would pass out rapidly. When not in motion the larvae lie with their feet at right angles to the body and with the gills projecting straight out at the side. By this means the filmy expansions of the gills are freely exposed to the water.

On the mornings and evenings of June 25, 26, 27, 28 and 29 at 7 A.M. and 8 P.M. respectively, along the western and southern shore there were no salamanders in sight. Temperature readings showed that the water was too cold. At night the salamanders go out into deeper water because that is warmer, and they do not return in the morning until the temperature is in the neighborhood of seventy degrees. The data for this statement are shown in the legend to Fig. 2.

From this time on the salamanders stayed in the places I have described, until about July 15, when, owing to a falling of the lake level, the shore line changed. With the change in shore line the salamanders changed their habitat until they found one which was comparable to the one which they had formerly occupied. The shore line on the western and southern side was carried out by the lowering of the lake level until it was at deep water with no chance for the salamanders to run under rocks. At the southeast end of the lake and only a little way from shore is a submerged bank which runs north-east by south-west along the whole east end of the lake. To the north-west of this bank the depth of the lake was about the same as that of the north-west shore before the change of shore line. Here the salamanders congregated under dense masses of Spirogyra. On the mornings and evenings of July 17, 18 and 19 no salamanders were in sight along this shore. Temperature readings showed the same conditions to exist as did in their former habitat. The data are shown below Fig. 3.

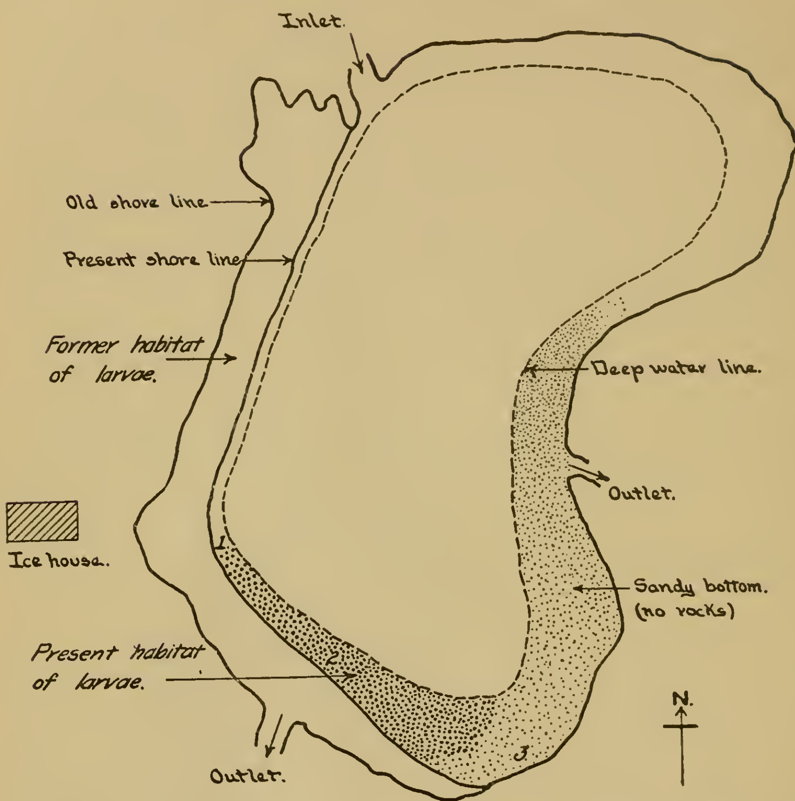

FIG. 3.—Diagram of Park Lake, Tolland, Colorado, showing the habitat of the salamanders after the shore line had changed. Notice the old shore line and the former habitat of the salamanders. The map shows also the places where the following temperature averages were taken.

Time of Day	7 A.M.	2 P.M.	8 P.M.
Ice House........	(1) 58°	(1) 76°	(1) 63°
Middle..........	(2) 59°	(2) 72°	(2) 64°
East............	(3) 58°	(3) 72°	(3) 63°

SUMMARY

This paper is intended to illustrate the following points relative to the habits of the salamander, *Amblystoma tigrinum*, as observed in Park Lake, Tolland, Colorado, in the summer of 1909.

(1) The most important features in the change from larval to adult stage.

(2) Distribution and some characteristic habits of the larvae in the lake under observation.

(3) The distribution and some characteristic habits of the adults.

(4) Some temperature features as follows:

(*a*) If the salamanders are to be active, the water must be of a favorable temperature, close to seventy degrees Fahrenheit.

(*b*) During the day they choose the shallow water close by deep water because the temperature there is nearest seventy degrees.

(*c*) At night they go out to deep water because it does not cool to so low a point as does the shallow water.

(*d*) They return in the morning from the deep water to the shallow water only when the temperature of the latter has risen above that of the former.

A STUDY OF THE LODGEPOLE–PINE FORESTS OF BOULDER PARK (TOLLAND, COLORADO)[1]

By Miss Katharine Bruderlin

Location and Extent of Boulder Park.—Boulder Park is situated at Tolland, Colorado, on the Denver, Northwestern and Pacific Railroad in South Boulder Canyon at an altitude of about 8,900 feet. The park is about 34 miles in a straight line northwest of Denver and 18 miles southwest of Boulder. In extent it is about one and one-half miles long and one-half mile wide, and is traversed from west to east by South Boulder Creek. The railroad enters from the east, going across the entire length of the park and leaving at the western end to ascend the southern slope of a high mountain north of the park. The ascent is made in three successive elevations and from this the mountain receives the name "Giant's Ladder." On the slopes of the mountains which hem in the park, there are lodgepole-pine forests in various stages of development.

General Appearance of Boulder Park.—Lodgepole-pine forest is the general covering of the mountains surrounding Boulder Park. A marked difference may be noted in the nature and abundance of the vegetation on the north and south sides of the valley. The slope of the south side is steeper, the soil has a coarser texture and there is less moisture than on the north side.

[1] *Publication of the Colorado Biological Survey*, No. 3.

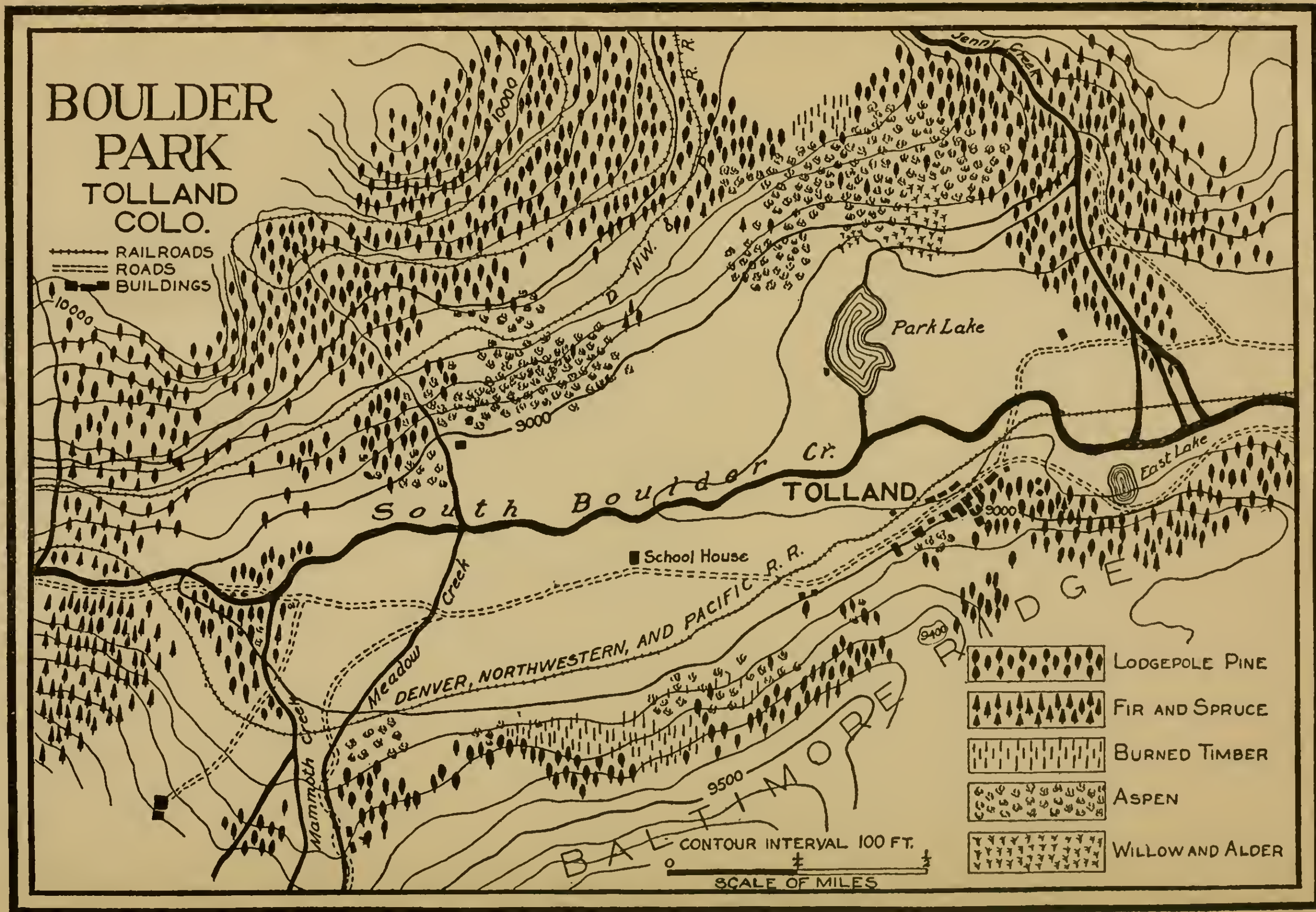

Fig. 1.—Map of Boulder Park, Tolland, Colo.

In the southwest end of the park on the slope facing to the north the pine forest occurs only at the top of the mountains. Below this and to the east is a large burned-over area. This is conspicuous because of the bare trunks of dead trees that tower above the young aspens. The central part of this slope is covered by an open formation of lodgepole pines, more dense toward the eastern end of the slope. Among the pines in the open formation are young spruces and firs and small societies of aspens. On dry, exposed places a few limber pines invade the forest. On this same north-facing slope at the eastern end of the park there is a well-developed forest of pines, firs and spruces.

The vegetation of the south-facing slope (i.e., the northern boundary of the park) is abundant and of greater variety. Here there are meadows, alder-willow thickets, aspen groves and pine forest. At the eastern end there is a large pine forest, which farther to the west is replaced by an aspen grove. This grove covers the entire central portion at the base of the Giant's Ladder. In the aspen grove there are large areas of grassland and associations of scrub willow and alder. Throughout the grassland are scattered various species of flowering herbs such as Delphinium, Aconitum, Helianthella, Erigeron, Campanula, Galium and Mertensia. From the summit of the Giant's Ladder a lodgepole-pine forest extends down to the western end of the park. On the north-facing slope to the west of the park is a close formation of firs and spruces among which are scattered a few lodgepole pines.

The Climax Formation.—The lodgepole pine, *Pinus murrayana* "Oreg. Com.," forms the climax formation at Boulder Park. It is a tall, straight tree, in this locality attaining a height of almost 60 feet. The diameter of trees 55 to 58 feet in height may vary from 9 inches to 22 inches. No trees over 22 inches in diameter were noted. It is probable that none of the lodgepole-pine trees of this locality are over 150 years old. Successive forest fires have ravaged the locality, a most serious one about forty years ago killing most of the lodgepole pines which were standing at that time. Here and there, however, certain groups of trees escaped; some trees were evidently injured but did not fall for many years. To the north of the park there are a few still standing, although now dead, which were probably injured at that time. A few trees which have fallen within the past ten years were over 200 years old at the time of their death.

The Development of the Lodgepole-Pine Forest.—After an area has been burnt, the first trees to appear are the aspens. Later, lodgepole pines appear among these. The ground becomes reseeded by the opening of the cones which takes place on account of the heat produced by the fire. When the lodgepoles reach a diameter of about six inches, Engelmann spruces and subalpine firs may appear. These trees do not grow until there is considerable shade. Here and there are a few willows. Spruces and firs are much more abundant on the steeper slopes and in moister places. The best developed spruces are found on very moist slopes of about 35 degrees as is shown in the forest on the north-facing slope at the western end of the park and on the steep mountain south of East Lake. On very dry slopes forestation may begin with the lodgepole pine without passing through the aspen stage.

The Close Formation.—At the northeast end of the park toward Jenny Creek there is the best example of a lodgepole forest. Here the stand is very close and the trees vary in size from seedlings to those that are almost two feet in diameter. The larger trees must be about 120 years old, and of a height of 58 feet. The best-developed and largest trees are found on a slope of about six degrees and in comparatively dry soil. The forest contains not only lodgepole pines but also Engelmann spruces and subalpine firs. The spruces and firs are younger and smaller trees, most of them not reaching a diameter greater than four inches. The number of spruces and firs in a given area of the forest varies, but in general we may say that to every one hundred pine trees there are about four spruces and one fir. Deeper in this forest, as the soil is more moist and the slope becomes greater, the spruces and firs increase in number and size. At Jenny Creek the spruces and firs are as large and well formed as the largest of the lodgepole pines. Some very large Engelmann spruces, doubtless 250 years old, are found in wet soil close to the creek.

The vegetation of the forest floor consists only of a few species which are mostly shrubs. The absence of flowering herbs is probably due to the lack of sunlight and to the shortness of the growing season. The spring snows often remain on the ground until the middle of June. The blueberry, rose and kinnikinic form dense mats, junipers occur at the bases of trees, wild strawberry and Oregon grape are found here and there. The pine drop, *Pterospora andromeda* Nutt., is not infrequent.

TABLE I

Some Observations as to Height, Diameter and Age of Lodgepole Pines

Diameter in Inches	Height in Feet	Age in Years
4	18	. .
5	32	39
6	40	. .
6½	. .	37
8	43	. .
8	46	. .
9	42	114
9	56	. .
11	55	. .
11	50	. .
11	58	. .
11¼	. .	117
10	. .	112
12½	. .	108
16	57	. . .
18	57	. . .
22	56	. . .

The Open Formation.—In the open formation as seen on the north-facing slope, the trees are farther apart and not as large as those along Jenny Creek. Here and there in depressions there are aspen groves. The slope is steep, varying from eight to thirteen degrees. Small growth consists almost entirely of young lodgepoles. The larger trees are not more than six inches in diameter and are about 38 years old. Thus, this part of the forest is not as old as the one before described. Since more light can reach the forest floor, the vegetation is more abundant.

The shrubby cinquefoil (*Potentilla fruticosa*), buffalo berry, honeysuckle and elder occur in the moist soil. Edwinia and ninebark grow in drier soil near the edge of the forest. The rose, kinnikinic and juniper occur here also, but seldom form as dense mats as in the close formation, since herbs occur more abundantly here. Herbs of many species occur, hence changes take place in the general appearance of the forest floor from week to week. This subject will be treated under a separate heading.

Other Trees of the Forest.—The coniferous trees are Engelmann spruce, subalpine fir, limber pine, Douglas spruce and rock pine. None of these form associations or societies excepting the Engelmann spruce and subalpine fir. They occur either solitary or in small groups. As has already been mentioned, a well-developed forest of Engelmann spruce and subalpine fir may be found at the west end of the park and on the high mountain south of East Lake. In these places the slope is very steep and the soil cold and wet.

On dry exposed situations along Baltimore Ridge and on the top of the Giant's Ladder, limber pines invade the forest. A few rock pines occur among the aspens at the western edge of the forest near Jenny Creek. In this locality there are also some Douglas spruces. One tree is of especial interest on account of its size, being about 80 feet high and four feet in diameter. This Douglas spruce is older than any of the surrounding trees; indeed it is probably 400 years old.

The aspens (*Populus tremuloides*) and willows are the only deciduous trees found in the lodgepole forest. The aspen association represents a stage in reforestration of conifers, the trees being often the first to appear after an area has been burnt over. They are gradually replaced by the lodgepole pine but may maintain themselves for some time in moist areas. The largest aspen groves are seen on the south-facing slope at the base of the Giant's Ladder and north of Park Lake. Smaller assemblages of aspens occur in depressions (glacial sink holes) on the slope south of Tolland. The soil in such depressions is very moist, due to seepage. The fact that the spring snows remain here longer than on the slopes may also account for the existence of aspens. The sink holes are likely to be filled with water for periods during rainy weather, and this standing water would kill coniferous trees.

A few willows (*Salix brachycarpa* Nutt., *Salix chlorophylla* Anders.) are found sparingly among the herbs and shrubs in the open formation.

Shrubs of the Forest Floor.—The occurrence of shrubs on the forest floor has already been mentioned. Close-growing species are *Vaccinum erythrococcum* Rydb., *Vaccinium oreophilum* Rydb., *Arctostaphylos uva-ursi* (L.) Spreng. *Linnaea americana* Forbes forms mats in shady places at the bases of trees and under fallen logs, and is found in parts of the forest where spruces and firs are more numerous. Other shrubs are *Sambucus microbotrys* Rydb., *Rosa sayi* Schweinitz., *Berberis aquifolium* Pursh, *Dasiphora fruticosa* Rydb., *Juniperus siberica* Burgsd., *Lepargyraea canadensis* (L.) Greene and *Lonicera involucrata* Banks. The species of Vaccinium are the commonest and most widely distributed of all the shrubs.

Herbs of the Forest Floor.—The number of flowering herbs on the forest floor is large, 62 species being noted, and this certainly does not include all. A succession of various plant associations follows the seasons. The appearance of the forest floor changes from week to week depending on the flowering of the more conspicuous species. An area may be covered by one society (Thermopsis, Chamaenerion) or by several smaller societies. Some of the most conspicuous changes in the aspect of the forest floor will be noted.

1. About April 15, *Pulsatilla hirsutissima* and *Thlaspi coloradense* appear, forming the chief part of the pre-vernal flora. These plants occur only on the edges of the forest and in open places.

2. Somewhat later, in May or early June, *Thermopsis divaricarpa* follows, producing large yellow patches among the trees. About the same time *Anemone cylindrica* and *Erysimum wheeleri* become conspicuous. In shady places at the bases of pine trees Arnica societies may be seen. The above named may be said to belong to the vernal flora, the first flowers appearing about May 15.

3. The appearance of the loco weed, *Aragallus lambertii*, marks

the beginning of summer. Pentstemon spp., Achillaea, Pseudocymopterus, Sedum, Chamaenerion and Castilleja spp. characterize the summer season. The blossoming of any of these plants may last from fifteen to twenty-eight days. The time at which each species is at the height of its blooming period may be noted in the table.

4. With the exception of the gentian and the fire weed the principal plants which characterize the autumnal flora belong to the Compositae. The golden rod and species of Erigeron form yellow and blue patches on the forest floor. Grasses occur abundantly at this season, thirteen species being noted, as follows: *Calamagrostis purpurascens* R. Br., *Bromus porteri* (Coult.) Nash., *Agrostis hiemalis* (Walt.) B.S.P., *Festuca brachyphylla* Schultes., *Sitanion brevifolium* J. G. Smith., *Trisetum montanum* Vasey., *Poa interior* Rydb., *Agropyron violaceum* (Hornem.) Vasey. *Agropyron caninum* (L.) Beauv., *Agropyron tenerum* Vasey., *Hordeum jubatum* L., *Panicularia holmii* Beal., *Dactylis glomerata* L. The tribes represented are Festuceae (5), Hordeae (5), Agrostideae (2), and Aveneae (1).

Besides the principal species mentioned, many secondary species occur. Some species, however, were noted which do not seem to belong properly in the lodgepole forest. They are probably invaders from drier or moister areas. *Aquilegia coerulea*, *Delphinium glaucescens* and *Geranium richardsonii* were noted near the aspen groves. *Eriogonum subalpinum* and *Capnoides aureum* grew in especially dry places. *Anaphalis subalpina* was found on the south-facing slope, *Leptasia austromontana* formed dense mats in a few places on the north-facing slope and *Pyrola chlorantha* occurred in shady places with the twin flower (*Linnaea americana*).

HERBS OF THE FOREST FLOOR

I. PREVERNAL FLORA

PRINCIPAL SPECIES

	Height of Blooming	Time of Fruiting
Pulsatilla hirsutissima (Pursh) Britton.......	June 1	July 1
Thlaspi coloradense Rydb.	June 1	July 1

II. VERNAL FLORA

Principal Species

	Date of Appearance	Height of Blooming	Length Blooming Season
Thermopsis divaricarpa A. Nels.	June 21	June 29	28
Anemone cylindrica A. Gray	June 29	July 2	14
Erysimum wheeleri S. Wats.	June 20	July 1	21
Arnica cordifolia Hook.	June 30	July 4	19

Secondary Species with Date of Greatest Abundance

Erigeron trifidus Hook.	June 29
Astragalus alpinus L.	June 29
Draba streptocarpa A. Gray	June 30
Arabis philonipha A. Nelson	July 2
Cerastium occidentale Greene	July 2
Sieversia ciliata (Pursh) Don.	July 1

III. ESTIVAL FLORA

Principal Species

	Date of Appearance	Height of Blooming	Length of Blooming Season
Aragallus lambertii (Pursh) Greene	July 1	July 8	25
Pentstemon alpinus Torr.	June 29	July 13	27
Pentstemon procerus Dougl.	July 10	July 15	15
Sedum stenopetalum Pursh	July 2	July 12	23
Achillea lanulosa Nutt.	June 30	July 14	26
Pseudocymopterus montanus (A. Gray) C. & R.	July 1	July 14	21
Castilleja sulphurea Rydb.	July 10	July 21	18
Castilleja rhexifolia Rydb.	July 10	July 21	18
Chamaenerion angustifolium (L.) Scop.	July 10		60

Secondary Species and Date of Greatest Abundance

Aragallus richardsonii (Hook.) Greene	July 8
Phacelia sericea Hook.	July 15
Androsace filiformis Retz.	July 15
Potentilla pulcherrima Lehm.	July 15
Potentilla concinna Richardson	July 15
Arenaria fendleri A. Gray	July 15
Pentstemon humilis Nutt.	July 15
Silene scouleri Hook.	July 15

Secondary Species and Date of Greatest Abundance—*Continued*

Antennaria rosea (D. C. Eaton) Greene....	July 10
Antennaria microphylla Rydb............	July 10
Antennaria anaphaloides Rydb...........	July 10
Pentstemon glaucus stenosepalus A. Gray....	July 15
Galium boreale L......................	July 15
Campanula petiolata D. C...............	July 15
Drymocallis glandulosa (Nutt.) Rydb.......	July 18
Frasera speciosa Dougl..................	July 14
Geum strictum Ait......................	July 14
Allium cernuum Roth....................	July 18
Pyrola chlorantha Swartz................	July 16

IV. AUTUMNAL FLORA

Principal Species

	Date of Appearance	Height of Blooming
Solidago nana Nutt..............................	July 18	July 26
Erigeron macranthus Nutt	July 15	July 24
Erigeron eximius Greene.........................	July 15	July 24
Dasystephana affinis (Griseb.) Rydb..............	July 26	Aug. 10
Chamaenerion angustifolium (L.) Scop.............	July 10	

Secondary Species and Date of Greatest Abundance

Senecio eremophilus Rich................	July 22
Senecio nelsonii Rydb	July 22
Carduus americanus (Gray) Greene.......	July 23
Amarella plebeja (Cham.) Greene.........	July 28
Agoseris purpurea (A. Gray) Greene......	July 24
Artemisia canadensis Michx.............	July 15
Artemisia frigida Willd.................	July 15
Geranium richardsonii Fish & Traut.......	July 23
Chrysopsis foliosa Nutt.................	Aug. 10
Anaphalis subalpina (A. Gray) Rydb......	July 26
Orthocarpus luteus Nutt................	July 25
Phacelia heterophylla Pursh.............	July 20

Summary.—The lodgepole-pine forest is the climax formation on the hillsides of Boulder Park, and belongs to the montane life-zone. The trees grow best on a moderate slope and in comparatively dry soil. Where steeper slopes occur, there is generally an admixture of Engelmann spruce and subalpine fir. In this locality the trees have attained a height of 58 feet and are not over 150 years old.

Forest fires at various times have burned over greater or smaller areas of the hillsides surrounding the park.

In the close formation the growing season for plants of the forest floor is very short and the vegetation consists purely of shrubs. The principal plants are blueberry, rose and kinnikinic. The aspect of the forest floor remains much the same throughout the growing period.

In the open formation flowering herbs are the principal species, so the aspect of the floor changes according to the season. The appearance of societies of Pulsatilla, Thermopsis, Anemone, Aragallus, Pentstemon, Castilleja, Chamaenerion, Solidago and Erigeron mark the various seasons.

In the course of the present study sixty-two species of flowering herbs, thirteen species of grasses, twelve species of shrubs and nine species of trees were noted.

Note.—The above study was undertaken at the suggestion of Professor Francis Ramaley while the writer was a student at the University of Colorado Mountain Laboratory in the summer of 1909. Additional observations were made at the second session of the laboratory (1910). The ecological terminology used is essentially that presented in the lectures at the laboratory and since published in outline form by Professor Ramaley in a paper entitled "Remarks on some Northern Colorado Plant Communities with Special Reference to Boulder Park (Tolland, Colorado)," in *University of Colorado Studies*, Vol. VII, pp. 223–236, July, 1910.

ECOLOGICAL CROSS-SECTION OF BOULDER PARK (TOLLAND, COLORADO)[1]

By Francis Ramaley and Louis A. Mitchell

The following ecological observations were made in Boulder Park, Colorado, during the late spring and part of the summer of 1909. There have been so few studies of this kind recorded that it has seemed worth while to put the material into shape for publication. An examination of the records of the few stations will give the reader some idea of environmental conditions in the mid-mountain districts (montane zone) of Colorado. Being selected so as to represent different plant associations, they should be rather generally useful. Various authors, among whom may be mentioned Mrs. Clements,[2] Shantz,[3] Pool,[4] Young,[5] Schneider[6] and one[7] of us, have made determinations of soil moisture and temperature in Colorado, but most of the studies have been in the plains area or in the foothill region.

Boulder Park is situated in Gilpin County in the north-central part of Colorado at an altitude of about 9,000 ft. It is really a mountain valley which extends two miles east and west, and is three-quarters of a mile wide. Mountains rise abruptly on either side; the valley narrows into a canyon at each end. The low morainal hills in the middle of the park and perched boulders on the canyon-

[1] *Publication of the Colorado Biological Survey*, No. 4.

[2] Clements, Edith S. "The Relation of Leaf Structure to Physical Factors," *Trans. Amer. Micr. Soc.*, pp. 19–102 (no date).

[3] Shantz, H. L., "A Study of the Vegetation of the Mesa Region East of Pike's Peak," *Bot. Gazette*, Vol. XLII, pp. 16–47 and 179–207, 1906.

[4] Pool, Raymond J., "Histological Studies in the Artemisia Formation," *University Studies* (Nebraska), Vol. VIII, pp. 411–38, 1908.

[5] Young, Robert J., "Forest Formations of Boulder County, Colorado," *Bot. Gazette*, Vol. XLVI, pp. 321–52, 1907.

[6] Schneider, Edward C., "The Succession of Plant Life on the Gravel Slides in the Vicinity of Pike's Peak," *Colorado College Publication*, Science Series, Vol. XII, pp. 289–311, 1911.

[7] Ramaley, Francis, "Remarks on Some Northern Colorado Plant Communities with Special Reference to Boulder Park (Tolland, Colorado)," *University of Colorado Studies*, Vol. VII, pp. 223–36, 1910.

side show the former presence of glaciers. Much of the morainic material was evidently washed away at a later time by the creek.

In the lower parts of the park, near the creek (South Boulder Creek), the water table is very close to the surface, as is to be expected. On higher ground a number of wells have been dug which it has been

FIG. 1.—Map of Colorado. Tolland is shown by the star in the north-central part of the state.

necessary to carry down to depths of 20, 30 and even 50 feet before reaching water.

The soil everywhere is of granitic or gneissic origin, formed by disintegration of igneous rocks from the adjacent hills and by the grinding of glaciers and the wearing action of running water. Wherever a fine-grained mass accumulates it has a more or less stiff and clay-like consistency, but there is generally so much sand and gravel that the soil is typically dry and well drained.

The present paper is a record of the vegetation at various points,

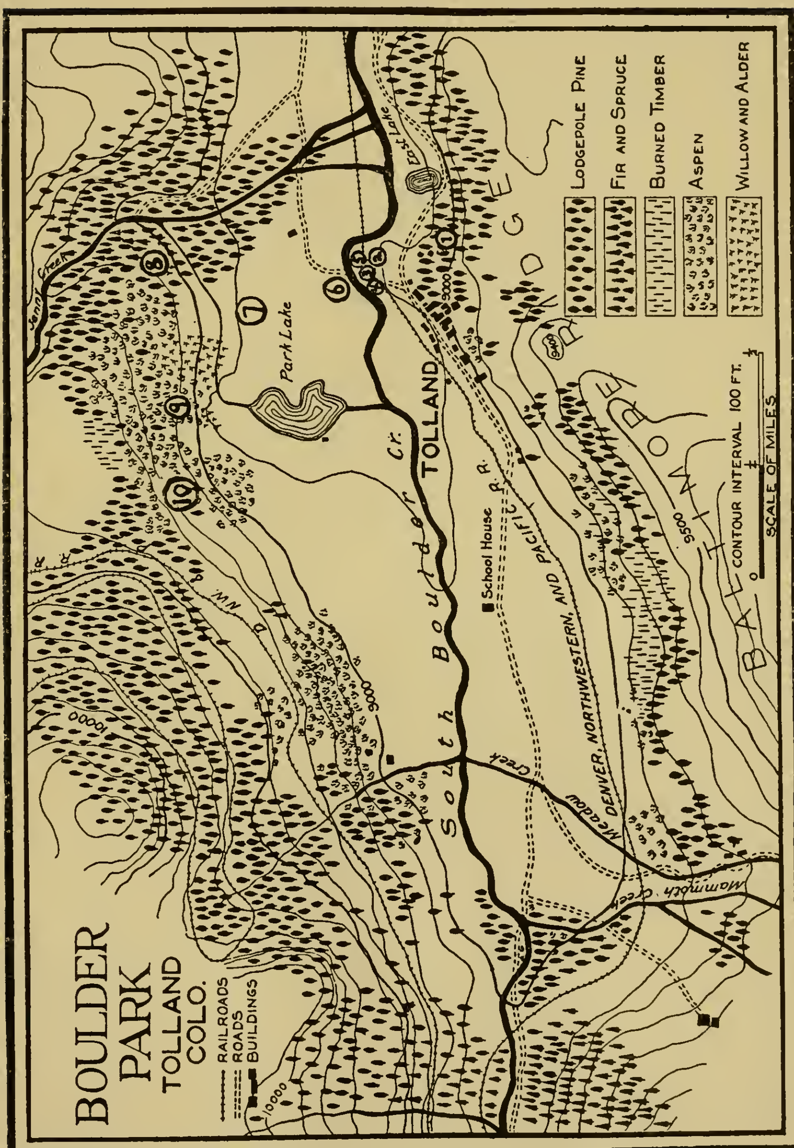

FIG. 2.—Map of Boulder Park, showing the stations where observations were made.

with ecological data. Situations were chosen, as far as possible, which represented all of the characteristic conditions in the park. No. 1 is at the south and No. 10 well to the north of the Park. Their positions are shown in the map (Fig. 2).

List of Stations

No. 1. Lodgepole-pine forest, north exposure.
No. 2. Railway cut, north exposure.
No. 3. Railway cut, south exposure.
No. 4. Dry grassland (flat).
No. 5. Meadow (moderately moist grassland).
No. 6. Willow scrub.
No. 7. Dry grassland, north exposure.
No. 8. Lodgepole-pine forest, south exposure.
No. 9. Aspen grove.
No. 10. Sagebrush ridge.

Station No. 1.—Lodgepole-pine forest. Slope 17 degrees. Exposure 14 degrees east of north. The formation is rather open and the earth has no covering either of herbaceous growth or of humus. The soil contains considerable gravel and is only moderately compact. Moisture varies little between surface and subsoil.

Facies—Lodgepole pine, *Pinus murrayana*.

Abies lasiocarpa
Populus tremuloides
Pinus flexilis
Picea engelmanni
Thermopsis divaricarpa
Erysimum wheeleri
Chamaenerion angustifolium
Castilleja sulphurea
Carex filifolia

Station No. 2.—Six-year-old railroad cut. Slope 30 degrees. Exposure 15 degrees west of north. It has a very scanty covering of herbaceous growth. The surface soil is much drier than that found lower down.

Principal species:

Aragallus richardsonii
Artemisia canadensis
Artemisia frigida
Achillaea lanulosa

Station No. 3.—Six-year-old railroad cut opposite No. 2. Slope 27 degrees. Exposure 14 degrees west of south. The vegetation is a little heavier than on the opposite bank, possibly on account of the more compact condition of the soil, which is more gravelly. Surface soil and subsoil differ little in moisture.

Principal species:

Artemisia canadensis	*Gaillardia aristata*
Agropyron caninum	*Artemisia frigida*
Chrysopsis foliosa	*Achillaea lanulosa*

Station No. 4.—Flat grassland. The soil is compact and gravelly, containing but little more moisture in the subsoil than near the surface.

Facies—*Koeleria cristata.*

Principal species:

Juncus balticus	*Aragallus lambertii*
Sedum stenopetalum	*Aragallus richardsonii*
Arenaria fendleri	*Artemisia canadensis*
Potentilla fruticosa (*Dasiophora fruticosa*).	*Solidago rubra*

Station No. 5.—Meadow. Slope 20 degrees. Exposure 60 degrees west of north. The surface soil is much richer than the soil below.

Facies—*Sporobolus brevifolius.*

Principal species:

Aragallus lambertii	*Artemisia canadensis*
Pentstemon procerus	*Solidago rubra*
Potentilla fruticosa	*Erigeron macranthus*
Aragallus richardsonii	*Dasystephana parryi*
Campanula petiolata	*Juncus balticus*

Station No. 6.—Among willows about one meter from the creek side. The soil here contains a large per cent of humus and is very moist throughout. The area is flat.

Facies—*Salix chlorophylla* and other willows.

Principal species:

Phleum alpinum	*Agrostis hiemalis*
Mertensia ciliata	*Senecio triangularis*
Elephantella groenlandica	*Dodecatheon radicatum*
Potentilla pulcherrima	*Betula glandulosa*

Station No. 7.—Dry grassland. Slope 5 degrees. Exposure 10 degrees east of north. The surface differs but little from the subsoil in moisture and quality, both being dry and gravelly.

Facies—*Koeleria cristata.*

Principal species:

Juncus balticus
Artemisia canadensis
Arenaria fendleri
Sedum stenopetalum
Aragallus richardsonii
Aragallus lambertii
Achillaea lanulosa

Station No. 8.—Lodgepole-pine forest. Slope 15 degrees. Exposure due south. This station lies just opposite to and at the same elevation as No. 1. The forest floor is covered with duff. The formation is open but the trees are so high that the ground is well shaded.

Facies—Lodgepole-pine (*Pinus murrayana*).

Principal species:

Juniperus sibirica
Vaccinium caespitosum
Arnica cordifolia
Rosa woodsii

Secondary species:

Antennaria aprica
Carex sp.
Calamagrostis canadensis

Station No. 9.—Aspen grove. Slope 20 degrees. Exposure 10 degrees east of south. This station lies somewhat above and to the west of No. 8. The grove is thick and a herbaceous growth covers the floor. The soil is rich with considerable humus. There is some seepage from the mountain side.

Facies—*Populus tremuloides.*

Principal species:

Geranium richardsonii
Thermopsis divaricarpa
Carduus pulchellus
Prunus melanocarpa
Campanula petiolata
Bromus porteri
Agropyron caninum
Calochortus gunnisonii
Campanula petiolata
Achillaea lanulosa

Station No. 10.—Sagebrush ridge. Slope 30 degrees. Exposure due south. It is much drier than the surrounding areas. The soil is hard and gravelly.

Facies—*Artemisia tridentata.*

Principal species:

Rosa woodsii
Campanula petiolata
Aragallus lambertii
Sedum stenopetalum
Astragalus alpinus
Gaillardia aristata
Eriogonum subalpinum
Calochortus gunnisonii
Prunus melanocarpa

In summing up the lists of characteristic plants from the various stations, we find that there are forty-nine species represented and that but few of these have a large distribution. *Artemisia canadensis* grows at five stations which cover all of the directly exposed places. *Calochortus gunnisonii* is found at two points which differ greatly in light intensity and soil moisture, showing that it can exist in a wide range of conditions. The conditions at Station No. 10, the sagebrush ridge, are rather extreme, but nearly all the plants which make up its flora are represented elsewhere, often in a very different habitat. *Thermopsis divaricarpa* grows only in the most shaded places. *Juncus balticus*, though present at a number of stations, is limited to dry grassland. *Campanula petiolata* is able to grow and flourish almost anywhere. It exists even in the extreme conditions of the sagebrush ridge at the north of the park. *Aragallus lambertii* grows at all of the dry, warm stations, while the other representative of the genus, *Aragallus richardsonii*, is much less widely distributed, although it has probably had the same opportunities of invasion. *Achillaea lanulosa* is the only other species which is abundant at more than two stations and it shows a tendency to grow under very varied conditions.

The discussion of each species in relation to its habitat would be rather beyond the range of this article.

A comparison of the individual stations shows, as would be expected, great similarities in the dry grassland areas and considerable likeness in the subsidiary plants of the two lodgepole-pine stations. The willow scrub, with its humus soil and high water content, has naturally a flora very different from the other stations.

As noted at the beginning of the paper, the stations were selected to give typical conditions. Some of the plants which are prominent in one locality may be present, though in small numbers, in another place. These are recorded only from the station where abundant. The following lists bring together the species which have been taken as representative of the flora of the different stations. Figures following the names are the station numbers.

Species Noted Especially in the Lodgepole-Pine Forest

Abies lasiocarpa, 1
Antennaria aprica, 8
Arnica cordifolia, 8
Calamagrostis canadensis, 8
Carex sp. undet., 8
Carex filifolia, 1
Castilleia sulphurea, 1
Chamaenerion angustifolium, 1
Erysimum wheeleri, 1
Juniperus siberica, 8
Picea engelmanni, 1
Pinus flexilis, 1
Pinus murrayana, 1, 8
Rosa woodsii, 8, 10
Thermopsis divaricarpa, 1, 8, 9
Vaccinium caespitosum, 8

Species Noted Especially in Dry Grassland Areas and in the Railway Cuts

Achillaea lanulosa, 2, 3, 7, 9
Agropyron caninum, 3, 9
Aragallus lambertii, 4, 5, 7, 10
Aragallus richardsonii, 5, 7
Arenaria fendleri, 4, 7
Artemisia canadensis, 2, 3, 4, 5, 7
Artemisia frigida, 2, 3, 7
Calochortus gunnisonii, 9, 10
Campanula petiolata, 5, 9, 10
Chrysopsis foliosa, 3
Gaillardia aristata, 4, 10
Juncus balticus, 4, 5, 7
Koeleria cristata, 4, 7
Sedum stenopetalum, 5, 7, 10

Species Noted Especially in the Willow-Scrub

Agrostis hiemalis, 6
Betula glandulosa, 6
Dodecatheon radicatum, 6
Elephantella groenlandica, 6
Mertensia ciliata, 6
Phleum alpinum, 6
Potentilla pulcherrima, 6
Salix chlorophylla, 6
Senecio triangularis, 6

Species Noted Especially in Meadow (Moderately Moist Grassland)

Dasystephana parryi, 5
Erigeron macranthus, 5
Pentstemon procerus, 5
Potentilla fruticosa, 4, 5
Solidago rubra, 4, 5
Sporobolus brevifolius, 5

Species Noted Especially in the Aspen Grove

Bromus porteri, 9
Geranium richardsonii, 2, 4, 9
Populus tremuloides, 1, 9

Species Noted Especially on the Sagebrush Ridge

Artemisia tridentata, 10
**Astragalus alpinus*, 10
**Eriogonum subalpinum*, 10
**Prunus melanocarpa*, 10

* Commonly in much moister situations.

TABLE I

PERCENTAGE OF WATER IN SOILS, AT DEPTH OF ONE FOOT, FROM VARIOUS STATIONS NEAR TOLLAND, COLO., 1909

STATION NO.	1	2	3	4	5	6	7	8	9	10
Description	Lodgepole-Pine Forest	Railway Cut, North Exposure	Railway Cut, South Exposure	Dry Grassland	Meadow	Willow Scrub	Dry Grassland	Lodgepole-Pine Forest	Aspen Grove	Sagebrush Ridge
June 24	6.5	8.3	6.0	4.0	11.0	48.0	7.0	9.0	14.0	1.2
July 2	7.0	2.7	4.0	1.9	30.4	46.5	2.0	10.0	10.3	1.0
July 8	5.6	5.0	5.8	7.4	12.0	45.0	8.0	11.3	13.6	0.7
July 12	4.0	7.0	7.5	3.0	5.3	45.0	3.2	11.5	7.1	0.4
July 17	6.7	3.1	3.1	1.3	5.0	47.6	1.0	8.2	8.0	3.0
July 24	...	5.9	6.9	2.5	13.0	47.0	3.3	4.3	3.0	2.1
Average	5.9	5.3	5.5	3.3	11.1	46.5	4.6	9.5	9.4	1.4

TABLE II

SOIL TEMPERATURES, AT DEPTH OF ONE FOOT, IN DEGREES F. AT VARIOUS STATIONS NEAR TOLLAND, COLO., 1909

Station No.	1	2	3	4	5	6	7	8	9	10
Description	Lodgepole-Pine Forest	Railway Cut, North Exposure	Railway Cut, South Exposure	Dry Grassland	Meadow	Willow Scrub	Dry Grassland	Lodgepole-Pine Forest	Aspen Grove	Sagebrush Ridge
June 24	57	60	67	71	56	51	66	57	56	61
June 30	58	61	70	64	57	54	62	57	79	64
July 2	...	67	71	67	55	52	73	58	60	70
July 8	62	62	64	...	58	50	62	57	58	68
July 12	63	64	70	73	61	53	67	57	60	77
July 17	63	67	76	70	58	52	69	59	64	62
July 24	52	60	61	60	66	55	63	58	62	62
Average	59	63	68	67	57	52	66	58	62	66

TABLE III

Relative Humidity of Air One Foot above Surface of Soil at Various Stations near Tolland, Colo., 1909

Station No.	1	2	3	4	5	6	7	8	9	10
July 8........	65	39	45	46	58	51	51	42	62	41
July 12.......	71	39	46	43	47	59	52	54	59	38

TABLE IV

Sunlight Percentage at Various Stations near Tolland, Colo., 1909

Station No.	1	2	3	4	5	6	7	8	9	10
July 24.......	25	100	100	100	100	25	100	31	4.6	100

Summary

The material presented in the foregoing pages consists of records of observation at ten stations in Boulder Park, a mountain valley in Gilpin County, north-central Colorado (altitude about 9,000 ft.). Lists are given of the principal species of plants at each station, together with a tabular statement of soil moistures, soil temperatures, relative humidity and light intensity. The stations selected show conditions in a lodgepole-pine forest, in dry grassland, along railway cuts, in a meadow, in an aspen grove and on a sagebrush ridge.

FIELD OBSERVATIONS ON THE SO-CALLED "ANEMONE" (*Pulsatilla hirsutissima*)[1]

By Francis Ramaley and Miss Marie Gill

The so-called "Anemone" of the Rocky Mountains is the "pasque flower" or the "crocus" of Wisconsin and Minnesota. In Colorado, it is abundant in the foothill and montane regions, occasionally extending up to the limit of trees on the mountains.

The flowers come into blossom before the leaves appear (Fig. 1). They are distinctly proterogynous. There are usually six petaloid sepals, commonly of a purplish color. Petals are absent. The sepals average about 3.5 cm. in length and 1.9 cm. in width. Soft hairs are present in abundance on the outer surface, but there are none inside. The stamens are very numerous, the outer ones shorter than the inner, the variation between the longest and shortest being 4 to 10 mm. The carpels are numerous, about 8.5 mm. in length, and are densely hairy toward the base.

The stamens of the outer row, about 25 to 30, are aborted and serve as nectar glands (Fig. 2). Anthers in these are of about the usual size, with the filaments extremely minute. In some flowers the transition between the taller stamens and the nectar glands is very gradual. In others, there are no stamens of intermediate size.

Variation

A number of variations were noted in the floral structure of the plants examined. About 500 specimens were collected from various stations in the vicinity of Boulder, Colorado, and carefully studied.

The sepals varied to a certain extent in number, color and size. There are usually six, but two flowers were found with four sepals, two with five, twelve with seven, and nine with nine. The usual color is light purple. One plant was found having pink flowers

[1] *Publication of the Colorado Biological Survey*, No. 5.

and two plants had flowers with white sepals. The sepals are usually of the same size, but a few flowers had three large sepals alternating with three smaller ones. In one instance a single sepal of normal size was accompanied by five which were very minute. Two flowers had all the sepals extremely small.

Stamens and nectar glands show certain variation. In two young flowers no anthers were present on the longer stamens, though present on a very few of the shorter ones. There was, however, the usual row of nectar glands. The same condition was found to exist at times in older flowers, but here it is possible that the anthers may have fallen off. In a few of the older ones there were no anthers or nectar glands. One comparatively young flower had no nectar glands and very few anthers. Those that were present were on the medium-sized stamens, while the longer and shorter filaments were completely without anthers.

Doubling occurred in two instances. Both flowers were found in the same cluster with some blossoms having the regular number of parts. One had twelve purple sepals narrower than the usual ones, being 2.5 cm. long and 8 mm. wide. Stamens and carpels were numerous, but no nectar glands were present. The flowers had two involucres, one 2.4 cm. below the flower, and the other 3 cm. below the first. The upper involucre was divided almost to the base into six segments, each of which was variously cleft and lobed. One of the segments was colored like the sepals and was three lobed (Fig. 3).

The other flower had eleven sepals 3 cm. long and 7 mm. wide. Two involucres were present, the lower one regular and 3 cm. below the upper. The flower was almost sessile upon the upper involucre, one of the four segments of which was formed by one of the eleven sepals of the flower. No nectar glands were found (Fig. 4).

Professor T. D. A. Cockerell has kindly given the writers an account of a specimen found by one of his students. The flower-stalk was jointed some distance below the flower and at the joint there was a single sepal. The flower was regular and a normal involucre was present some distance below the joint.

We are indebted to Professor George L. Cannon of Denver for three specimens of Pulsatilla showing variations. The flowers were collected by him in 1878 at Idaho Springs, Colo. One of the specimens had seven sepals of different sizes. The involucre was regular, but was densely hairy on the outside. The flower-stalk above the involucre was also thickly covered with soft, white hairs. Another specimen had a regular flower, but the base of the involucre and the flower-stalk above the involucre were densely hairy. Doubling occurred in the flower of the third specimen (Fig. 5.) The outer sepals were of ordinary size, but were branched. Inside of these were several narrower sepals, also branched. Those of the innermost rows were very narrow and very hairy. Stamens were absent—all having been suppressed or else converted into sepals. About the ordinary number of carpels were found. The involucre consisted of four dissected leaves, two of which were inside the other two. The outer leaves were united at the base, the inner ones separated.

Pollination

Knuth, in his *Handbuch der Blütenbiologie*, describes the flowers of seven European species of Pulsatilla, and lists the insects found in them. *Pulsatilla alpina* is a yellow-flowered species found in the Alps. It differs from ours in having some of the plants cross pollinated and some self pollinated. There are also some which are andro-dioecious, and some andro-monoecious. *P. vernalis* is not so distinctly proterogenous as the American species. Some of the flowers are self pollinated. *P. patens* agrees in the main with this species. *P. pratensis*, *P. vulgaris*, *P. montana*, *P. transsylvanica* do not differ radically from our species in the method of pollination. Of the insects listed by Knuth bees seem to occupy the most important places as pollinating agents. Ants, flies and bugs are also mentioned, and in two cases beetles and butterflies were found.

Our own observations are that in *Pulsatilla hirsutissima* the stigmas are ready for pollination before the anthers of the same flower are ripe. They produce a secretion which is thin and gives them a shiny appearance. Bees are the most important agents in carrying the pollen, those of the family Andrenidae visiting the flowers most often. Other insects, such as beetles, flies, ants and plant bugs are also present, but are probably of little use in pollination. Spiders may be found catching the insects which alight on the flower.

The following insects and arachnids were found by one of us, and determinations kindly made by Professor T. D. A. Cockerell:

April 19, 1906

Apis mellifera *L.*, four
Andrena nigrihirta *Ashmead*, 2 females
Spider (family Thomisidae)

April 23, 1906

Bombomelecta fulvida *Cresson*
Apis mellifera *L.*
Beetle (Anthrenus scrophulariae)
Ant (Formica)
Spider (family Attidae)
Fly (family Syrphidae)
Beetle
Plant bugs

April 25, 1906

Andrena bridwelli *Cockerell*, two females
Andrena carlini *Cockerell*, male
Fly (Syrphidae)
Plant bug
Halictus cooleyi *Crawford*, 1 female

May 1, 1906

Nomada subrutila *Lovell and Cockerell*
Andrena nigrihirta *Ashmead*, 1 male
Halictus pilosus *Smith*, variety, 1 female
Ant (Formica)
Fly (Syrphidae)
Plant bug
Halictus
Andrena bridwelli *Cockerell*, 1 female

May 2, 1906

Andrena prunorum *Cockerell*
Agapostemon texanus *Cresson*
Halictus cooleyi *Crawford*
Plant bug

Fig. 1

Fig. 2

Fig. 3

Fig. 4

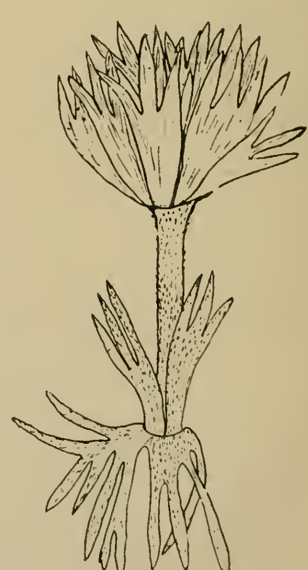

Fig. 5

Professor Cockerell has kindly furnished also the following list of the insects which he and Mrs. Cockerell and Professor Bethel of Denver found on the flowers of Pulsatilla in the spring of 1906.

Bees

Andrena carlini *Cockerell*, April 14—male (E. Bethel)

Halictus lerouxii *Lepeletier*, females, April 14 (E. Bethel); Abundant, April 20 (T. D. A. & W. P. Ckll.).

Halictus cressonii *Robertson*, female, April 16, Gregory Canyon (T. D. A. Ckll.).

Agapostemon texanus var. subtilior, *Cockerell*, female, April 20 (W. P. Ckll.).

Bombus nevadensis *Cresson*, female, are found at rest on outside of flower, April 20 (T. D. A. & W. P. Ckll.).

Andrena prunorum var. gillettei, *Cockerell*, male and female, April 20 (T. D. A. & W. P. Ckll.).

Nomada pulsatillae *Cockerell*, April 20 (T. D. A. Ckll.).

Nomada undulaticornis *Cockerell*, April 20 (W. P. Ckll.).

Osmia olivacea *Cockerell*. Boulder, April 20 (W. P. Ckll.).

Osmia pulsatillae *Cockerell*. Boulder, April 20 (W. P. Ckll.).

Osmia aprilina *Cockerell*. Boulder, April 20 (T. D. A. & W. P. Ckll.).

Sphecodes hesperellus pulsatillae *Cockerell*. Boulder, April 20 (W. P. Ckll.).

Moths

Plusia sp., April 20, sucking (T. D. A. & W. P. Ckll.).

Explanation of Figures

Fig. 1.—*Pulsatilla hirsutissima* (from Ramaley's "Wild Flowers and Trees of Colorado.").

Fig. 2.—Carpels, stamens and nectar glands of a normal flower.

Fig. 3.—Side view of a double flower, showing petaloid segment of upper involucre.

Fig. 4.—Side view of another double flower, showing the flower sessile upon the upper involucre, one of the segments of which is formed by a sepal.

Fig. 5.—Side view of abnormal flower, showing lobed sepals; segments of the involucre in two rows. (This specimen was kindly furnished by Professor George L. Cannon of Denver.)

ALPHABETICAL INDEX TO VOLUME VIII